# DESIGN CRITERIA
# AND
# CONSTRUCTION SPECIFICATIONS

## DIVISION I
## STREETS

**Town of Windsor**

**September 2009**
**Revised August 2014**

**DEPARTMENT OF ENGINEERING**

**TOWN OF WINDSOR, COLORADO**

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# FORWARD

This Town of Windsor's **Design Criteria and Construction Specification, Division I, Streets**, document is intended to provide guidance for the design, review, and construction of those public improvements in or under the public right-of-way and public easements. These Standards shall be required for all development projects within the Town limits of the Town of Windsor and its Growth Management Area (GMA).

This document represents an attempt to assist those in the design, review, and construction industry in providing quality and long-lasting public improvements. The document also provides for consistency in the design, review, and construction areas.

The document is not intended to replace or restrict the design function of the engineer nor the innovativeness and expertise of developers and contractors. Users of this document are encouraged to submit their ideas and methods of improving the document.

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Dennis Wagner, P.E.
Town Engineer

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**REVISIONS TO DESIGN CRITERIA AND CONSTRUCTION SPECIFICATIONS - DIVISION I STREETS**
**August 15, 2014**

These Specifications and revisions are applicable and shall be required for all development projects within the Town limits of the Town of Windsor and its Growth Management Area (GMA). These updates are effective July 22, 2013, through adoption of Resolution No. 2013-44, and minor amendments subsequent thereto.

SECTION 1 – Street Design Criteria:

1. On page 4 & 5, 1.02.D "DEFINITIONS" – add "*CUL-DE-SAC – A non-connective, one inlet/one outlet, local roadway with a circular turn around area at the end, enabling trucks and school buses to maneuver.*" Also add "*HAMMERHEAD – A non-connective, one inlet/one outlet, local roadway with a T-shaped turn around area at the end, enabling trucks and school buses to maneuver*."
2. On page 25, 1.06.B.2.b "Driveway Approach Gradient." Revise to read –"*All driveway approaches within the road right-of-way shall maintain a positive slope toward the street. Unless otherwise approved by the Town Engineer, the driveway profile grade, measured at the center of the drive, shall not exceed ten (10%) percent. The driveway profile grade within twenty (20') feet of flowline for non-residential installations, shall not exceed eight (8%) percent; while the gradient for the remainder of the driveway should not exceed ten (10%) percent.*"
3. On page 27, 1.06.B.6.d "Culvert." - Add "*Steel pipe material is prohibited*."
4. On page 31, TABLE 1.07.3:
   a. Line: "ACCESS MANAGEMENT" – add footnote - "*centerline to centerline*".
   b. Line: "Min distance between Intersections [No signal]"-
      i. Column: "URBAN MAJOR 3 LANES" – change 660' to *330'* and add footnote "*Increase as necessary per Table 1.25.1*".
      ii. Column: "URBAN MINOR 2 LANES" – change 330' to *250'*.
      iii. Column: "URBAN Ind/Comm 2 LANES" – change 330' to *250'*.
   c. Line: "MINIMUM DISTANCE BETWEEN DRIVEWAYS" – add "*(edge to edge)";* and
      i. Column: "URBAN MINOR 2 LANES" – remove footnote (3) and add footnote "*Not applicable for residences*".
      ii. Columns: "URBAN LOCAL" & "RURAL LOCAL" – add footnote – "*Except for cul-de-sacs*".
   d. Add "*Re-revised August, 2014*".
5. On page 34, TABLE 1.07.6 & 1.07.7, for crest and sag vertical curves, change "GRADE CHANGE %", values in each table from 0.00 – 0.99 change to *0.00 – 1.00*; 1.00 – 1.99 change to *1.01 – 2.00*; 2.00 – 2.99 change to *2.01 – 3.00*; 3.00 – 3.99 change to *3.01 – 4.00*; 4.00 – 4.99 change to *4.01 – 5.00*; 5.00 – 5.99 change to *5.01 – 6.00*; 6.00 – 6.99 change to *6.01 – 7.00*; 7.00 – 8.00 change to *7.01 – 8.00*.
6. On page 49, 1.10 "NON-CONNECTIVE ROADWAYS, A. GENERAL":
   a. First paragraph, first sentence, add at end – " *unless they include a pedestrian outlet at the closed-end.*"
   b. First paragraph, last sentence, eliminate: *"Non-connective roadways actually increase traffic and safety problems and do not encourage pedestrian travel, and their design and use should be discouraged in new developments because of their effect of reducing the efficiency of traffic flow and circulation."*.
   c. Second paragraph, eliminate: "*A cul-de-sac is a short, local access street having one end open to traffic and being permanently terminated by a circular turn-around for vehicles. Cul-de-sacs are used when a developer can either not continue the current path of a street (because of a wetland or other topographical constraint) or chooses not to continue the*

*established street layout. Although considered a popular design configuration, cul-de-sacs present several operation and maintenance problems for the Town of Windsor. Unlike through streets, which typically have a driveway access every fifty to eighty (50' to 80') feet, typical cul-de-sacs have between five and seven (5 & 7) accesses intersecting them in very short intervals. Although the Town does not plow cul-de-sacs, the home owner's association is forced to plow snow into a pile in the middle because otherwise the driveways get buried beneath mounds of snow. Cul-de-sacs reduce emergency vehicle response time and they have a negative affect on the orderly growth and street patterns of the Town."*.

d. Fourth paragraph, #1. Place a period after "local streets" and eliminate last two lines of paragraph: "*and only when and where specifically permitted upon review and approval by the Town Engineer. Hammerhead design for no-outlet streets are allowed only upon approval by the Town Engineer.*".

e. Fifth paragraph, #2. Eliminate last sentence: "*Offset cul-de-sacs are permitted only upon approval of the Town Engineer.*".

f. Sixth paragraph, #3. Eliminate entire paragraph: "*From a stormwater perspective, cul-de-sacs create a huge bulb of impervious cover, increasing the amount of stormwater runoff. Designers should consider and pursue innovative cul-de-sac designs that reduce the total amount of impervious surface.*".

7. On page 65, 1.22.C.2.a.1v. "Sign Face." Change last sentence in paragraph to read – "*Borders on street name signs shall be per the MUTCD*".
8. On page 68, 1.22.D.4.c "Crosswalks." Revise to read – "*Crosswalks shall be used at all signalized intersections, approved crossings, school routes, adjacent to schools, and as directed by the Town Engineer and shall be "Continental" style bars that are nine (9') feet long and twelve (12") inches wide, white, thermoplastic symbols.*"

SECTION 3 – Street Construction Specifications:

1. In Section 02575, page 8, 1.2 "QUALITY ASSURANCE", J.2., revise to read – "*Selection of SuperPave Gyratory Design Revolution. SuperPave Gyratory Design Revolutions shall be as follows: for Arterial roadways – 75 gyrations; for Collector and Local roadways – 75 gyrations.*"
2. In Section 02575, page 20, "COMPACTION", Table 02575-19, footnote (b), revise to read – "*All street classifications shall require 75 Gyrations.*"
3. In Section 03310, page 5, 2.7.C., "ADMIXTURES", after first sentence, add – "*Windsor Red concrete shall be similar to Davis Red 160, but use three (3#) pounds per ninety-four (94#) pound sack cement.*"
4. In Section 03310, page 10, 3.8.C., add a period at end of sentence.

END OF REVISIONS

# TOWN OF WINDSOR, COLORADO

## DEPARTMENT OF ENGINEERING

## DESIGN CRITERIA

## AND

## CONSTRUCTION SPECIFICATIONS

### DIVISION I

## STREETS

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# STREET DESIGN CRITERIA

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## SECTION 1
## MINIMUM DESIGN CRITERIA

### 1.01 SCOPE

The purpose of this section of this document is to present the Town of Windsor criteria for the design of streets. It is to be used by developers, design architects, and design engineers in the design of public and private streets for which approval by the Town of Windsor Engineering Department is required. All street design, layout, alignment, and classification shall conform to these design criteria, the Town of Windsor Subdivision Regulations, the Town of Windsor Comprehensive Plan, and Chapters 8, 11, 13 and 17 of the Windsor Municipal Code.

### 1.02 GENERAL

#### A. MINIMUM STANDARDS

1. The provisions stipulated in this section are general in nature and shall be considered as applicable to all parts of these specifications, including any supplements and revisions. All construction within the public right-of-way shall be designed by or under the direct supervision of a Professional Engineer (P.E.) registered in the State of Colorado. All final drawings and support data submitted to the Town for approval must bear their seal and signature. No permits for construction will be issued until these documents have been certified by a P.E. and approved by the Town. Any over-lot grading completed during the design phase of the project must be certified by a P.E. or Professional Land Surveyor (P.L.S.) prior to issuance of any permits for construction.

2. The design criteria as presented is intended to aid in preparation of plans and specifications for the Town of Windsor including minimum standards where required. These design criteria are considered minimum and a complete design will usually require more than is presented in this document. As with any design criteria, occasions may arise where the minimum standards are inappropriate. In these cases a variance shall be considered. Written request for each variance should be directed to the Town Engineering Department and shall conform to the requirements of **Section 1.03B.1**.

3. Whenever the provisions of these Standards are found to be inconsistent with any other regulations or codes, the Town Engineer shall determine the standard to apply. The provisions of these regulations are minimum requirements that do not preclude imposition of more restrictive standards by agreement or by law.

4. Projects shall comply with all laws, regulations, codes, and ordinances applicable to the design and the furnishing and performance of the work. Except where otherwise expressly required by applicable laws, regulations, codes or ordinances, the Town shall not be responsible for monitoring compliance with any law, regulation, code or ordinance.

5. The Town has subdivision regulations and development code that can help define the various processes required for projects.

6. Prior to the contractor beginning work, an approved set of plans and specifications must be on file with the Town of Windsor. All contracts, bonds, insurance, permits, and licenses must be fully executed by the Contractor before beginning work. Contractor shall have a copy of these standards and specifications on the site at all times during construction.

7. Town's review and approval will only be to determine if the plans, specifications, and construction conform to the Town's requirements. Town's review and approval will not relieve the Design Professional and Contractor/Owner from responsibility for any variation from the Town requirements or adequate design standards. The Town's review and approval shall not constitute any assumption of responsibility or liability for the design or construction and the Town's review and approval of any plans, reports, or drawings or the Town's inspection and approval of any

improvements constructed by the Developer in accordance with these Standards, does not constitute a representation, warranty, or guarantee by the Town that such improvements are free from defects or will operate adequately for the purpose intended.

8. It is the intent and purpose of these standards and specifications to obtain high quality construction throughout, with the completed work complying with the standards and specifications.

9. Reference to standard specifications, manuals, or codes of any technical society, organization, or association or to the laws or regulations of any governmental authority, whether such reference is specific or by implication, shall mean the latest standard specification, manual, code, or laws or regulations in effect at the time of Town's acceptance. However, no provision of any referenced standard specification, manual, or code shall be effective to change the duties and responsibilities of the Town or any of their consultants, agents, or employees from those set forth in these Standards and Specifications. Work shall be done in compliance with the accepted plans and to the satisfaction of the Town.

10. Consideration shall be given, within the established framework of local streets, to provide for uniformity of street widths, proper alignment, street names, and conformity to existing street patterns. The street design shall be directly related to the traffic needs. The streets, intersections, driveways, and pedestrian facilities shall be designed to provide for the greatest safety for motorists, pedestrians, and bicyclists.

11. All alleys, when permitted by the Town Engineer, shall be paved to a full width and shall provide paved access to a paved street at both ends.

12. Streets of less than the entire minimum right-of-way roadway width should be avoided and permitted only by approval of the Town Engineer. Sufficient engineering data shall be provided to establish feasibility of widening without causing unacceptable drainage, sight distance troubles, or other problems. Street improvement plans shall include the entire width.

13. Development projects and/or subdivisions adjacent to existing public roadways must, in addition to dedicating additional right-of-way for future street expansion needs, evaluate existing improvements along those rights-of-ways. These improvements include but are not limited to public and private utilities, storm water facilities, irrigation facilities, fences, etc. Developers must provide for proper engineering and construction as necessary to modify and/or protect those facilities as well as providing proper development grading along the existing roadways to accommodate the design and construction of the future roadway improvements. Design Engineer shall include preliminary profiles and cross -sections.

14. All proposed projects shall be referenced to the Town of Windsor’s adopted survey control network and shall obtain the location and elevation of the nearest appropriate reference monument from the Engineering Department prior to survey. The monument name and elevation used shall be clearly marked on all construction drawings.

## B. SOILS REPORT AND PAVEMENT DESIGN REPORT

A Soils Report and Pavement Design Report shall be submitted to the Town, for review and acceptance, prior to any construction related to the installation of public improvements. The reports shall comply with the requirements outlined in Section 2 of the Street Design Criteria part of this manual. A checklist is provided in the Appendix to assist in the preparation of the reports.

## C. TRANSPORTATION IMPACT STUDIES

Transportation Impact Studies (TIS) are required in order to adequately assess the impacts of a development proposal on the existing and/or planned street system. Unless waived by the Town's Engineer, a TIS report shall be required for all development proposals. The TIS shall be prepared by a Professional Engineer.

## D. DEFINITIONS AND ABBREVIATIONS

Wherever the following words, phrases, or abbreviations appear in these specifications they shall have the following definition and meaning.

1. AADT – Average Annual Daily two way traffic volume.

2. AASHTO – American Association of State Highway and Transportation Officials.

3. ABC – Aggregate Base Course.

4. ACI – American Concrete Institute.

5. ADA – Americans with Disabilities Act.

6. ADT – Average Daily Traffic Count.

7. ALLEY – Minor public throughways that abut the side or rear of residential, industrial or commercial property and are used for vehicular access.

8. ANSI – American National Standards Institute.

9. APWA – American Public Works Association.

10. ARTERIALS – That part of the roadway system serving as the principal network for through traffic flow. Arterials connect areas of principal traffic generation and important rural highways entering the urban areas. Arterials may contain two, four, or six (2, 4, or 6) through lanes.

11. ASTM – American Society for Testing Materials.

12. ATTACHED SIDEWALK – Sidewalk that is adjoining the curb.

13. BICYCLE (BIKE) LANE – The portion of the shoulder or roadway that has been designated by striping, signing, and pavement markings for the preferential or exclusive use of bicyclists.

14. BID – The offer or proposal of a Bidder submitted on the prescribed form setting forth the prices for the Work to be performed.

15. BIDDER – The individual, firm, corporation, or other legal entity submitting a Bid directly to the Owner.

16. CDOT – Colorado Department of Transportation.

17. CHANNELIZATION – Channelization is the separation or regulation of conflicting traffic movements into definite paths of travel by traffic islands or pavement marking to facilitate the orderly movements of both vehicles and pedestrians.

18. CMP – Corrugated Metal Pipe.

19. CODE – The latest official adopted ordinances, policies, codes, resolutions, and/or regulations of the Town of Windsor, Colorado.

20. COLLECTOR – A street that provides both land access service and traffic circulation within residential neighborhoods and commercial and industrial areas. The primary purpose is to collect traffic from local streets and properties and channel it into the arterial system.

21. CONSTRUCTION DRAWINGS – Detailed and working drawings including plan, profile, and detail sheets of proposed utility, drainage and street improvements approved by the Town Engineer which graphically shows the scope, extent, and character of the Work to be performed by the Contractor.

22. CONSULTANT – The partnership, corporation, or individual who is registered as a professional engineer, according to Colorado statutes, and who is hired by the Developer/Owner, and is empowered to act as his agent for the project.

23. CONTINUITY – The continuous length of a roadway segment that is uninterrupted by ninety (90°) degree turns or controlled intersections.

24. CONTRACTOR – The person, firm, or organization to whom a construction contract is awarded by the Developer, or Owner, or who has been issued a right-of-way work permit by the Town. Agents, employees, workers, or designers employed by the Contractor are also bound by the terms of the contract or permit.

25. CROSS SLOPE – Slope of the pavement surface, excluding gutter, measured perpendicular to the street centerline.

26. CUL-DE-SAC - A non-connective, one inlet/one outlet, local roadway with a circular turn around area at the end, enabling trucks and school buses to maneuver.

27. CULVERT – Any structure not classified as a bridge which provides an opening under the roadway.

28. DESIGN ENGINEER – The partnership, corporation, or individual who is registered as a professional engineer, according to Colorado statutes, and who is hired by the Developer/Owner, and is empowered to act as his agent for the project. The Design Engineer may also be referred to as the Professional Engineer, Consultant, Civil Engineer, Geotechnical Engineer, or Traffic Engineer.

29. DESIGN SPEED – A speed determined for design and correlation of the physical features of a street that influence vehicle operation; the maximum safe speed maintainable on a specified section of street when conditions permit design features to govern. Design speed is generally higher than the posted speed limit in order to provide a factor of safety and consider other conditions or uses of the street that may affect vehicle operation.

30. DETACHED SIDEWALK – Sidewalk that is offset from the curb.

31. DEVELOPER – The owner, corporation, association, partnership, or individual who, desiring to construct a public or private improvement within the Town's right-of-way or easements, having secured all required and necessary approvals and permits, has entered into an agreement with the Town and has entered into an agreement with the Contractor to perform the construction work.

32. DHV – Design Hourly Volume; thirtieth ($30^{th}$) highest hourly traffic volume in one (1) year. Synonymous with Peak Hour Volume (Pk Hr).

33. DIP – Ductile Iron Pipe.

34. DRIVEWAY APPROACH – That portion of the private access (driveway) extending from the street to the property line or back of sidewalk, or the full width of the access from the roadway to private property.

35. EASEMENT – The property right of the Town (or other specific entity) to use lands owned in fee by a private party for the purposes of ownership, maintenance, access, inspection, drainage, and/or

other related incidentals associated with public improvements and utilities, as specified on a plat or deed of dedication.

36. EQUIPMENT – All machinery, tools, and apparatus together with supplies for upkeep and maintenance, necessary for the proper construction and acceptable completion of the Work.

37. EYEBROW – A bulb or semi-circular extension of a curb on one side of a street to provide more street frontage for adjacent lots.

38. FEMA – Federal Emergency Management Agency.

39. FENCE – An artificially constructed barrier of wood, masonry, stone, wire, metal, or other manufactured material, or combination of materials, erected to enclose, partition, beautify, mark or screen areas of real property.

40. FINAL ACCEPTANCE – The written notification from the Town, that the Warranty Period has been satisfactorily completed, that all public improvements are free of defects and the Town releases the Developer from future maintenance obligations.

41. FIRM – Flood Insurance Rate Map.

42. GEOTECHNICAL ENGINEER – The partnership, corporation , or individual who is registered as a Professional Engineer or Professional Geologist, according to Colorado Statutes, and who is hired by the Developer/Owner to prepare the Soils Report and Final Pavement Design Report for the project.

43. GMA – Growth Management Area – The areas defined in the Town of Windsor's Comprehensive Master Plan and Inter-Governmental Agreements with near or adjacent municipalities, as existing or future potential annexation areas.

44. HAMMERHEAD - A non-connective, one inlet/one outlet, local roadway with a T-shaped turn around area at the end, enabling trucks and school buses to maneuver.

45. HAZARDOUS WASTE – The term Hazardous Waste shall have the meaning provided in Section 1004 of the Solid Waste Disposal Act (42 USC Section 6903) as amended from time to time.

46. HBP – Hot Bituminous Pavement. Pavements constructed with a mix of aggregate and asphaltic/bituminous cement. (Similar acronyms used by other references may include: ACP – Asphalt Concrete Pavement, HAC – Hot Asphalt Concrete, HMA – Hot Mixed Asphalt, and similar variations.)

47. HDPE – High Density Polyethylene (pipe).

48. HIGHWAY – A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

49. INSPECTOR – An authorized representative of the Town Engineer, assigned to make inspections to assure Work is completed in compliance with plans, standards and specifications.

50. ITE – Institute of Transportation Engineers.

51. K-VALUE – The "K-value" on vertical curves is the length of the curve divided by the algebraic difference in grades, in percent.

52. KNUCKLE - A bulb or semi-circular extension of a curb on one side of a street at an elbow intersection to provide more street frontage for adjacent lots.

53. LANDSCAPING – Materials including, without limitation, grass, ground cover, shrubs, vines, trees, and non-living materials, commonly used in landscape development, as well as attendant irrigation systems.

54. LIFT – The maximum specified thickness of material that may be placed at one time.

55. LOCAL STREETS – All street facilities that are not in one of the higher systems. Their primary purpose is to provide direct access to abutting lands and connections to the higher classification streets.

56. MAJOR STREETS – A Major Collector or Arterial street. Major Streets are typically designated on the Master Street Plan or Transportation Master Plan.

57. MAY – A permissive condition. No requirement for design or application is intended.

58. MGPEC – Metropolitan Government Pavement Engineers Council.

59. MUTCD – Manual on Uniform Traffic Control Devices.

60. NCHRP – National Cooperative Highway Research Program Report.

61. NEIGHBORHOOD – A residential or commercial area defined by ordinance, resolution or common understanding.

62. NON-CONNECTIVE ROADWAYS – Non-connective roadways, consisting of cul-de-sacs, hammerheads, eyebrows, knuckles, alleys, and dead-ends, are roadways that do not provide for traffic circulation within the Town's street system.

63. OFFICIAL – A person appointed by the Town to administer these Standards.

64. OPINION OF COST (COST ESTIMATE) – Unit costs, based on those approved by the Town and assigned to materials and related quantities. The Opinion of Cost shall be broken down by Phase, when applicable, for each project and shall be submitted by the Designer at the time of final plan review by the Town.

65. OSHA – Occupational Safety and Health Administration.

66. OVERSIZING AGREEMENT – An agreement between the installing Developer and the Town of Windsor for the purpose of reimbursing the installing Developer for oversizing of certain improvements in the project.

67. OWNER – The developer, corporation, association, partnership, or individual who has entered into an agreement with the Town and has entered into an agreement with the Contractor to perform the Work.

68. PAVEMENT STRUCTURE – The combination of one or more of the following courses placed on a subgrade to support and distribute the traffic load to the roadbed.

    a. Subgrade. The layer or sub-layer of stabilized soil on which the various layers of road materials are placed.
    b. Subbase. The layer or layers of specified or selected material placed on a subgrade to support a base course, surface course, or both. Subgrade that has been treated with lime, fly ash, cement kiln dust, or combination thereof for stabilization is considered subbase.
    c. Base Course. The layer or layers of specified or selected materials placed on a subbase or a subgrade to support a surface course.

d. Surface Course. One or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion, and the disintegrating effects of climate. The top layer is sometimes called "Wearing Course."

69. P.C. – Point of Curvature.

70. P.C.R. – Point of Curb Return.

71. P.I. – Point of Intersection.

72. PLANS – Detailed and working drawings including plan, profile, cross-sections, and detail sheets depicting proposed public utility improvements to be constructed for the project, approved by the Town Engineer, which show the location, character, dimensions, and details of the Work to be done.

73. P.R.C. – Point of Reverse (or opposite) Curvature.

74. PROFESSIONAL ENGINEER (P.E.) – An individual whom has been licensed as a professional engineer and has active status as determined by the Colorado Department of Regulatory Agencies, State Board of Registration for Professional Engineers and Surveyors.

75. PROFESSIONAL LAND SURVEYOR (P.L.S.) – An individual whom has been licensed as a professional land surveyor and has active status as determined by the Colorado Department of Regulatory Agencies, State Board of Registration for Professional Engineers and Surveyors.

76. PROJECT – The public or private improvement(s) designated in the approved plans, which are to be constructed in conformance with these Standards. The term "Project" includes any and all public or private improvement projects for or within the Town of Windsor, whether development projects, private utility projects, or capital improvement projects.

77. PROVIDE – Furnish and install complete in place.

78. P.T. – Point of Tangency.

79. PUBLIC IMPROVEMENTS – Those public-type facilities to include: pavement, curb and gutter, sidewalk, pedestrian/bike/equestrian paths, storm drain facilities with related appurtenances, culverts, channels, bridges, water distribution or transmission facilities with related appurtenances, sanitary sewer collection facilities with related appurtenances, water and wastewater treatment facilities, pavement markings, signage and striping, traffic signals and related appurtenances, erosion control and right-of-way grading, or earth excavation processes integral to construction of other public improvements listed herein.

80. PUNCHLIST – A written list of work items, compiled by the Inspector, Engineer, Official, or other authorized individual, which do not conform to these Standards, the plans or other associated Town Codes that govern the project.

81. P.V.C. – Point of Vertical Curve.

82. PVC – Polyvinyl Chloride (pipe).

83. P.V.I. – Point of Intersection of the tangents of a Vertical Curve.

84. RCP – Reinforced Concrete Pipe.

85. RECORD DRAWINGS – Original design drawings updated and revised by a Professional Engineer depicting all modifications from the design that occurred during construction.

86. REIMBURSEMENT AGREEMENT – An agreement between the installing Developer and the Town of Windsor for the purpose of reimbursing the installing Developer for the front footage charge, when collected from the Developer of an adjacent property.

87. RIGHT-OF-WAY – All streets, highways, avenues, lanes, alleys, courts, places, squares, curbs, sidewalks, easements, or other public ways in the Town of Windsor which have been or may hereafter be dedicated and opened for public use, or such other public property so designated in any law of this state.

88. ROAD OR STREET – As used in this specification shall include the pavement section, right-of-way, sidewalks, driveway approaches, bikeways, alleys, and alley approaches.

89. ROUNDABOUT – A circular street intersection used as a traffic control device in lieu of a multi-way stop or a traffic signal.

90. SHALL – A mandatory condition. Where certain requirements in the design of application are described with the "shall" stipulation, it is mandatory that these requirements be met.

91. SHARED ROADWAY – Any roadway upon which a bicycle lane is not designated and which may be legally used by bicyclists regardless of whether such facility is specifically designated as a bikeway.

92. SHOULD – An advisory condition. Where the word "should" is used, it is considered to be advisable usage, but not mandatory. Deviations may be allowed when reasons are given which show that the intent of the standard is met.

93. SHOULDER – The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of the base and surface courses.

94. SIDEWALK – Paved or otherwise improved area for pedestrian use, located within the public street right-of-way that also contain roadway for vehicular traffic.

95. SIGHT DISTANCE – Sight distance is that length of the roadway ahead that is visible to the driver and should be of minimum length to enable drivers travelling at or near the design speed, to control the operation of their vehicles to avoid striking an unexpected object in the traveled way.

96. SPECIFICATIONS – Construction specifications and standards adopted by the Town of Windsor.

97. SPEED CHANGE LANE – A speed change lane is an auxiliary lane, including tapered areas, primarily for the acceleration or deceleration of vehicles entering or leaving the through-traffic lanes.

98. STANDARD SPECIFICATIONS for ROAD AND BRIDGE CONSTRUCTION – CDOT's printed manual, 2005 (or more recent) Edition, for construction and material details.

99. STANDARD STREET SPECIFICATIONS – the current Town of Windsor Design Criteria and Construction Specifications for Streets.

100. STOPPING SIGHT DISTANCE – The distance required by the driver of a vehicle traveling at the design speed to bring the vehicle to a stop after an object on the road becomes visible. This distance is measured from the drivers' eye, three and a half (3.5') feet above the pavement to the top of any object six (6") inches high on the pavement anywhere on the road.

101. STREET WIDTH – That distance measured from edge of oil to edge of oil across a street which generally does not include the gutter pans of vertical curbs on each side, for Urban Street Sections, and that distance measured from outside edge of shoulder to outside edge of shoulder across a street for Rural Street Sections.

102. SUBCONTRACTOR – A person, firm, or organization, other than the Contractor, supplying labor and materials, or labor only, for the Project, and working for the Contractor or Developer or Town.

103. SUBSTANTIAL COMPLETION – The time at which the Work (or a specified part thereof) has progressed to the point where, in the opinion of the Town Engineer, the Work (or a specified part thereof) is sufficiently complete so that the Work (or a specified part thereof) can be put to beneficial use and can be utilized for the purposes for which it was intended. The terms "substantially complete" and "substantially completed" as applied to all or part of the Work refer to Substantial Completion thereof.

104. SUPERELEVATION – Superelevation, or roadway banking, is employed on horizontal curves to alter the roadway cross section allowing for the safe and comfortable operation of motorized vehicles at higher speeds.

105. TIS – Transportation Impact Study.

106. TMP – Transportation Master Plan

107. TOWN – The Town of Windsor, Colorado, a Home Rule Municipality, or an individual employed by the Town of Windsor whom is authorized to make the applicable decisions on behalf of the Town.

108. TOWN ENGINEER – A term used in situations where a decision or action may be required by the Town Engineer or his authorized representative employed by the Town of Windsor. The Engineer shall have the authority on behalf of the Town to ascertain that all design and construction is equal to or exceeds the minimum requirements set forth in these criteria and standards.

109. TRAFFIC CONTROL PLAN (TCP) – Those portions of the Contract Documents and/or plans that contain the requirements and procedures for the maintenance of traffic during construction of the project.

110. USGS – United States Geological Survey.

111. UTILITIES – Shall mean all utilities on site prior to the time of any design; such as but not limited to water lines, sanitary sewer lines, drainage lines, electric lines, gas lines, telephone lines, and cable television lines.

112. WARRANTY PERIOD – The period of time that the Contractor/Owner or Developer is responsible for material and workmanship defects in the public improvements, until written notification by the Town of final acceptance of the public improvements.

113. WORK – All construction activity, including materials, labor, supervision, and use of tools and equipment necessary to complete the Project in full compliance with these Standards, approved Plans, or Improvement Agreements.

## 1.03 DEVELOPMENT PROCEDURES AND POLICIES

### A. GENERAL

This section is intended to describe the development procedures and policies of the Town of Windsor as they pertain to planning, design, approval, and construction of streets for which approval by the Town is required.

### B. VARIANCES AND APPEALS PROCESSES

#### 1. VARIANCES

Any design that does not conform to these Standards must be approved by the Town Engineer. Variances from these Standards will be considered on a case-by-case basis following a written request for a variance prepared by a Professional Engineer. If the special district, developer, contractor, or utility responsible to the Town for public improvements desires to design and construct such improvements in variance to criteria in these standards, such variance(s) shall be identified in a written attachment to the initial submittal of construction plans to the Town Engineer. Generally, the plans should show the design variance. Variances may be administered by either of the following two processes:

a. Variances requested as part of an application for approval of a preliminary plat only, shall be shown on the preliminary plat (or on the preliminary construction plans) and shall also be specifically substantiated and justified in a letter addressed to the Town Engineer.

b. Variances requested as part of the submittal for approval of final public improvements construction plans shall be shown in the plans and shall also be specifically substantiated and justified in a letter addressed to the Town Engineer.

The variance request(s) shall include the following:

a. Identifying Issue. Identification of the standard to be waived or varied and why the standard is unfeasible or is not in the public interest.

b. Proposing Alternate Design. Identification of the proposed alternate design or construction criteria.

c. Comparing to Standards. A thorough description of the variance request including impact on capital and maintenance requirements, costs, and how the new design compares to the standard.

d. Justification. The Design Engineer must determine and state that the variance will not be detrimental to the public health, safety and welfare, will not reduce design life of the improvement nor cause the Town additional maintenance costs. The proposed plan (as varied) must advance the public purpose of the standard sought to be varied equally well or better than would compliance with such standard.

e. Approval or Denial of Variance. Based upon review of the plans and additional information submitted, and an analysis of the criteria set forth in this subsection, the Town Engineer may approve or deny the variance request. If the Town Engineer approves the variance request, the plans will continue to be reviewed and approved within the typical review process. If the Town Engineer denies the variance request, the developer shall subsequently submit revised plans in compliance with these Standards. The Town Engineer shall provide a written response outlining the basis for all approvals or denials of variance requests.

2. **APPEALS**

a. Appeal to the Town Manager. If a variance request is denied by the Town Engineer, the Developer may appeal the decision to the Town Manager. All appeals shall be processed through the Town Engineer. The Developer shall give written notice of appeal to the Town Manager within ten (10) days after denial by the Town Engineer. The Town Manager shall respond within fifteen (15) working days after receipt of the Developer's notice to appeal. If the Town Manager overturns the Town Engineer's decision, the Developer may then proceed with the requested variance(s) in the plans. If the Town Manager concurs with the Town Engineer's decision, the Developer shall bring the plans into compliance with these Standards, or appeal the Town Manager's decision to the Town Board.

b. Appeal to the Town Board. The Developer may appeal to the Town Board of Windsor within ten (10) days from receipt of denial from the Town Manager. The appeal shall be placed on the agenda for consideration by the Town Board in accordance with normal Town Board procedure, but no later than sixty (60) days following receipt of the written notice of appeal. The Town Board shall hold a public hearing on the appeal in accordance with Town Board procedure. All notices and appeals shall be in writing. Any such appeal shall constitute a "new hearing" on the variance request before the Town Board.

3. **GRANTED**

Any variances granted as specified herein, are on a site specific basis only and do not carry or grant any future acceptance, precedent, or variance.

## C. STREET CONSTRUCTION AND OVER-SIZING POLICY

1. **STREET CONSTRUCTION RESPONSIBILITY**

The responsibility for the design, right-of-way acquisition, and construction of all new streets and the widening of existing streets necessary to provide adequate transportation service to, or within, a development rests exclusively with the Developer, except as outlined in **Section 1.03C.3**, below. All traffic generated by a development must meet the transportation level of service requirements adopted by the Town of Windsor. The following list outlines the improvements that are considered to be an integral part of the street construction:

a. Street grading and subgrade preparation or stabilization.
b. Concrete curb and gutter for Urban Street sections.
c. Concrete sidewalk for Urban Street sections.
d. Roadside borrow ditches for Rural Street sections.
e. Pavement section including aggregate base courses and asphaltic or Portland cement concrete pavement.
f. Traffic signals.
g. Traffic signing and pavement markings.
h. Railroad crossings.
i. Ditch and drainage crossings.
j. Street lighting.
k. Water distribution system.
l. Sanitary sewer collection system.
m. Storm water management system.
n. Erosion control management systems as necessary.

2. **REQUIRED STREET IMPROVEMENTS**

a. General. The Developer is responsible for all improvements required of their development. In some cases, a financial security in a form acceptable to the Town may be allowed in lieu of construction of all or part of an improvement.

b. On-Site Criteria. The Developer is responsible for all improvements internal to the site. Necessary right-of-way and easements must be dedicated to the Town of Windsor prior to or concurrent with approval of the development.

c. Off-Site Criteria. The Developer is responsible for the following improvements external to the site boundaries:

   i. Streets Adjacent to the Development Boundaries. Where street upgrades are needed to comply with these Standards and the Town's Transportation Master Plan, the Developer shall be responsible for the design and construction of street improvements adjacent to the exterior boundary of the subject property. When such improvements are designed and constructed, they shall be extended along the entire boundary(s) of the property at the horizontal and vertical location that establishes the approved alignment for the long-range transportation facility as defined in these Standards. The design shall be for the ultimate roadway development, but the developer will be required to build out one half (½) of the ultimate design and one (1) through lane.

   ii. Transitions. Where an improved street must be tied into an existing street, transition areas must be provided to safely shift traffic back onto the existing street. Transition plans must meet the length and design requirements provided in these Standards. All transitions necessary to safely shift traffic back onto an existing street or roadway shall typically be designed and constructed off-site from the project. The off-site transition(s) may be installed as a permanent street improvement (i.e., long-range pavement thickness and location) or as a temporary improvement (i.e., interim thickness and location as approved by the Town Engineer). Permanent off-site transitions may be eligible for future reimbursement by the Town or a future Developer, while temporary off-site transitions will not be eligible for reimbursement. Transitions adjacent to the Development may be approved by the Town in situations where the long-range improvements are constructed adjacent to the property and traffic safety or operational concerns warrant a waiver of the off-site transition requirement.

   iii. Connection to the Arterial Street Network. Any development which does not have direct access to an improved arterial street within the Improved Arterial Street Network will be required to improve certain off-site streets to provide adequate access to the nearest Improved Arterial Street.

   Improved access must be provided in the most reasonable and/or most heavily traveled route, as determined by the Town Engineer. In some cases, more than one (1) off-site street may need to be improved. Pavement thickness shall be based on a twenty (20) year design life including both projected site generated and background traffic growth. To facilitate construction of off-site street improvements, routing traffic through nearby residential areas will not be allowed unless the required traffic volume level of service for the respective street classification is maintained.

d. Off-Site Right-of-Way and Easements. Prior to approval of any development which requires acquisition and dedication of off-site right-of-way or easements, the Developer shall provide legal documentation demonstrating their ability to obtain such right-of-way or easements without any restrictions and at no cost to the Town. Prior to final approval of plat and construction plan documents, all off-site rights-of-way and easements must be dedicated and recorded with the County Clerk.

3. **EXCEPTIONS FOR OFF-SITE CONSTRUCTION RESPONSIBILITY**

A Developer may not be responsible for constructing the off-site street improvements needed to serve that development if circumstances meet any of the following conditions:

a. Improvements are included in the most recent Town of Windsor Street Capital Improvement Plan, the funds necessary for construction of the improvements have been appropriated, and the improvements are scheduled for construction by the Town within three years from the time of the Town Board's approval of the final plat for the development; or

b. Improvements are included in a fully funded plan by another public agency, such as the Colorado Department of Transportation, and are scheduled for construction within three years from final plat approval; or

c. Improvements are included in a binding agreement with another developer or private party for which financial security acceptable to the Town that fully covers the costs of the improvements is held by the Town.

4. **WAIVER FROM STREET CONSTRUCTION RESPONSIBILITY**

The obligation to design and construct any street improvements may be waived for a development that has been determined to have an Insignificant Traffic Impact Development, as determined by the Town Engineer.

## D. REIMBURSEMENT POLICY

Developments may be eligible for reimbursement of costs for street and trail improvements made off-site and/or adjacent to the development if the requirements of the reimbursement policy for new street construction are followed and will be considered on a case by case basis. Additionally, those improvements for which capital expansion fees (oversizing) are collected, may also be eligible for credit or reimbursement, subject to the provisions in the Town Code.

1. **NON-CAPITAL EXPANSION FEE STREETS**

a. General. When any Developer, as a Town required condition of development, constructs a public street, alley, or pedestrian bikeway to serve property through undeveloped areas or areas that may be redeveloped, or constructs a public street, alley, or pedestrian bikeway along the perimeter of the property, the entire cost of such engineering and construction, including acquisition of all necessary rights-of-way, shall be the responsibility of such person or Developer.

b. Front Footage Charge. If the following conditions are satisfied, the installing Developer may enter into a reimbursement agreement with the Town such that, as a condition of approval of subsequent development or re-development of property adjacent to the newly constructed public street, alley, or pedestrian bikeway, the Town may collect a front footage charge from the abutting Developer prior to the issuance of any building permits for the abutting property. The front footage charge shall be established by prorating the total amount of original certified costs to the lineal frontage of all properties abutting the constructed improvement.

c. Notice of Agreement. The Town shall not attempt to make such collection until the reimbursement agreement is properly prepared and executed and the owners of abutting property have received or reasonably should have received notice of the reimbursement agreement.

d. Letter of Intent. Within thirty (30) days of the completion and acceptance by the Town of such improvements, the Developer shall notify the Town in writing of its intent to enter into a proper reimbursement agreement with the Town.

e. Full Payment. All costs for the construction of improvements must be fully paid by the Developer before such person shall be entitled to reimbursement under any agreement established hereunder.

f. Documentation of Costs and Obligated Properties. After written acknowledgment by the Town of receipt of said written intent to enter into a reimbursement agreement, the Developer shall have sixty (60) days to provide the Town Engineer with copies of the following:

   i. A letter from the Designer with detailed breakdown of all fees that are directly attributable to the street, alley, or pedestrian bikeway improvements eligible for reimbursement and a statement certifying that all such fees have been paid in full.
   ii. A letter from the Developer's Contractor with a detailed breakdown of costs for all improvements eligible for reimbursement and a statement certifying that all such costs have been paid in full.
   iii. A letter from the Developer's financing office certifying any financial charges assessed that are eligible for reimbursement.
   iv. An accurate map prepared by a licensed Engineer or Surveyor which shows:
      - The location and limits of the eligible street, alley, or pedestrian bikeway improvements;
      - The name, address, and telephone number of the owner of each property abutting the eligible improvements;
      - The frontage of each property (with lineal footage shown);
      - The reimbursement amount due from each property based on the original certified costs, divided by the frontage of all abutting properties, multiplied by the frontage of the individual property;
      - The book, page, reception number, and name of County, from the records of the County Clerk and Recorder or the name of the recorded plat from which the information for each property was obtained; and
      - Any other information deemed necessary by the Town Engineer to properly prepare a reimbursement agreement.

g. Reimbursement Agreement Forms. After receipt of written notice from the Town Engineer documenting Certified Costs, the Developer shall provide three (3) signed original Reimbursement Agreement forms to the Town. Following execution of the agreement by the Town, two (2) signed originals shall be returned to the Developer, who shall record the agreement with the appropriate County Clerk and Recorder.

h. Notification of Agreement. After execution and recording of the reimbursement agreement, the installing Developer shall certify, by affidavit, that all owners of properties obligated to provide reimbursement have been notified in writing through certified mail with return receipt requested. The Town shall then cause to be published a public notice listing the properties and reimbursement amounts. The Town shall endeavor to provide notice on future plats of property obligated to provide reimbursement of the recorded agreement, but the failure to provide notice shall not relieve the owner of the platted property of any reimbursement obligation.

i. Inflation Adjustment. The amount of reimbursement assessed by the Town for each adjacent property as it develops shall be based on the certified costs of the improvements plus an adjustment for inflation based on the construction cost index for Denver, Colorado, as published monthly by "Engineering News Record". The Town Engineer's determination concerning total eligible costs shall be final.

j. Collection. The Town's obligation to reimburse the Developer shall be contingent upon the Town's actual collection of the front footage charge from the abutting developer. The Town shall have no obligation to reimburse any funds that it fails to collect, for whatever reason, provided that the Town made a good faith attempt to collect such funds.

k. Service Charge. When the front footage charge is collected, the Town shall reimburse the installing Developer to the extent of such collection after deducting a service charge of five hundred ($500.00) dollars or three (3%) percent of the amount collected, whichever is greater, to cover the Town's legal, engineering, and administrative costs.

l. Payment. Funds collected pursuant to a reimbursement agreement shall be paid to such person as identified in the agreement, and if such person cannot be found, to an alternate if designated in the agreement.

m. Limitations. Any right to reimbursement pursuant to this provision shall not exceed a period of ten (10) years from the acceptance by the Town of the street, alley, or pedestrian bikeway improvements. The Town Board may approve extensions of the reimbursement agreement for additional ten (10) year periods. No such reimbursement shall be made unless the person entitled to reimbursement has fully satisfied their obligations under any other agreements with the Town.

2. **CAPITAL EXPANSION FEE STREETS**

Upon prior budget appropriation by the Town Board and approval by the Town Engineer, Developers of certain improvements may be entitled to receive a reimbursement from the Town, against a portion of the amounts paid for public improvements installed and paid for by such Developer on specified arterial streets designated in the Comprehensive Master Plan. Payment of such reimbursement shall be subject to the following:

a. Required but Unnecessary Street Over-Sizing Improvements. If the Town requires a Developer to construct street over-sizing improvements that are not necessary to safely serve the development and these improvements are identified as part of the Comprehensive Master Plan, then the Town will reimburse the Developer for approved construction costs as soon as funds are available after completion and final acceptance of the street improvements by the Town. If the Town is unable to reimburse the Developer because of insufficient funds in the street reimbursement plan budget, the Developer will be paid interest at the same rate the Town is earning on its pooled investments during the reimbursement period beginning three (3) months after acceptance of the approved over-sizing improvements until reimbursement is completed.

b. Required and Necessary Street Over-Sizing Improvements. If the over-sizing improvements are necessary to safely serve the development, as determined by the Town Engineer, and the improvements are part of the Comprehensive Master Plan, the Town shall reimburse the Developer for approved construction costs or as predefined in a development agreement. Interest will not be paid on the reimbursement because the need for the improvements was dictated by the development.

## E. MAINTENANCE OF PRIVATE IMPROVEMENTS

1. Compliance. When a request is made for the Town to assume maintenance of any private improvement, it shall be the responsibility of the person(s) making the request to satisfactorily demonstrate that the private improvement has been constructed in accordance with these Standards.

2. Review. The Town will review these requests under normal review procedures.

3. Refusal of Responsibility. The Town will not accept maintenance responsibilities for private street improvements associated with land development activities. Private improvements that were not constructed in accordance with the applicable design and construction standards and specifications shall not be accepted for maintenance by the Town.

## 1.04 STREET LAYOUT REQUIREMENTS

### A. GENERAL

1. All street design and layout for new developments shall conform to these Standards and the Town's Transportation Master Plan (TMP) and other applicable Comprehensive Master Plans, codes and standards adopted by the Town.

2. Sufficient right-of-way shall be provided as required for the traffic needs and cross-section and maintenance of the street including cut or fill slopes, auxiliary lanes, landscaping, signing, utilities, and other aspects of the development.

3. Standard right-of-way and street widths shall meet or exceed the minimums set forth in these Standards. Additional right-of-way and roadway width may be required to accommodate traffic or other development needs such as turn lanes, deceleration lanes, extra lanes, pedestrian or bicycle facilities, landscaping, utilities, or construction requirements such as cut or fill slopes.

### B. STREET LOCATIONS

The locations of Major streets shall be in accordance with the TMP. Other streets shall be located in accordance with all other applicable street layout requirements.

1. All streets shall have a logical relationship to the existing topography and to the location of existing or platted streets within adjacent properties. Certain streets within the Development may need to be extended to the Project boundary to provide for the future logical extension of the street through adjacent properties.

2. To ensure connectivity, enhance general circulation, and to provide secondary points for emergency access, the street layout for all subdivisions should be designed so that there is, on average, at least one connecting street to neighboring land for every thirteen hundred twenty (1320') feet of development perimeter.

3. The TMP for the Town of Windsor shows the approximate locations of all Arterial streets and some Collector streets for the Town and its Growth Management Area (GMA). The TMP shall be used for establishing approximate locations of Major streets. The Town Engineer shall hold approval authority for specific locations for all Arterial and Collector streets.

4. Layout of new Local streets and Collector streets not covered by the Town's TMP shall meet the needs of the specific development and satisfy all other specific requirements of these standards. The Town retains the authority to designate Collector streets and retains authority for approval of the overall street layout.

5. Alleys are not included in these criteria because of the large amount of variables in their design, however, any permanent alley design must be approved by the Town Engineer.

### C. SAFETY AND ACCESSIBILITY

1. All street classifications shall be designed for the safety of motorists, pedestrians and bicyclists. A major component in neighborhood street layout is traffic safety. Traffic calming is the implementation of physical and perceptual techniques to slow or divert traffic on local roadways and minor collectors to minimize high speeds and volumes of vehicular traffic.

2. Local Roadways and Minor Collectors are intended as low volume roadways used for direct access to residences fronting on the street and as a multi-modal system that is shared by vehicular, bicycle, and pedestrian traffic equally in a manner that minimally impact residents who reside in these areas. New streets shall be laid out and planned to maximize traffic calming techniques and minimize opportunities for cut-through traffic.

3. Commercial Local streets have less multi-modal conflicts and are permitted to have longer continuity.

4. Safety is an important factor in all types of roadway design and construction. Every effort should be made to provide as much clear roadside as is practical; the judicious use of flatter slopes, roadside barriers, and warning signs helps to improve roadside safety as well as proper placement of utility infrastructure.

5. Accessibility shall be provided in accordance with all ADA (Americans With Disabilities Act) requirements.

## D. DESIGN CRITERIA

1. See **General Parameters**, **Table 1.04.1**. Standard right-of-way and street widths shall meet or exceed the following minimum criteria.

**Table 1.04.1**
**General Parameters**

| Street Classification | URBAN SECTION | | | | | | RURAL SECTION | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Major Arterial | Minor Arterial | Major Collector | Minor Collector | Local Ind/Comm. | Local Residential | Major Arterial | Minor Arterial | Collector Residential | Local Residential |
| Number of Lanes | 7 | 5 | 3 | 2 | 2 | 2 | 5 | 3 | 3 | 2 |
| Right-of-Way Width | 135 ft | 110 ft | 80 ft | 60 ft | 50 ft | 50 ft | 150 ft | 130 ft | 120 ft | 90 ft |
| Roadway Width(1) | 104 ft | 80 ft | 52 ft | 40 ft | 36 ft | 36 ft | 76 ft | 48 ft | 36 ft | 34 ft |
| Width at Intersections(1) | N/A | N/A | N/A | N/A | N/A | N/A | 100 ft | 72 ft | 48 ft | N/A |
| Number of Travel Lanes | 4 | 4 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| Travel Lane Width | 12 ft | 12 ft | 12 ft | 12 ft | 11 ft | 11 ft | 12 ft | 12 ft | 12 ft | 11 ft |
| Designated Bike Lanes | Yes | Yes | Yes | No | No | No | No | No | No | No |
| Bike Lane Width | 6 ft | 6 ft | 6 ft | 10 ft (2) | 10 ft (2) | 10 ft (2) | N/A | N/A | 10 ft (2) | N/A |
| Parking Lane Width | None | None | None | 8 ft | 7 ft | 7 ft | None | None | None | None |
| Sidewalk Width | 5 ft | 5 ft | 5 ft | 4 ft | 4 ft | 4 ft | N/A | N/A | N/A | N/A |
| Vertical or Driveover Curb and Gutter | V | V | V | D (3) | V | D | N/A | N/A | N/A | N/A |
| Traffic Volume (ADT) | >25,000 | >10,000 | >2,500 | >1,000 | <1,000 | <1,000 | >12,000 | >5,000 | >1,500 | <1,500 |
| Design Speed (MPH) | 65 | 55 | 50-45 | 40 | 35 | 35 | 60 | 55 | 50 | 35 |
| Posted Speed (MPH) | 55 | 45 | 45-35 | 35 | 30 | 30 | 55 | 45 | 45 | 30 |
| Turn Lanes (4) | Required | Required | Required | Varies (5) | NO | NO | Required | Required | Varies (5) | NO |

(1) Flow Line to Flow Line (Urban Section) or shoulder to shoulder (Rural Section).
(2) Detached Bikeway in lieu of on-street Bike Lane (where required).
(3) Vertical curb required for industrial/commercial development.
(4) Left-turn lanes are always required, right-turn lanes are required if TIS indicates need.
(5) Where Minor Collectors intersect with streets of high traffic volume or high speeds, left turn lanes required.

See standard details for performance options.

Sep't, 2009

## 1.05 STREET CLASSIFICATIONS, FUNCTIONS, AND PLANNING CHARACTERISTICS

### A. GENERAL

All streets are classified as Arterial, Collector or Local streets. These classifications relate to the function of the streets. Lower order streets function primarily as access to individual lots, and higher order streets function primarily for the purpose of mobility (expeditious movement of people and goods). The Town of Windsor Growth Management Area (GMA) includes both urban and rural areas and, thus, minimum street standards are defined that are appropriate for each area type.

1. Urban Street Standards. Urban streets generally are designed in areas that are already developed or are planned for future development closer to the downtown core of Windsor. Within these areas, higher vehicle traffic volumes with accompanying pedestrian, bicycle, and possibly bus activity must be provided for. Raised medians are recommended on Major and Minor Arterials. The primary function of Urban Arterials should be to provide better mobility for the arterial traffic, with access as a secondary function. Providing raised medians will help to control access to the street as well as provide a safer environment for turning traffic. Providing detached sidewalks adjacent to the right-of-way line on Major and Minor Arterials, and Major Collector streets will maximize the buffer area between vehicle traffic and pedestrians, thereby reducing the possibility of vehicle/pedestrian conflicts.

2. Rural Street Standards. The GMA encompasses many areas that are now very rural in character. Current zoning also designates large areas of very low density single family residential use. The land use goals are to preserve much of the rural character of these areas and, thus, Rural street standards have been established. These streets will typically carry less traffic and pedestrians; however, bicycling may be a very viable mode of transportation along these roadways. Since intersection spacing along a rural roadway will usually be greater, and traffic volumes will likely be at a lower level than on an urban street, less pavement width is desired. A six to one (6:1) ground slope of four to twelve (4-12') feet adjacent to the shoulder adds additional space for vehicles to pull off the road if the available shoulder width is not adequate (i.e., large trucks) and a flatter area along the shoulder provides a recovery zone for errant vehicles.

3. General Guidelines. See Town of Windsor Standard Detail Drawings for specific cross sections for Urban Street Cross Sections or Rural Street Cross Sections and associated details.

### B. DESIGN CRITERIA

1. *RURAL LOCAL – Residential*

   FUNCTION – Rural local residential streets serve primarily to provide access for local traffic to farms, residences or other abutting properties and have low traffic volumes. Traffic carried by Rural local streets should have an origin or a destination within the neighborhood, and these streets should be designed to discourage through traffic. Rural local streets are typically designed to connect to Collector streets, although they can also be designed as cul-de-sacs or to provide connectivity to adjacent subdivisions.

   PLANNING CHARACTERISTICS – Rural local residential streets are intended for use in residential developments with larger lot sizes. Rural local streets should not intersect Major Collectors or Arterial streets. Drainage is handled using borrow ditches adjacent to the roadway with culverts to remove stormwater runoff. Traffic control shall be provided using stop signs at all four (4) way intersections, with stop signs situated on the minor (lower volume) roadway. All three (3) way (tee) intersections shall use a yield sign, unless sight problems exist or it connects with a high volume, high speed roadway.

2. *URBAN LOCAL – Residential*

   FUNCTION – Urban local streets are public roadways for vehicular travel including public transit. They also serve pedestrian and bicycle traffic and usually accommodate public utility facilities

within the right-of-way. These streets serve local traffic and have low traffic volumes. Traffic carried by Urban local streets should have an origin or a destination within the neighborhood, and these streets should be arranged to discourage through traffic. Urban local streets are typically designed to connect to Collector streets, although they can also be designed as cul-de-sacs or to provide connectivity to adjacent subdivisions.

PLANNING CHARACTERISTICS – Urban local residential streets are intended for use in medium to high density residential neighborhoods. Urban local streets should not intersect Major Collectors or Arterial streets. Parking shall be allowed on both sides of local residential streets. Stormwater runoff is channeled through concrete curb and gutters into inlet basins with storm sewers to collect and remove runoff. Traffic control shall be provided using stop signs at all four (4) way intersections, with stop signs situated on the minor (lower volume) roadway. All three (3) way (tee) intersections shall use a yield sign, unless sight problems exist or it connects with a high volume, high speed roadway.

3. *URBAN LOCAL – Commercial/Industrial*

FUNCTION – On Urban local streets that serve commercial/industrial areas, the vehicle dimensions, traffic volumes and vehicle loads can differ greatly from those on residential streets and different design values are often appropriate. Safety and traffic are usually the major design controls. These streets serve local commercial/industrial traffic and usually have low traffic volumes. Street alignment in commercial/industrial areas should be commensurate with the topography but should be as direct as possible and designed to discourage through traffic. Urban local streets are typically designed to connect to Collector streets, although they can also be designed as cul-de-sacs or to provide connectivity to adjacent subdivisions.

PLANNING CHARACTERISTICS – Urban Local Commercial/Industrial streets are intended for commercial/industrial developments. These streets may intersect Major Collectors in some situations, but should not intersect with an Arterial Street. On-street backing or loading and off loading maneuvers shall not be allowed. Stormwater runoff is channeled through concrete curb and gutters into inlet basins with storm sewers to collect and remove runoff. Traffic control shall be provided using stop signs at all four (4) way intersections, with stop signs situated on the minor (lower volume) roadway. All three (3) way (tee) intersections shall use a yield sign, unless sight problems exist or it connects with a high volume, high speed roadway.

4. *URBAN MINOR COLLECTOR*

FUNCTION – Urban Minor Collectors collect and distribute traffic between Arterials, Major Collectors, and Local streets and serve as main connectors within communities, linking one neighborhood with another. The collector street usually serves moderate traffic volumes. Since collectors provide access function to adjacent residential development and to some neighborhood facilities, the design of a collector street should reflect its function as a collector and should not be conceived or developed simply as a continuous access street.

PLANNING CHARACTERISTICS – Urban Minor Collectors are generally intended for use within residential neighborhoods or to connect smaller neighborhoods. Intersections with other Collector and Arterial streets should be at least one-quarter (¼) mile apart. Parking shall be allowed on both sides of Urban Minor Collector streets. Stormwater runoff is channeled through concrete curb and gutters into inlet basins with storm sewers to collect and remove runoff. Regulation of traffic shall be accomplished through the use of stop signs and channelization.

5. *RURAL COLLECTOR*

FUNCTION – Rural Collectors collect and distribute traffic between Arterials, Major Collectors, and Local streets and serve as main connectors within rural communities, linking one neighborhood or areas of homogenous land use with another. These streets serve local, rural traffic and usually have low to moderate traffic volumes. Safety is an important factor in all roadway improvements. Every effort should be made to provide as much clear roadside as is practical; the

judicious use of flatter slopes, roadside barriers, and warning signs helps to improve roadside safety as well as proper placement of utility features. Basic information needed for design of Rural Collectors includes crash history, traffic volumes, terrain and alignment.

PLANNING CHARACTERISTICS – Rural Collectors are generally intended for use within rural residential neighborhoods or to connect smaller neighborhoods. Intersections with other Collector and Arterial streets should be at least one-quarter (¼) mile apart. If the design of foreslopes are flatter and shoulders and ditches are well rounded or otherwise made traversable, drivers who inadvertently leave the traveled way can often recover control of their vehicles. Such recoverable slopes should be provided where terrain and right-of-way conditions allow. Parking shall be allowed on both sides of Rural Collector streets. Drainage is handled using borrow ditches adjacent to the roadway with culverts to remove stormwater runoff. Regulation of traffic shall be accomplished through the use of stop signs, signals, and channeling. Traffic signals, where warranted, will normally be located only at intersections with Arterial Streets.

6. *URBAN MAJOR COLLECTOR*

FUNCTION – Urban Major Collector streets shall be designed to permit relatively unimpeded traffic movement and are intended for use on those routes where two (2) or more moving lanes are required but where a larger classified street is not warranted. The function of Urban Major Collectors is equally divided between mobility and access. Management of driveway access to Urban Collectors is desirable; if the Design Hourly Volume (DHV) exceeds one hundred (100) in the opposing direction to the turn or the Average Daily Traffic Volume (ADT) for both directions exceeds one thousand (1,000), access may be restricted. The Urban Major Collector street usually serves moderate to moderately heavy traffic volumes.

PLANNING CHARACTERISTICS – Urban Major Collector streets should be employed where traffic demands dictate. Urban Major Collector streets are intended for use in commercial/ industrial areas or high density residential. See the Street Standards Technical Design Criteria Chart for allowable intersection spacing. Street parking is not allowed on Urban Major Collector streets. Bicycle lanes shall be provided for on both sides of the roadway. Access from streets of lower classification will be permitted, but in all cases will be controlled by traffic control devices. Direct access to abutting property is not permitted unless no other access is reasonably available and then only upon approval by the Town. Stormwater runoff is channeled through concrete curb and gutters into inlet basins with storm sewers to collect and remove runoff. Regulation of traffic shall be accomplished through the use of traffic signs, signals, and channeling. Traffic signals will normally be located only at intersections with Arterial Streets.

7. *RURAL MINOR ARTERIAL*

FUNCTION – Rural Minor Arterial streets permit relatively unimpeded traffic movement and are intended for use on those routes where two (2) moving lanes and one left-turn lane are required but where a Major Arterial cross section would not be warranted. Such roadways are adequate where traffic volumes are not heavy and long sight distances are generally available. A smooth flowing alignment is desirable on a Rural Minor Arterial street. Changes in alignment, both horizontal and vertical, should be so gradual that they will not surprise the driver.

PLANNING CHARACTERISTICS – Rural Minor Arterials should be employed where traffic demand dictates. Rural Minor Arterials should be spaced approximately one (1) mile apart and should, where possible, be continuous. Minor Arterials should act as boundaries between neighborhood areas. Intersections with Collectors streets should be at least one-quarter (¼) mile apart. See the Street Standard Technical Design Criteria Chart for allowable intersection spacing. No street parking is allowed on Minor Arterial streets. Adjacent paved shoulders can double as bicycle lanes on both sides of the roadway. Access from streets of lower classification will be permitted, but in all cases will be controlled by traffic control devices. Direct access to abutting property is not permitted unless no other access is reasonably available and then only on approval by the Town. Drainage is handled using borrow ditches adjacent to the roadway with culverts to

remove stormwater runoff. Regulation of traffic shall be accomplished through the use of traffic signs, signals, and channeling. Traffic signals will normally be required at intersections.

8. *URBAN MINOR ARTERIAL*

FUNCTION – Urban Minor Arterial streets permit relatively unimpeded traffic movement and are intended for use on those routes where four (4) moving lanes and one left-turn lane are required but where a Major Arterial cross section would not be warranted. Urban Minor Arterial streets are divided highways with four or more lanes and typically carry heavy traffic volumes.

PLANNING CHARACTERISTICS – Urban Minor Arterials should be employed where traffic demand dictates. Urban Minor Arterials should be spaced approximately one (1) mile apart and should, where possible, be continuous. Minor Arterials should act as boundaries between neighborhood areas. Intersections with Collectors streets should be at least one-quarter (¼) mile apart. See the Street Standard Technical Design Criteria Chart for allowable intersection spacing. No street parking is allowed on Urban Minor Arterial streets. Bicycle lanes shall be provided for on both sides of the roadway. Stormwater runoff is channeled through concrete curb and gutters into inlet basins with storm sewers to collect and remove runoff. Regulation of traffic shall be accomplished through the use of traffic signs, signals, and channeling. Traffic signals will normally be required at intersections. Access from streets of lower classification will be permitted, but in all cases will be controlled by traffic control devices. Direct access to abutting property is not permitted unless no other access is reasonably available and then only upon approval by the Town.

9. *RURAL MAJOR ARTERIAL*

FUNCTION – Rural Major Arterial routes permit rapid and relatively unimpeded traffic movement throughout the Town, connecting major land use elements as well as connecting to outside communities. Rural Major Arterials are undivided arterials with four (4) or more lanes and experience heavy to high traffic volumes. The ability to pass without travelling in the lane of opposing traffic results in a large increase in arterial capacity over that of two (2) lane arterials.

PLANNING CHARACTERISTICS – Rural Major Arterial streets should not bisect neighborhoods but should act as boundaries between them. Major Arterials should be spaced approximately one (1) mile apart. See Street Standards Technical Criteria Chart for intersection spacing criteria. Local streets should not intersect with Major Arterials. Direct access to abutting property is not permitted unless no other access is reasonably available and then only upon approval by the Town. Street parking is not allowed on Major Arterials. Adjacent paved shoulders can double as bicycle lanes on both sides of the roadway. Drainage is handled using borrow ditches adjacent to the roadway with culverts to remove stormwater runoff. Signs, pavement delineation, and pavement marking play an important role in the optimum operation of Rural Major Arterials. Regulation of Traffic shall be accomplished through the use of these devices and traffic signals and channeling.

10. *URBAN MAJOR ARTERIAL*

FUNCTION – Urban Major Arterial routes permit rapid and relatively unimpeded traffic movement throughout the Town, connecting major land use elements as well as connecting to outside communities. Urban Major Arterial streets are divided highways with seven or more lanes and carry large traffic volumes. To accommodate left turn movements, a median separator shall be designed between the turning lane and the opposing traffic lane.

PLANNING CHARACTERISTICS – Urban Major Arterial streets should not bisect neighborhoods but should act as boundaries between them. Major Arterials should be spaced approximately one (1) mile apart. See Street Standards Technical Criteria Chart for intersection spacing criteria. Local streets should not intersect with Major Arterials. Street parking is not allowed on Major Arterials. Bicycle lanes shall be provided for on both sides of the roadway. Stormwater runoff is channeled through concrete curb and gutters into storm inlet basins with

storm sewers to collect and remove runoff. Signs, pavement delineation, and pavement marking play an important role in the optimum operation of Urban Major Arterials. Regulation of Traffic shall be accomplished through the use of these devices and traffic signals and channeling. Direct access to abutting property is not permitted unless no other access is reasonably available and then only upon approval by the Town.

## 1.06 ACCESS REQUIREMENTS AND CRITERIA

### A. GENERAL

Access to the Town of Windsor roadways may occur as one of two types: 1) access for land use (driveways) and, 2) access to other roadways (street intersections). A driveway is defined as an access constructed within the Town's right-of-way, connecting a public roadway with adjacent property and intended to provide vehicular access into that property in a manner that will not cause the blocking of any sidewalk, border area, or street roadway. The portion of the driveway within the right-of-way is called the driveway approach. An intersection is defined as the general area where two (2) or more roadways join or cross, including the roadway and roadside facilities for traffic movements. Some of the principles of intersection design apply directly to driveways.

Regulating access is termed "access control" or "access management". The functional advantage of regulating access on a street or roadway is the management of interference with through traffic. Regulated limitation of access is needed on arterials and collectors to enhance their primary function of mobility. Conversely, the primary function of local roads and streets is to provide access rather than traffic movement. Arterial and collector roadways must serve a combination of both property access and traffic movement.

The following general guidelines apply to all driveway access issues in the Town of Windsor and its Growth Management Area (GMA):

1. The design of driveways and access approaches shall provide for the safety of motorists, pedestrians, and bicyclists.

2. Driveways and entrances should be located away from other intersections to reduce traffic interference and to provide for adequate storage lengths for turning vehicles.

3. The minimum separation distances between accesses shall be as shown in the Access Management section of **Technical Design Criteria**, **Table 1.07.3**. Greater separation may be required to eliminate conflicts or overlaps of center left turn lanes as determined by the Transportation Impact Study (TIS) or as determined by the Town Engineer. For intersection location criteria, refer to the current Town of Windsor's Comprehensive Transportation Master Plan (TMP), and the Access Management section of **Technical Design Criteria, Table 1.07.3**.

4. Direct property access shall be denied or restricted along all arterial roadways to enhance their primary function of mobility whenever *reasonable* access can be provided to a lower class roadway.

5. Generally, no private direct access shall be allowed onto any Arterial and/or most Collector street classifications in the Town of Windsor. Access approval must be obtained from the Town for any private access. Approval may be granted during the development review process (through plan approval), by approval of an Access Management Plan, or by issuance of a right-of-way or access permit from the Town.

6. Private direct access on some Arterial and Collector streets may be permitted only when the property in question has no other reasonable access to the general street system and appropriate auxiliary turn lanes are provided. Such access shall continue only until such time that some other reasonable access to a lower function category street is available and permitted.

7. For some Collector streets, the center lane between left turn bays may be used for a continuous center two-way left-turn lane (TWLTL) design. If access points are needed on opposite sides of the roadway, they should be situated directly opposite each other. When establishing the placement of offset accesses (either driveways or intersections), the designer shall ensure that traffic making left hand turns into the accesses does not conflict or compete for the simultaneous use of a center left turn lane.

8. Local streets shall be designed to provide direct access, divert traffic to Collector streets, and provide for circulation and movement within the neighborhood. New streets should be laid out so the streets interconnect with simple routes (not circuitous) and multiple routes provided for all locations in the development. Additionally, the streets should be located to match the Town's planning requirements. No local streets should intersect Arterials.

9. Where access is needed for two (2) adjacent properties or where different land uses adjoin one another, consideration of providing one driveway to serve both properties can reduce the number of access locations needed. Recorded, private access easements are required for all shared accesses. No more than one (1) access shall be provided to an individual parcel or to contiguous parcels under the same ownership unless specifically waived by the Town Engineer.

10. Access is granted for new developments through Town approval of the final plat, final construction plans, or final site plan. The number and location of access points shall conform to the criteria outlined in this section of these Standards.

11. If the use of an existing access to right-of-way changes, or there is a change in the use of the property, the change in access use must be approved through the development review process, access management plan, or the Town's work in right-of-way or access permit. Change in access or property use may include, but is not limited to, change in the amount or type of traffic (twenty (20%) percent or twenty five (25 vph) vehicles per hour, whichever is less), structural modifications, remodeling, change in type of business, expansion in existing business, change in zoning, change in property division creating new parcels, etc.

12. It is important to locate driveways away from major intersections. This constraint is as much for the ability to enter and leave the property as for the benefit of intersection safety and operations. Exiting a driveway during peak-hour conditions at traffic signals is difficult where the queue of standing or slow-moving vehicles never allows a sufficient gap for entry from the driveway. Corner clearances shall be as shown in the Access Management section of the **Technical Design Criteria, Table 1.07.3**.

13. Access to state highways is governed by the State Highway Access Code, state highway access plans and these Standards. All access issues on State Highways shall be reviewed and approved by the Colorado Department of Transportation (CDOT).

## B. DRIVEWAY DESIGN CRITERIA

1. General. Driveway design shall be regulated as to width of entrance, placement with respect to property lines and intersecting streets, angle of entrance, vertical alignment, and number of entrances to a single property.

    a. Location. Driveways should have well defined locations. Curb openings for driveways require minimum dimensions in some instances and maximum dimensions in other instances. Appropriate design will provide good driveway access operation and at the same time minimize interference to street and pedestrian traffic.

    b. Maintenance Responsibility. Maintenance of the access and drainage improvements within the right-of-way shall be the responsibility of the adjacent property owner, including all improvements to driveways within the right-of-way, including sidewalk, curb and gutter and parkway.

2. Layout Criteria. The opening or driveway approach width shall be adequate to properly handle the anticipated traffic volume and character of traffic, as well as being within the limits specified for the type of property development. The radius of the curb shall be kept as small as possible.

    a. Radial Access. All driveways shall have a radial access opening; that is it shall be as near perpendicular to the centerline of the street as possible. The minimum angle permitted shall be ninety (90º) degrees plus or minus ten (10º) degrees for a minimum of twenty five (25') feet, measured perpendicular to the street and measuring from the curb or edge of pavement toward the property served.

    b. Driveway Approach Gradient. All driveway approaches within the road right-of-way shall maintain a positive slope toward the street. Unless otherwise approved by the Town Engineer, the driveway profile grade, measured at the center of the drive, shall not exceed ten (10%) percent. The driveway profile grade within twenty (20') feet of flowline for non-residential installations, shall not exceed eight (8%) percent; while the gradient for the remainder of the driveway should not exceed ten (10%) percent.

    c. Driveways Crossing Sidewalks. Wherever a driveway crosses a sidewalk, the driveway shall conform in width, cross slope, and grade to the design requirements for sidewalks in order to maintain accessibility for pedestrians with disabilities. Unramped curb returns are not permitted. Construct sidewalks across driveways with cross slopes of two (2%) percent and provide a pedestrian access route away from inaccessible driveway ramp flares.

    d. High Volume Driveways. Any driveway onto a Collector Street and any commercial driveway or driveways serving three hundred fifty (350) or more trip-ends per day are termed High Volume Driveways and shall have a maximum width of thirty six (36') feet. Additionally, the need for turn lanes will be evaluated in the TIS. If it is necessary to increase the maximum width, a median (minimum width of six (6') feet) shall be provided to divide the inbound traffic from the outbound traffic.

    e. Low Volume Driveways. Any driveways with a volume less than three hundred fifty (350 vpd) vehicles per day, shall be designed and constructed as a standard driveway in accordance with these Standards and the Town's Standard Drawings. These low volume driveways shall have a minimum width of twelve (12') feet and a maximum width of twenty four (24') feet.

    f. Multi-Family Dwelling Unit Driveways. Multi-dwelling unit driveways (three (3) or more units) are permitted with a minimum width of twenty four (24') feet. Driveways that serve twelve (12) units or more shall have a minimum width of twenty eight (28') feet and a maximum width of thirty six (36') feet.

3. Sight Distance. Sight distance is an especially important design parameter for driveways. Driveway locations where sight distances are not sufficient shall be avoided.

    a. Ingress to Driveways. All openings for driveways shall be located at a point of adequate sight distance along the street. Accesses to commercial establishments shall have sufficient space reasonably clear of any obstructions to provide drivers entering the property sufficient sight distance for proper and safe movements.

    b. Egress from Driveways. The profile of a driveway approach and the grading of the adjacent areas shall be such that when a vehicle is located on the driveway outside the traveled portion of the street the driver can see a sufficient distance in both directions to enter the street without creating a hazardous traffic situation. The driveway profile grade shall not exceed those parameters stated above.

c. Sight Distance Triangle. Sight distance for curb openings to private property shall consist of a sight triangle conforming to the requirements of the intersection sight distance (ISD) given in **Section 1.08.B.8**, **Intersections**.

4. Commercial/Industrial Driveway Approaches. All non-residential driveway approaches shall comply with these Standards, the Standard Drawings and the following:

   a. Allowable Access Points. In general, commercial property having less than one hundred fifty (150') feet of frontage and located mid-block should be limited to one access point to the street. Exceptions to this rule may be where a building is constructed in the middle of the lot and parking is provided for on each side of the building. Industrial access shall be determined on a case-by-case basis. The Town shall consider good traffic engineering practice and the information supplied by the applicant in the TIS. Unless otherwise provided herein, no more than two (2) service driveways shall be permitted for any one (1) commercial frontage.

   b. Driveway Frontage. Except for cul-de-sacs and flag lots, the total length of curb opening on a street for access to commercial property shall not exceed forty (40%) percent of the street frontage.

   c. Continuous Sidewalks. All sidewalks shall be designed and built with a uniform, continuous profile grade at driveway crossings. The maximum cross slope of two (2%) percent (¼ inch per foot) shall be maintained where the sidewalk crosses the driveway.

   d. Surface Requirements. The driveway approach shall extend from right-of-way line to edge of curb and shall be constructed with a minimum of six (6") inches of concrete or HBP in accordance with the Town's Standard Drawings. The width of the driveway within the right-of-way shall be as previously specified.

   e. Unacceptable Access Approaches. Access approaches shall not be approved for parking or loading areas that require backing maneuvers within the right-of-way except on Local Residential streets. All off-street parking areas must include on-site maneuvering areas and aisles to permit use vehicles to enter and exit the site in forward drive.

   f. Minimum Space Between Openings. The minimum spacing between curb openings shall be the footage measured at the curb line. This spacing will apply to the distance between drives serving adjoining properties. Refer to the Access Management section of the **Technical Design Criteria**, **Table 1.07.3**.

5. Residential Driveway Approaches (Urban). All residential driveway approaches shall access the street through a curb cut or drive over curb and gutter and shall comply with these Standards, the Standard Drawings and the following:

   a. Allowable Access Points. In general, each Single Family residential property should be limited to one (1) access point. Multiple accesses may be provided as long as spacing and clearance requirements are satisfied, and where deemed acceptable by the Town Engineer.

   b. Driveway Frontage. Except for cul-de-sacs and flag lots, no more than fifty (50%) percent of the street frontage of a residential lot shall be occupied with a driveway.

   c. Continuous Sidewalks. All sidewalks shall be designed and built with a uniform, continuous profile grade at driveway crossings. The maximum cross slope of two (2%) percent (¼ inch per foot) shall be maintained where the sidewalk crosses the driveway.

   d. Surface Requirements. The driveway approach shall extend from right-of-way line to edge of curb and shall be constructed with a minimum of four (4") inches of concrete

or HBP in accordance with the Town's Standard Drawings. The width of the driveway within the right-of-way shall be as previously specified.

e. Wider Driveways. Driveways serving three (3) car garages may have a maximum driveway approach width of thirty (30') feet; additional width may be permitted where deemed acceptable by the Town Engineer.

f. Minimum Space Between Openings. The minimum spacing between curb openings shall be the footage measured at the curb line. This spacing will apply to the distance between drives serving adjoining properties. This does not apply to residential developments using drive over curb and gutter and sidewalks. For minimum spacing requirements, refer to the Access Management section of **Technical Design Criteria**, **Table 1.07.3**.

6. Residential Driveway Approaches (Rural – with no curb and gutter). Private drive access to Rural roadways that have no curb and/or gutter improvements shall comply with these Standards, the Standard Drawings and shall be constructed to meet the following requirements:

   a. Allowable Access Points. In general, each Single Family rural residential property should be limited to one (1) access point. Multiple accesses may be provided as long as spacing and clearance requirements are satisfied, and where deemed acceptable by the Town Engineer.

   b. Driveway Frontage. Except for cul-de-sacs and flag lots, no more than fifty (50%) percent of the street frontage of a rural residential lot shall be occupied with a driveway.

   c. Surface Requirements. The driveway shall extend from right-of-way line to edge of existing roadway surface and shall be constructed with a minimum of four (4") inches of asphalt or concrete in accordance with the Town's Standard Drawings. The width of the driveway within the right-of-way shall be twelve (12') to twenty two (22') feet.

   d. Culvert. A culvert shall be installed at the established roadside ditch flowline elevation beneath the private drive access and the culvert diameter (fifteen (15") inch minimum diameter) shall be specified by the approved storm drainage report or in absence of the report, as specified by the Town Engineer. The culvert pipe shall have flared end sections, or approved headwalls, on both ends, in accordance with the Standard Drawings. The minimum cover over the culvert should be at least one (1') foot. Steel pipe material is prohibited.

   e. Sketch Plan. A drawing of the proposed driveway installation showing all dimensions shall be submitted and approved prior to construction.

7. Drainage. No curb chases or point discharge of surface drainage from private property shall be within any driveways except for sheet flow from a driveway less than five hundred (500 $ft^2$) square feet in area. Where curb cuts are allowed, concentrated storm water runoff from property adjoining the right-of-way shall not be discharged across the sidewalk. These flows must be directed elsewhere or directed to a sidewalk chase where storm water may pass under a sidewalk section. If not possible due to grading restraints and radius returns, a crosspan must be used.

## 1.07 GENERAL DESIGN ELEMENTS

### A. GENERAL

1. The design of the horizontal and vertical alignment shall provide for the safety of motorists, pedestrians, and bicyclists.

2. All streets shall be designed in accordance with design speeds specified for each above-referenced street classification. Refer to Design Speed section of **General Parameters**, **Table 1.04.1**.

3. Horizontal and vertical street alignments should conform as much as possible to existing land layout.

4. The street pattern in a subdivision shall be the most advantageous configuration to serve adjoining areas and the entire neighborhood or district. Where appropriate to the design, proposed streets shall be continuous and in alignment with existing, planned, or platted streets.

5. Streets shall be placed in accordance with the current edition of the Town of Windsor's Comprehensive Transportation Master Plan (TMP) where applicable.

6. Local streets should not intersect Major Collectors or Arterial streets.

7. Proposed streets shall be extended to the boundary lines of the subdivision, except where prohibited by topography or other physical conditions, or where such extension is not necessary for connection to adjacent properties. Where streets will be extended beyond the property line, sufficient engineering data shall be provided to establish feasibility of extension meeting Town standards.

8. Signs, pavement and other markings, and, where appropriate, traffic signal controls are essential elements for all local roads and streets. Refer to the MUTCD for details of the devices to be used and, for some conditions, warrants for their use.

9. All slopes and drainage areas should be designed with proper regard for the desired natural ground cover and growth regeneration on areas opened during construction. Various acceptable methods of erosion control, including seeding and mulching of slopes, sodding, or other protection of swales and other erodible areas, should be included in the local road design.

**B. DESIGN CRITERIA - <u>(HORIZONTAL ALIGNMENT)</u>**

1. All proposed streets shall intersect at right angles unless topography and other limiting factors of good design and safety require otherwise.

2. Where streets intersect with other streets and are not in alignment, the streets shall be offset in accordance with the following table:

**Table 1.07.1**
**Street Flowline Offsets**

| INTERSECTING ROADWAY | MINIMUM OFFSET |
|---|---|
| Arterial | 660 feet |
| Collector | 330 feet |
| Local | 135 feet |

Note: Flowline offset distances shall be measured from nearest flowline to nearest flowline.

3. Deflections in the centerline of streets shall be connected by horizontal curves.

4. On Arterial and Major Collector roadways, curve radii and tangents shall be as large as possible using the minimums only where necessary. However, minimum radius curves may be used on Local Residential, Minor Collector, and Connector Local streets unless otherwise required.

    a. <u>Horizontal Curve Radii</u>. The minimum allowable centerline radii for horizontal curves shall be as designated in the Horizontal section of the **Technical Design Criteria**, **Table 1.07.3**.

b. Compound and Reverse Curves. Two (2) consecutive circular curves constitute a compound curve if they join at a point of tangency where both curves are on the same side of the common tangent. The radii of the two (2) curves are different but in the same direction at their junction. When two (2) such curves have their centers on opposite sides of the common tangent, the combination is known as a reverse curve. Reverse and compound curves should be used only when a single radius curve will not work.

i. Compound Curves. The use of compound curves should be avoided for roadways with design speeds in excess of forty five (45 mph) miles per hour. Avoid compound curve designs that mislead the motorist's expectation of how sharp the curve radius is. Compound curves shall have a ratio no greater than one and one half (1.5) where the value of the larger radius is divided by the smaller radius. Where practical, a smaller difference in radii should be used.

ii. Lengths of Circular Arcs. In compound curves of decreasing radii, each curve should be long enough to enable the driver to decelerate at a reasonable rate. The minimum length of the circular arc (length of curve) should be no less than one half (½) the length of the radius.

iii. Broken Back Curves. The "broken back" or "flat back" arrangement of curves (with a short tangent between two (2) curves in the same direction) should be avoided except for very unusual conditions; however, when justified, they shall be separated by a tangent with a length of at least two (2) times the minimum length shown in the Horizontal section of the **Technical Design Criteria**, **Table 1.07.3**.

iv. Reverse Curves. Reverse curves shall be separated by a tangent length no less than the length shown in the **Technical Design Criteria**, **Table 1.07.3**.

c. Minimum Tangent Length at Intersections. Whenever a Minor street intersects a street of higher classification, a tangent length (measured from the nearest gutter flowline of the intersected street to the point of curvature in the intersecting street) shall be provided for a safe sight distance and safe traffic operation. The minimum required tangent lengths indicated in the Horizontal section of the **Technical Design Criteria**, **Table 1.07.3**, apply to the minor leg(s) only. The angle of departure shall not exceed ten (10°) degrees for the length of tangent.

d. Consistent Radii. To provide consistency and minimize unexpected, difficult, or quick maneuvers for the driver, all curves along a street shall be designed with radii that are approximately equal.

e. Centerline Arc Lengths. To reduce the appearance of kinks in the street, minimum lengths of curve shall be designed with minimum arc lengths in accordance with the following table:

**Table 1.07.2**
**Centerline Arc Lengths**

| STREET CLASSIFICATION | MINIMUM ARC LENGTH |
|---|---|
| Arterial | 400 feet |
| Collector | 300 feet |
| Local, Comm/Ind | 200 feet |
| Local, Residential | 100 feet |

f. Abrupt Reversals. Avoid abrupt reversals in alignment; such changes in alignment make it difficult for drivers to keep within their own lane.

g. Horizontal Curves on Vertical Curves. Horizontal curves shall not begin near the top of a crest vertical curve nor near the bottom of a sag vertical curve.

5. Off-site Design. To assure that future street improvements will meet these Standards, the centerline, flowline, and cross sections of all local and collector streets, except cul-de-sacs, shall be continued for five hundred (500') feet beyond the proposed construction. The grade and ground lines of all Arterials shall be continued one thousand (1000') feet beyond the end of the proposed construction.

6. Connection with existing streets shall be made to match the existing alignment grade of the existing improvements, in accordance with horizontal alignment criteria.

7. The number of intersecting streets along Arterials and Collectors shall be held to a minimum. The allowable spacing of intersections varies depending on signalization and presence of a raised center median. Refer to Access Management section of **Technical Design Criteria**, **Table 1.07.3**.

8. In restricted or unusual conditions, it may not be practical to meet the design criteria presented in this section. In such cases, every effort should be made to obtain the best possible alignment, grade, sight distance, and drainage that are consistent with terrain, development (present and anticipated), safety, and environmental concerns. Any variance from these standards shall be so documented and the variance request process initiated, as detailed in **Section 1.03.B.1**.

**Table 1.07.3**
**Technical Design Criteria**

| Roadway Classification | | Arterial | | | | Collector | | | Local | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Design Elements** | | **Urban Major 7 lanes** | **Urban Minor 5 lanes** | **Rural Major 5 lanes** | **Rural Minor 3 lanes** | **Urban Major 3 lanes** | **Urban Minor 2 lanes** | **Rural Collector 3 lanes** | **Urban Ind/Comm 2 lanes** | **Urban Local 2 lanes** | **Rural Local 2 lanes** |
| **Overall Design Parameters** | | | | | | | | | | | |
| Design Speed (MPH)<br>Posted Speed (MPH) | | 65<br>50-55 | 55<br>45-50 | 60<br>50-55 | 55<br>45-40 | 50-45<br>45-35 | 40<br>35-30 | 50<br>45-40 | 35<br>30 | 35<br>30 | 35<br>30 |
| Stopping Sight Distance | | 645 ft | 495 ft | 570 ft | 495 ft | 315 ft | 305 ft | 425 ft | 250 ft | 250 ft | 250 ft |
| **Horizontal Alignment** | | | | | | | | | | | |
| Min. Centerline radius | | 1660 ft | 1200 ft | 1415 ft | 1200 ft | 700 ft | 400 ft | 700 ft | 300 ft | 200 ft | 200 ft |
| Max. Superelevation | | 6% | 5% | 5% | 5% | 4% | 4% | 4% | NA | NA | NA |
| Min. Tangent lengths[1] | | 250 ft | 200 ft | 200 ft | 200 ft | 150 ft | 100 ft | 150 ft | 100 ft | 100 ft | 100 ft |
| **Vertical Alignment** | | | | | | | | | | | |
| Max. Centerline Grade | | 5% | 5% | 4% | 4% | 5% | 5% | 5% | 6% | 8% | 7% |
| Min. Gutter Flowline Grade | | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% | 0.5% |
| Min. K-value for Vertical curves | Crest | 195 | 125 | 150 | 125 | 90 | 60 | 110 | 40 | 40 | 40 |
| | Sag | 120 | 90 | 100 | 90 | 75 | 60 | 90 | 45 | 45 | 45 |
| **Intersection Design** | | | | | | | | | | | |
| Min. sight distance at drives & intersections[2] | | 1030 ft | 940 ft | 975 ft | 940 ft | 800 ft | 660 ft | 800 ft | 390 ft | 390 ft | 390 ft |
| **Access Management**[3] | | (A) (B) | (A) (B) | | | | | | | | |
| Min. distance between Intersections | w/ Signal | 2640' | 2640' | 2640' | 1320' | NA | NA | NA | NA | NA | NA |
| | No signal | NA 1320' | 1320' 660'[4] | 1320' | 660' | 330'[5] | 250' | 330' | 250' | 200' | 200' |
| Min. distance between driveways (edge to edge) | | NA 590'[6] | NA 350'[6] | 800' | 660' | 550' | 150'[7] | 200' | 50' | 10'[8] | 10'[8] |
| Driveway Configuration | | Radial curb return | Radial curb return | NA | NA | Radial or Curb cut | NA | NA | Radial or Curb Cut | NA | NA |

(1) Between reverse curves or at intersections.
(2) Left-turn from Stop Sign
(3) Centerline to Centerline
(A) Without Raised Median
(B) With Raised Median
(4) ¾ Movement Only Per Approval of Town Engineer
(5) Increase as necessary per Table 1.25.1
(6) Right-in / Right-out Only Per Approval of Town Engineer.
(7) Not applicable for Residences
(8) Except for Cul-de-sacs
Note: Deviations require a traffic study and analysis by a licensed engineer and must be approved by the Town Engineer.

## C. DESIGN CRITERIA - (VERTICAL ALIGNMENT)

1. Vertical alignment and grades shall be designed to bear a logical relationship to the existing topography, drainage needs, sight requirements, and shall provide for the safety of motorists, pedestrians, and bicyclists.

2. All proposed streets shall conform to the minimum and maximum allowable street slope and street grade standards shown in the following table:

**Table 1.07.4**
**Minimum and Maximum Allowable Street Slope and Street Grades**

| Street Type | Street Grades %Min. /% Max. | Cross Slope (%) |
|---|---|---|
| Urban Major Arterial | 0.5/5.0 | 2.0 Normal crown<br>6.0 Max – for superelevation. |
| Urban Minor Arterial | 0.5/5.0 | 2.0 Normal crown<br>5.0 Max – for superelevation. |
| Rural Arterial | 0.5/4.0 | 2.0 Normal crown<br>5.0 Max – for superelevation. |
| Urban Major Collector | 0.5/5.0 | 2.0 Normal crown<br>4.0 Max – for superelevation. |
| Urban Minor Collector | 0.5/5.0 | 2.0 Normal crown<br>4.0 Max – for superelevation. |
| Rural Collector | 0.5/5.0 | 2.0 Normal crown<br>4.0 Max – for superelevation. |
| Urban Ind./Comm. | 0.5/6.0 | 2.0 Normal crown |
| Urban Local | 0.5/8.0 | 2.0 Normal crown |
| Rural Local | 0.5/7.0 | 2.0 Min. |

3. All proposed streets shall conform to the following grading guidelines:

   a. Grading Behind Sidewalks**.** Grading behind sidewalks and between detached sidewalk and curb shall be a maximum of four to one (4:1). Special conditions outside of this range may be necessary. Any variances from these standards shall be so documented and the variance request process begun, as detailed in **Section 1.03.B.1**.

   b. Grading of Foreslopes and Backslopes. In cases where curb and gutter and sidewalk are not present (Rural roadways), the slope from the pavement or shoulder to the drainage ditch is the foreslope and the slope from the ditch to the right-of-way is the back slope. Grading of foreslopes and backslopes shall be a maximum of four to one (4:1). Special conditions outside of this range may be necessary. Any variances from these standards shall be so documented and the variance request process begun, as detailed in **Section 1.03.B.1**.

   c. Crown Slope. Normal crown slope is two (2%) percent. One (1%) percent to five (5%) percent is allowable at transition and other non-normal sections with special design review.

   d. Minimum Flowline Grade. Minimum flowline grade on curb and gutter shall be five tenths (0.5%) percent. Particular attention shall be given to maintain five tenths (0.5%) percent minimum grade especially on a sag vertical curve. Crosspans, cul-de-sacs, eyebrows, and curb return gutters shall have a minimum flowline grade of seven tenths (0.7%) percent.

e. Maximum Grades in Cul-de-Sacs. The maximum centerline grade in the bulb of a cul-de-sac shall not exceed three (3%) percent.

4. Connections with existing streets shall be made in a way that will create a smooth transition. The higher volume street at an intersection shall govern the through grade and cross-sections. The maximum allowable approach grade at an intersection shall be two (2%) percent for a distance as designated by the following table:

**Table 1.07.5**
**Minimum Distance for Maximum 2% Approach Grade**

| Approaching street | Local | Collector | Arterial |
|---|---|---|---|
| Local | 30 Feet | 50 Feet | 75 Feet |
| Collector | | 75 Feet | 150 Feet |
| Arterial | | | 200 Feet |

Distances shown are measured from the flowline intersections.

The intersection of any street with a Major street shall be designed to the ultimate street grade of the Major street. The grading of the property adjacent to the Major street shall meet these ultimate grades. A detailed drawing of the intersection sufficient to show drainage and grades shall be provided.

Connection with existing streets shall be smooth transitions and existing grades shall be shown for at least one hundred and fifty (150') feet on all sides of the connection. To assure that future street improvements will meet these standards, the grade and ground lines of all local and collector streets, except cul-de-sacs, shall be continued for five hundred (500') feet beyond the proposed construction. The grade and ground lines of all Arterial Streets shall be designed to continue one-thousand (1000') feet beyond the end of proposed construction.

5. Vertical curves joining the intersecting grade lines of streets tend to smooth out the changes in vertical motion and are required for grade changes that exceed one (1.0%) percent. Both centerlines and the curb and gutter flowlines shall be designed with vertical curves to meet the requirements of these standards. For minimum K-values to be used in design, refer to the Vertical Alignment section of **Technical Design Criteria**, **Table 1.07.3**.

6. In selecting the length of vertical curves over crests or into sags, the algebraic difference of gradients enters into the calculations. The “K-value” on vertical curves is the length of the curve divided by the algebraic difference in grades, in percent.

7. Vertical curves should result in a design that is safe and comfortable in operation, pleasing in appearance, and adequate for drainage. The major control for safe operation on crest vertical curves is the provision of ample sight distances for the design speed; while, for driver comfort, in sag vertical curves the rate of change of grade should be kept within tolerable limits.

8. On infrequent occasions, because of critical clearance or other controls, the use of asymmetrical vertical curves may be appropriate. Use of asymmetrical curves is allowed only upon approval of the Town Engineer.

9. Crest vertical curves shall meet or exceed the following minimum length criteria:

**Table 1.07.6**
**Minimum Length of Crest Vertical Curves (in feet)**

| Grade | Urban Arterials | | Rural Arterials | | Urban Collector | | Rural Collector | Local |
|---|---|---|---|---|---|---|---|---|
| Change % | Major K=195 | Minor K=125 | Major K=150 | Minor K=125 | Major K=90 | Minor K=60 | K=110 | K=40 |
| 0.00 – 1.00 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 1.01 – 2.00 | 390' | 250' | 300' | 250' | 180' | 120' | 220' | 80' |
| 2.01 – 3.00 | 580' | 375' | 450' | 375' | 270' | 180' | 330' | 120' |
| 3.01 – 4.00 | 780' | 500' | 600' | 500' | 360' | 240' | 440' | 160' |
| 4.01 – 5.00 | 975' | 625' | N/A | N/A | 450' | 300' | 550' | 200' |
| 5.01 – 6.00 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 240' |
| 6.01 – 7.00 | “ | “ | “ | “ | “ | “ | “ | 280' |
| 7.01 - 8.00 | “ | “ | “ | “ | “ | “ | “ | 320' |

Note: Lengths above do not allow passing on crest of vertical curves. Design may warrant a passing move on Collectors or Arterial, which would lengthen the vertical curves. The required lengths for passing will be calculated on a case-by-case basis by the Design Engineer.

10. Sag vertical curves shall meet or exceed the following minimum length criteria:

**Table 1.07.7**
**Minimum Length of Sag Vertical Curves (in feet)**

| **Grade** | Urban Arterials | | Rural Arterials | | Urban Collector | | Rural Collector | Local |
|---|---|---|---|---|---|---|---|---|
| **Change %** | Major K=120 | Minor K=90 | Major K=100 | Minor K=90 | Major K=75 | Minor K=60 | K=90 | K=45 |
| 0.00 – 1.00 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 1.01 – 2.00 | 240' | 180' | 200' | 250' | 150' | 120' | 180' | 90' |
| 2.01 – 3.00 | 360' | 270' | 300' | 375' | 225' | 180' | 270' | 135' |
| 3.01 – 4.00 | 480' | 360' | 400' | 500' | 300' | 240' | 360' | 180' |
| 4.01 – 5.00 | 600' | 450' | N/A | N/A | 375' | 300' | 450' | 225' |
| 5.01 – 6.00 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 270' |
| 6.01 – 7.00 | “ | “ | “ | “ | “ | “ | “ | 315' |
| 7.01 - 8.00 | “ | “ | “ | “ | “ | “ | “ | 360' |

Note: Profile may be designed with a maximum one percent (1%) change in grade at the vertical point of intersection (VPI)

11. Drainage of curbed roadways on sag vertical curves needs careful profile design to retain a grade of not less than one half (0.5%) percent.

12. A smooth gradeline with gradual changes should be sought for in preference to a line with numerous breaks and short lengths of grades. Specific design criteria are the maximum grade and

the critical length of grade, but the manner in which they are applied and fitted to the terrain on a continuous line determines the suitability and appearance of the final roadway.

13. Minimum vertical clearance above a roadway, for most structures, shall be at least sixteen and one half (16½') feet, measured from the highest point on the roadway to the lowest point on the overhead structure or feature. On two (2) lane roadways, for low speed and low volume under-crossings [design speed less than fifty (<50 mph) miles per hour and an average daily traffic volume less than seven hundred fifty (ADT< 750)], the minimum clearance may be reduced by up to two (2') feet, only with approval of the Town Engineer. Minimum vertical clearance above a roadway for pedestrian structures shall be at least seventeen and one half (17½') feet, and the minimum vertical clearance above a roadway for railroad bridges shall be at least twenty three (23') feet, measured as stated above.

## D. DESIGN CRITERIA - (HORIZONTAL AND VERTICAL ALIGNMENT)

1. Horizontal and vertical alignment should not be designed independently. They complement each other and poorly designed combinations can aggravate the deficiencies of each. The specific design should consist of harmonizing of the vertical and horizontal lines such that the finished street will be an economical, pleasant, and safe facility on which to travel.

2. Curvature and grades should be in proper balance. Tangent alignment or flat curvature at the expense of steep or long grades and excessive curvature with flat grades should be avoided.

3. Vertical curvature superimposed on horizontal curvature, or vice versa, generally results in a more pleasing street, but such combinations should be analyzed for their effect on traffic.

4. Sharp horizontal curvature should not be introduced at or near the top of a pronounced crest vertical curve; similarly, sharp horizontal curvature should not be introduced near the bottom of a steep grade approaching or near the low point of a pronounced sag vertical curve.

5. Coordination of horizontal alignment and profile should not be left to chance but should begin with a preliminary design where adjustments can be readily made. Even for local street design, it is desirable to work out long, flowing alignment and profile sections rather than a connected series of block-by-block sections.

6. Superelevation.

    a. Purpose. The purpose of superelevating (roadway banking) a roadway is to improve the riding comfort on curves where the traveling speed is great enough to exert a lateral thrust greater than that which can reasonably be resisted by friction alone.

    b. Town Approval Required. Superelevation may only be used when other means of design will not work and is permitted only on Arterial and selected Collector streets. Superelevation shall not be used on Local streets. When superelevations are utilized, the design shall be in accordance with the recommendations of AASHTO and as approved by the Town Engineer.

    c. Maximum. The maximum amount of superelevation shall not exceed the values given in the Horizontal Alignment section of **Technical Design Criteria**, **Table 1.07.3**.

    d. Run-out. When superelevation is used, a minimum one hundred (100') foot run-out shall be used entering and exiting the super-elevated portion.

    e. Drainage. In cases where the superelevation transition changes the gutter on one side of the street from water carrying to non-water carrying, the water must enter a storm sewer system or other acceptable outlet from the street rather than crossing said street in sheet flow or crosspans. The gutter shall always be inflow type.

    f. Details. When superelevation is used, the rate of superelevation shall be clearly shown on the drawings along with exaggerated (preferably 1"= 20' Horizontal, 1"= 1' Vertical)

profiles of the centerline and both flowlines. The superelevation run-out length, crown run-out length, and point at which full superelevation is reached shall be clearly shown.

7. Travel Sight Distance. Travel sight distance is that length of the roadway ahead that is visible to the driver. Although greater lengths of visible roadway are desirable for safety, the available sight distance on a roadway should be designed sufficiently long to enable drivers traveling at or near the design speed, to control the operation of their vehicles to avoid striking an unexpected object in the traveled way. Certain two-lane roadways should also have sufficient sight distance to enable drivers to occupy the opposing traffic lane for passing other vehicles without risk of a crash. Two-lane rural roadways should generally provide such passing sight distance at frequent intervals and for substantial portions of their length.

    a. Stopping Sight Distance. The sum of the distance traversed during the brake reaction time and the distance to brake the vehicle to a stop is the stopping sight distance. In no case shall the design distance be less than the stopping sight distance given in the Stopping section of **Minimum Sight Distance**, **Table 1.07.8**.

    b. Stopping Sight Distance on Horizontal Curves. Slight obstructions (such as walls, cut slopes, foliage, buildings, barriers) on the inside of curves or the inside of the median lanes on divided highways, may require alteration of sight distance calculations and other alignment design considerations. Each curve should be checked for actual and potential conditions and make appropriate design adjustments to provide adequate sight distance.

    c. Stopping Sight Distance on Gradients. When a roadway is on a grade greater than two (2%) percent, the minimum stopping sight distance given in the Stopping section of **Minimum Sight Distance**, **Table 1.07.8**, shall be adjusted. For downgrades, the stopping distance shall be increased by adding, in feet, the product of the Design Speed (in mph) times the grade (in percent) times ten (10). For upgrades, the stopping distance shall be decreased by subtracting that same product. All roadways shall be designed for the greatest required sight distance calculation.

    d. Passing Sight Distance. On two-lane two-way roadways, passing maneuvers in which faster vehicles move ahead of slower vehicles must be accomplished on lanes regularly used by opposing traffic. Minimum passing sight distances for design on two lane roadways are given in the Passing section of **Minimum Sight Distance**, **Table 1.07.8**. Passing sight distance should be increased on upgrades. Design of passing sight distance with gradients in excess of two (2%) percent shall require review and approval of the Town Engineer. The frequency and length of passing sections for roadways depend, principally, on the topography, the design speed and the classification of roadway. It is not practical to directly indicate the required frequency of passing sections on two-lane roadways; the design engineer shall work in co-operation with the Town Engineer to develop a proposed plan.

    e. Decision Sight Distance. Stopping sight distances may not provide sufficient visibility distances for drivers to perceive the unexpected, make complex and instantaneous decisions and initiate and complete appropriate evasive maneuvers, safely and efficiently. It is evident that there are many locations where it would be prudent to provide longer sight distances. Critical locations include intersection locations where unexpected maneuvers are required, changes in cross section, or areas of concentrated demand. In these circumstances, decision sight distance provides the greater visibility distance that drivers need. Decision sight distances vary depending on whether the location is on a rural or urban road and are as given in the Decision section of **Minimum Sight Distance**, **Table 1.07.8**.

    f. Sight Distance Triangles and Easements. All sight distances must be within the public right-of-way or a sight distance easement. If the line of sight crosses onto private property, a "Sight Distance Easement" must be dedicated to provide the required sight distance. See **Section 1.08.B.8** for intersection sight-distance triangle legs.

g. Sight Obstructions. Any object within the sight distance easement more than thirty (30") inches above the flowline elevation of the adjacent street shall constitute a sight obstruction, and shall be removed or lowered. Such objects include but are not limited to berms, buildings, parked vehicles on private property, cut slopes, hedges, trees, bushes, utility cabinets or tall crops. Mailboxes must not pose a fixed object hazard for vehicles and pedestrians. In no case shall any permanent object encroach into the line-of-sight of any part of the sight-distance triangle. Trees are exempted from this requirement if pruned up to eight (8') feet.

**Table 1.07.8**
**MINIMUM REQUIRED SIGHT DISTANCES (IN FEET)**

| Design Speed (mph) | Minimum Sight Distances | | | |
|---|---|---|---|---|
| | Stopping (feet) | Passing (feet) | Decision | |
| | | | Rural (ft) | Urban (ft) |
| 20 | 115 | 800 | N/A | N/A |
| 25 | 155 | 950 | " | " |
| 30 | 200 | 1100 | 300 | 500 |
| 35 | 250 | 1300 | 400 | 600 |
| 40 | 305 | 1500 | 450 | 700 |
| 45 | 360 | 1650 | 525 | 800 |
| 50 | 425 | 1835 | 600 | 900 |
| 55 | 495 | 1985 | 700 | 1000 |
| 60 | 570 | 2135 | 800 | 1100 |
| 65 | 645 | 2285 | 850 | 1250 |

8. The design engineer shall show either centerline profile or both flowline profiles. If centerline profiles are provided, the flowline profile information, distances and grades, shall also be provided everywhere it is not parallel to the centerline and along all horizontal curves. If flowline profiles are provided, the design engineer shall also show centerline profiles through intersections and details at any mid-block crosspans to provide smooth riding transitions. The actual distance and grades of curb returns shall be given for all intersections. Flowline profiles shall be shown around cul-de-sacs, roundabouts, kneecaps, knuckles, eyebrows, hammerheads, bulb-outs, and elbows. For arterial and major collector streets and for widening of existing streets, the design engineer shall provide cross-sections to the construction limits at fifty (50') foot intervals on all streets, showing existing and proposed construction. Cross-section profiles shall be provided to include the street, curb, gutter and walk to a point twenty (20') feet beyond the walk.

9. The alignment of a roadway or street produces a great impact on the environment, the fabric of the community, and the roadway user. The alignment is comprised of a variety of elements joined together to create a facility that serves the traffic in a safe and efficient manner. Each alignment element should complement others to produce a consistent, safe, and efficient design. In some unusual conditions, it may not be practical to meet the design criteria presented in this section. In such cases, every effort should be made to obtain the best possible alignment, grade, sight distance, and drainage that are consistent with terrain, development (present and anticipated), safety, and environmental concerns. Any variance from these standards shall be so documented and the variance request process initiated, as detailed in **Section 1.03.B.1**.

## 1.08 INTERSECTIONS

### A. GENERAL

1. Intersections shall be designed to provide for the safety of motorists, pedestrians, and bicyclists.

2. An intersection is defined as the general area where two or more roadways join or cross, including the roadway and roadside facilities for traffic movements within the area. Each roadway radiating from an intersection and forming part of it is an intersection leg. The most common intersection at

which two roadways cross one another has four legs. It is not recommended that an intersection have more than four legs.

3. By their nature, intersections are conflict locations. Vehicles, pedestrians, and bicycles all cross paths; each crossing is a conflict point. Intersections contain many conflict points and their design should minimize points of conflict and simplify areas of conflict as well as limit conflict frequency and conflict severity; provisions for pedestrians and bicycle movements must be considered in intersection design.

4. The design and use of auxiliary, or speed-change lanes, such as left turn and right turn lanes, increases capacity and creates better operational conditions for turning vehicles. Intersections with separate left turn lanes permit following-through vehicles to maneuver around these slower turning vehicles. Intersection design shall take into consideration auxiliary turn lanes as required by these Standards, by the approved Transportation Impact Study (TIS), or as required for site specific conditions.

5. Crossing roadways should intersect at ninety (90°) degrees whenever possible. In no case shall they intersect at less than eighty (80°) degrees or more than one hundred (100°) degrees.

6. The functional advantage of regulating access, called "access control", on a street or roadway, is the management of interference with through traffic. Local street classifications emphasize property access rather than traffic movement. Arterial and collector roadways must serve a combination of both property access and traffic movement.

   Direct property access should be limited along higher classified roadways whenever *reasonable* access can be provided to a lower class roadway. Traffic signals should be located to emphasize through traffic movements and signalized access points should fit into the overall signal coordination plan for traffic progression. Driveways and entrances should be located away from other intersections to reduce traffic interference and to provide for adequate storage lengths for turning vehicles. For intersection location criteria, refer to **Section 1.06**, **Access Requirements and Criteria**, the current Town of Windsor's Comprehensive Transportation Master Plan (TMP), and the Access Management section of **Technical Design Criteria, Table 1.07.3**.

7. All intersections shall be designed and constructed with pedestrian curb ramp access on all corners in accordance with all ADA requirements and sufficient right-of-way shall be provided to accommodate not only the intersecting roadways, but sidewalks, curb ramps, utilities, and other necessary appurtenances.

8. No pedestrian crossing across a nonsignalized intersection shall exceed fifty (50') feet without a refuge area being provided.

B. **DESIGN CRITERIA**

1. In the design of intersections, one of the most important analyses to be undertaken is a capacity and level-of-service assessment, second only to safety considerations. Refer to **Section 1.26**, **Traffic Impact Study (TIS)**.

2. Intersection types are determined primarily by the number of intersecting legs, the topography, the character of the intersecting roadways, the traffic volumes, patterns, and speeds, and the desired type of operation. Intersection types can vary greatly in scope, shape, and degree of channelization. Once the intersection type is established, the design controls and criteria herein should be applied by the designer to arrive at a suitable geometric design and traffic control plan that addresses the uniqueness of the particular intersection. Roundabouts represent one means of traffic control for an intersection. Criteria for the design of Roundabouts are presented in **Section 1.09**, **Roundabouts**.

3. The design criteria for all street intersections shall conform to the Horizontal and Vertical Alignment Design Criteria outlined in **Section 1.07** above. The alignment and grades are subject to greater constraints at or near intersections than on the open road; the alignment should be as

straight and the gradients as flat as practical. Sight distance should be equal to or greater than the minimum values for specific intersection conditions, as derived and discussed later in this section.

All lanes shall be in alignment through each intersection, with a maximum of a two (2') foot shift in a hardship situation only, subject to review and approval by the Town Engineer.

4. Combinations of grade lines that make vehicle control difficult should be avoided at intersections. The profile grade lines and cross sections on the legs of an intersection should be adjusted for a distance back from the intersection proper to provide a smooth junction and proper drainage. See **Section 1.07.C.3** for additional detailed criteria.

   The grade of the street with the higher classification shall prevail at intersections. The lesser street shall adapt to the grade of the Major street. Grading of adjacent property and driveways shall adapt to the street grades. When roads are of equal classification, the Town Engineer shall determine which street grade prevails.

   For simple unchannelized intersections involving low design speeds and stop, yield, or signal control, it may be desirable to warp the crowns of both roadways into a plane at the intersection; the appropriate plane depends on the direction of drainage and other conditions.

5. Turning Lanes. The widths and radius of turning roadways for intersections are governed by the volumes of turning traffic and the types of vehicles to be accommodated. Generally, the widths for right-turning roadways may also be applied to other roadways within an intersection. Ideally, left turn lanes should be provided at driveways and street intersections along major arterial and collector roads wherever left turns are permitted.

   a. Design Criteria. Turning lanes shall be designed to accomplish the following functions:

      i. Left turn lanes shall be designed to provide a means for safe deceleration outside the high speed through lane; provide sufficient storage length long enough for left turning vehicles so that signal phasing can be optimized and intersection delay minimized; a means of separating movements at unsignalized intersections to reduce left turn impacts on other flows.

      ii. Right turn lanes shall be designed to provide a means for safe deceleration outside the high speed through lane; provide a separate storage area for right turns to assist in the optimization of traffic signal phasing; provide a means of separating right turn movements at stop controlled intersections.

   b. Design Vehicles. As a minimum, intersections shall be designed to accommodate the following AASHTO design vehicles for the specified turns.

      i. SU-30 (Single Unit Truck). The requirement that *all SU-30 vehicles must be able to turn easily from one street to the next and remain in the correct lane for each roadway* shall apply to all classifications of roadways and alleys.

      ii. B-40 (Bus). The requirement that *all B-40 vehicles may use more than one traffic lane to complete the turn when turning from the correct lane without crossing into opposing traffic lanes and without tracking onto the curb at corners* shall apply to all streets.

      iii. WB-50 (Large Semitrailer). The requirement that *all WB-50 vehicles may use more than one traffic lane to complete the turn without tracking onto the curb at corners and must make the turn in one forward maneuver* shall apply to these classifications of roadways: Arterial/Arterial, Arterial/Collector, Arterial/Local Industrial-Commercial, Collector/Collector, and Collector/Local Industrial-Commercial streets. For all other intersections, the vehicles may use the entire paved surface of the street to negotiate the turn and may have to back up to complete the turn.

iv. WB-67 (Large Semitrailer). All modern Roundabouts shall be designed to accommodate a WB-67 vehicle. This classification shall include semi-trucks, articulated buses, motor homes, motor coaches and passenger cars pulling trailers or boats.

v. Other Vehicles. For special and/or unusual circumstances, other design vehicles may necessitate additional analysis as required and directed by the Town Engineer.

c. Curb Types & Curb Return Radii Criteria. The minimum allowable intersection turning radii are shown in **Table 1.13.1**, **Curb Return Radii Criteria**.

d. Curb Return Grades. The minimum allowable grade for flowlines around the perimeter of the curb return shall be seven tenths (0.7%) percent.

e. Storage Length. The storage length of all turning lanes shall be sufficient to accommodate the longest queue expected most of the time.

f. Exclusive Left Turn Lanes. Exclusive left turn lanes shall be provided on all arterial streets and other streets wherever left turn lanes are specified as needed by an access plan, required by these Standards or warranted and approved by the Town Engineer. Recommendations in the TIS shall also be used to determine whether an exclusive left turn lane is warranted.

i. Warrants for Signalized Intersections. A separate left turn lane shall be required if one of the following criteria is met: the left turn design volume is at least twenty (20%) percent of total approach volumes, or if the left turn design volume exceeds one hundred (100 vph) vehicles per hour in peak periods, or the LOS criteria are not satisfied without a left turn lane.

ii. Warrants for Unsignalized Intersections. Left turn lanes may be required at approaches to unsignalized intersections for which the combination of through, left, and opposing volumes exceeds warrants specified in the National Cooperative Highway Research Program Report 279 (NCHRP 279). The Town Engineer shall specify which peak hours to consider in this evaluation.

iii. Speed Warrant. The TIS shall review the proposed or posted speeds and evaluate if the speed warrants turn lanes. This warrant shall be based on the Colorado Department of Transportation (CDOT) State Highway Access Code.

iv. Accident Warrant. The TIS shall discuss the evaluation of the available traffic data for the previous two (2) years and provide recommendations for turn lanes on major intersections and accesses. This warrant shall be based on the Colorado Department of Transportation (CDOT) State Highway Access Code.

v. Design Elements. The design elements for a left turn lane are the approach taper, bay taper, lengths of lanes, and departure taper and are as shown in the National Cooperative Highway Research Program Report 279 (NCHRP 279). Required left turn lane widths shall be as specified in the Travel Lane Width section of **General Parameters**, **Table 1.04.1**.

g. Exclusive Right Turn Lanes. Exclusive right turn lanes shall be provided at locations where they are specified as needed by an access plan, or where required by the applicable TIS, approved by the Town Engineer.

i. Need for Right Turn Lanes. The need for a separate right turn lane leading to the turning roadway for the accommodation of right turn traffic depends on the number of vehicles desiring to turn right as well as the approach speeds and the number of vehicles desiring to continue in the through direction. Unless specifically waived by the Town Engineer, all roadways classified higher than

local, intersecting with an Arterial or Major Collector roadway, shall be designed with a right turn lane.

ii. Warrants for Right Turn Lanes. A separate right turn lane shall be required if the guidelines and warrants listed in the National Cooperative Highway Research Program Report 279 (NCHRP 279) indicates that a right turn lane shall be provided at intersections or accesses.

iii. Design Elements. The design elements for a right turn lane are the approach taper, bay taper, lengths of lanes, and departure taper and are as shown in the National Cooperative Highway Research Program Report 279 (NCHRP 279). Required right turn lane widths shall be as specified in the Travel Lane Width section of **General Parameters**, **Table 1.04.1**.

iv. Free-flow Right Turn Lanes. Right turns without stop or yield control are sometimes provided at channelized intersections. Such free-flow right turns should be used only where an adequate merge is provided.

h. Acceleration/Deceleration Lanes. Speed-change lanes are warranted on high-speed and on high-volume roadways where a change in speed is necessary for vehicles entering or leaving the through-traffic lanes. A speed-change lane should be of sufficient width and length to enable a driver to maneuver a vehicle into it properly, and once in it, to make the necessary change between the speed of operation on the roadway or street and lower speed on the turning roadway. At each high-volume driveway and major intersection, speed-change lanes shall be investigated. The specific requirements and design criteria shall meet the design requirements of the State of Colorado, State Highway Access Code, dated August 31, 1998, or the latest revision, and/or **Section 1.25**, **Acceleration, Deceleration, and Turning Lanes** of these specifications, and shall be in accordance with the National Cooperative Highway Research Program Report 279 (NCHRP 279) and this section. Acceleration lanes are not always desirable at stop-controlled intersections.

i. Pedestrian Refuge. Where larger curb radii are used, an intermediate refuge or median island is desirable or crosswalks may need to be offset so that crosswalk distances are not objectionable. Pedestrian Refuge shall be investigated and designed as detailed in **Sidewalks and Curb Types**, **Section 1.12**.

6. Adjacent to all roadways, adequate space should be provided on the borders for sidewalks, traffic control devices, utility lines, parking, drainage channels, structures, proper slopes, clear recovery zones, and landscaping. Additional right-of-way may be required at intersections to provide space for additional left or right turn lanes without reducing the widths of standard required facilities. Additional right-of-way may be required at intersections to be designed as Roundabouts or at standard intersections to accommodate the potential for expansion or installation of a Roundabout in the future. All intersection rights-of-way, utility easements, and sight distance easements shall be dedicated to the Town of Windsor, as specified by the Town Engineer, to provide adequate right-of-way to include roadways, curb and gutter, sidewalks, access ramps, and utilities.

7. The need for the design and use of medians, islands and channelizing islands in intersections shall be as determined from an approved access plan, or where required by the applicable TIS, or as required by the Town Engineer. The design of medians and islands shall be as referenced in **Medians, Islands, & Channelization**, **Section 1.11**.

8. Intersection obstruction-free area shall mean that area which the Town shall require to be maintained in order to preserve the sight, distance, and safety of motorists, pedestrians, and bicyclists, by requiring an unobstructed intersection sight distance (ISD) area. ISD is the unobstructed line of sight necessary for most drivers at an intersection to see an approaching vehicle to avoid a collision. When the lines of sight for both left and right directions are combined, a sight triangle is formed. There should be no visual obstructions.

The ISD depends on the street operating speed and desired maneuver of exiting vehicles. These areas shall be free from shrubs, ground covers, berms, fences, signs, structures, parked vehicles, or other materials. Trees, within the sight distance triangle (whether within the public right-of-way or on private property) must not impair sight distance.

a. Sight Distance Triangles and Easements. All sight distances must be within the public right-of-way or a sight distance easement. If the line of sight crosses onto private property, a "Sight Distance Easement" shall be dedicated to provide the required sight distance. The easement or right-of-way shall be dedicated to the Town of Windsor; however, maintenance shall be noted on the final plat as the responsibility of a private entity such as the property owner or the home owners association. All sight distance easements must be shown on the street plan and profile plans and the final plat.

b. Sight Obstructions. Any object within the sight distance easement more than thirty (30") inches above the flowline elevation of the adjacent street shall constitute a sight obstruction, and shall be removed or lowered. Such objects include but are not limited to berms, buildings, walls, fences, parked vehicles on private property, cut slopes, hedges, trees, bushes, utility cabinets or tall crops. Maibox clusters must be installed a minimum of two (2') feet from back of walk and not cause any sight obstruction. Mailboxes must not pose a fixed object hazard for vehicles and pedestrians. Since parked vehicles are under the control of the Town, parked vehicles shall not be considered an obstruction for design purposes. The sight distance shall be measured to the centerline of the closest through-lane in both directions along the centerline of the road. In no case shall any permanent object encroach into the line-of-sight of any part of the sight-distance triangle. Trees are exempted from this requirement if pruned up to eight (8') feet.

The distances given in **Table 1.08.1**, **Length of Intersection Sight Distance (ISD) Triangle Legs** are typical sight distance triangle legs to be used under normal conditions and may be modified by the Town in order to protect the public safety and welfare, in the event that exceptional sight conditions necessitate such a modification.

**Table 1.08.1**
**Length of Intersection Sight Distance (ISD) Triangle Legs**

| Design Speed | Length of ISD Leg (ft) | |
|---|---|---|
| | Minor Rd | Major Rd |
| 35 mph | 15 ft | 390 ft |
| 40 mph | 15 ft | 445 ft |
| 45 mph | 15 ft | 500 ft |
| 50 mph | 15 ft | 555 ft |
| 55 mph | 15 ft | 610 ft |
| 60 mph | 15 ft | 665 ft |
| 65 mph | 15 ft | 720 ft |

Notes: Sight distance shown is for stopped passenger car, turning or crossing a two lane highway with no median, 3% grade or less. For other conditions (steeper grades, curved roadways, trucks, multiple lanes, skewed intersections, etc.), the time gap must be adjusted and the required site distance recalculated, per AASHTO. All distances shall be measured fifteen (15') feet perpendicular from flowline of streets to the front of the vehicle.

At intersections with traffic signal control, the first vehicle stopped on one approach should be visible to the driver of the first vehicle spotted on each of the other approaches. Left turning vehicles should have sufficient sight distance to select gaps in oncoming traffic and complete left turns. Apart from these sight conditions, generally no other sight triangle dimensions are needed for signalized intersections.

At intersections with all-way stop control, the first stopped vehicle on one approach should be visible to the drives of the first stopped vehicles on each of the other approaches. There are no other sight distance criteria applicable to intersections with all-way stop control and, indeed, all-way stop control may be the best option at a limited number of intersections where sight distance for other control types cannot be attained.

## 1.09 ROUNDABOUTS

### A. GENERAL

Roundabouts are circular intersections with specific design and traffic control features. These features include yield control of all entering traffic, channelized approaches, and appropriate geometric curvature to ensure that travel speeds on the circulatory roadway are typically less than thirty (30 mph) miles per hour. Roundabouts are a safe and efficient form of traffic control, which can be used at many of the same locations as traffic signals or stop controls. Because of their safety and operational advantages, it is the policy of the Town of Windsor to encourage the use of roundabouts as a substitute where they are shown to operate as well or better than other types of intersection control but are allowed only where approved by the Town Engineer. Roundabouts can be allowed on local streets, minor and major collectors, minor and major arterials, but are limited to no more than two approach lanes.

Roundabout design involves trade-offs among safety, operations, and accommodating large vehicles. The process of designing roundabouts requires a considerable amount of iteration among geometric layout, operational analysis, and safety evaluation. The most critical design objective is achieving appropriate vehicular speeds through the roundabout. For each roundabout, there exists an optimum design speed to minimize crashes. The design speed is determined from the smallest radius, which usually occurs on the circulatory roadway around the central island; however, the entry path radius should not be significantly larger than this radius. Where pedestrians are present, tighter exit curvature may be necessary to ensure sufficiently low speeds at the downstream pedestrian crossing. Recommended maximum entry design speeds for various categories of roundabouts are given in **Table 1.09.1**, **Suggested Roundabout Geometry Criteria**.

Another important factor determining a roundabout's layout is the need to accommodate the largest motorized vehicle likely to use the intersection. The turning path requirements of the *design vehicle* will dictate many of the roundabout's dimensions. The choice of design vehicle will vary depending upon the approaching roadway types and the surrounding land use characteristics. Suggested design vehicles for various categories of roundabouts are given in **Table 1.09.1**, **Suggested Roundabout Geometry Criteria**.

In general, the roundabout is optimally located when the centerlines of all approach legs pass through the center of the inscribed circle. This radial alignment also makes the central island more conspicuous to approaching drivers. When the inscribed circle is relatively small or if radial alignment is not possible, a slight offset to the left is acceptable. An offset to the right is almost never acceptable.

Like the motorized design vehicle, the design criteria of nonmotorized potential roundabout users (bicyclists, pedestrians, skaters, wheelchair users, strollers, etc.) must be considered when developing many of the geometric elements of a roundabout design.

Site related factors that might affect a roundabout selection include:

1. Right-of-way limitations, drainage problems, utility conflicts, etc.

2. Proximity of high volumes of oversized trucks.

3. Proximity of railroad tracks, draw bridges, or other conflicts which might impact traffic circulation and queuing of vehicles in the roundabout.

4. Proximity of bottlenecks that would routinely back up traffic into the roundabout, such as over capacity signals, freeway entrance ramps, etc. Roundabouts depend on unimpeded flow on the circulatory roadway.

5. Problems of grade or topography that limit visibility; a primary safety concern is that drivers are aware in adequate time of the need to decelerate and negotiate the turns of a roundabout.

6. Heavy pedestrian or bicycle traffic.

## B. DESIGN CRITERIA

1. Roundabouts shall be designed to provide for the safety of motorists, pedestrians, and bicyclists.

2. Roundabouts are divided into two types; 1) Mini Roundabouts and 2) Modern Roundabouts. Mini Roundabouts are typically utilized for traffic calming purposes in a neighborhood setting and are not encouraged for use in the Town of Windsor. Modern Roundabouts can range from Urban Compact, Urban One-lane, Rural One-lane, to Urban or Rural Two-lane.

3. Geometric Elements. The basic form and features of roundabouts are uniform regardless of their location; however, the design techniques and parameters are different, depending on the speed environment and desired capacity at individual sites. Care must be taken in the design to ensure that the interactions between the components of the geometric elements are all compatible with each other so that the overall safety and capacity objectives are met.

    a. Inscribed circle diameter is defined as the distance across the circle inscribed by the outer curb (or edge) of the circulatory roadway. It is the sum of the central island diameter (which includes the apron, if present) and twice the circulatory roadway.

    b. Entry width is the largest determinant of a roundabout's capacity. Entry width is measured from the point where the yield line intersects the left edge of the traveled-way to the right edge of the traveled-way along a line perpendicular to the right curb line. Determining the entry width and circulatory roadway width involves a trade-off between capacity and safety. The design should provide the minimum width necessary for capacity and accommodation of the design vehicle in order to maintain the highest level of safety. Typical entry widths for single-lane entrances range from fourteen (14') feet to sixteen (16') feet.

    c. Circulatory roadway width. The required width of the circulatory roadway is determined from the width of the entries and the turning requirements of the design vehicle. The circulatory roadway must always be at least as wide as the widest entry width (up to one hundred twenty (120%) percent of the maximum entry width) and shall remain constant throughout the roundabout. For single-lane roundabouts, the circulatory roadway should just accommodate the design vehicle. In cases where the inscribed diameter is small or the design vehicle is large, the circulatory roadway width may be reduced and a truck apron, placed behind a mountable curb on the central island can be used to accommodate larger vehicles. At double-lane roundabouts, the circulatory roadway width is usually not governed by the design vehicle.

    d. Central Island. The central island of a roundabout is the raised, non-traversable area encompassed by the circulatory roadway; this area may also include a traversable apron. Central islands shall always be raised, not depressed and should be circular in shape. A mountable apron added to the outer edge of the central island provides additional paved area to allow the over-tracking of large semi-trailer vehicles. Where aprons are used, they should be designed so that they are traversable by trucks, but discourage passenger vehicles from using them They should be from three (3') feet to thirteen (13') feet wide and have a cross slope of three to four (3-4%) percent away from the central island with the outer edge of the apron raised a minimum of one and a half (1½") inches above the circulatory roadway surface to discourage passenger

vehicle use. The apron should be constructed of colored and/or textured paving materials.

In general, roundabouts in rural environments typically need larger central islands than urban roundabouts in order to enhance their visibility and to enable the design of better approach geometry.

e. Entry curves. The entry curves are the set of curves along the right curb (or edge of pavement) of the entry roadway leading into the circulatory roadway. The entry radius, in conjunction with the entry width, the circulatory roadway width, and the central island geometry, controls the amount of deflection imposed on a vehicle's entry path and it has significant impacts on both capacity and safety. Typical entry radii vary between thirty three (33') feet for local streets with small design vehicles, to a characteristic range of thirty three (33') feet to ninety eight (98') feet for urban single-lane roundabouts. At double-lane roundabouts, the design of the entry curvature is more complicated.

f. Exit curves usually have larger radii than entry curves to minimize the likelihood of congestion at the exits; however, this is balanced by the need to maintain low speeds at the pedestrian crossing on exit. At single-lane roundabouts in urban environments, exit radii should be about fifty (50') feet; however, at locations with pedestrian activity and no large semi-trailer traffic, exit radii may be as low as thirty three (33') feet to thirty nine (39') feet which produces a very slow design speed to maximize safety and comfort for pedestrians. In rural locations where there are few pedestrians, exit curvature may be designed with large radii, allowing vehicles to exit quickly and accelerate back to traveling speed; however, it is recommended that pedestrian activity be considered at all exits except where separate pedestrian facilities (paths, etc.) or other restrictions eliminate the likelihood of pedestrian activity in the foreseeable future. As with the entries, the design of the exit curvature at double-lane roundabouts is more complicated than at single-lane roundabouts.

g. Pedestrian Crossing locations must balance pedestrian convenience, pedestrian safety, and roundabout operations.

   i. Pedestrian convenience: Pedestrians want crossing locations as close to the intersection as possible to minimize out-of-direction travel.

   ii. Pedestrian safety: Both crossing location and crossing distance are important. Crossing distance should be minimized to reduce exposure of pedestrian-vehicle conflicts. Pedestrian safety may also be compromised at a yield-line crosswalk because driver attention is directed to the left. Crosswalks should be located to take advantage of the splitter island for refuge.

   iii. Roundabout operations: Roundabout operations (primarily vehicular) can also be affected by crosswalk locations, particularly on the exit.

h. Pedestrian Crossing Design. Pedestrian crossings should be designed as follows:

   i. At single-lane roundabouts, the pedestrian crossing should be located one vehicle-length (25 feet) away from the yield line. At double-lane roundabouts, the pedestrian crossing should be located one, two, or three car lengths (25, 50, or 75 feet) away from the yield line.

   ii. The pedestrian refuge should be a minimum width of six (6') feet to adequately provide shelter and should be designed at street level, rather than elevated to the height of the splitter island.

   iii. Ramps should be provided on each end of the crosswalk to connect the crosswalk to other crosswalks around the roundabout and to the sidewalk network.

iv. Detectable warning surfaces should be applied to the surface of the refuge within the splitter island and shall meet the requirements of ADAAG. The detectable warning surface shall begin at the curb line and extend into the pedestrian refuge area a distance of two (2') feet, on each side of the refuge area.

i. Splitter Islands (also called separator islands or median islands) should be provided on all roundabouts, except those with very small diameters. Their purpose is to provide shelter for pedestrians (including wheelchairs, bicycles, and baby strollers), assist in controlling speeds, guide traffic into the roundabout, physically separate entering and exiting traffic streams, and deter wrong-way movements. The total length of the island should generally be at least fifty (50') feet to provide refuge for pedestrians and to alert approaching drivers to the roundabout geometry.

j. Stopping sight distance is the distance along a roadway required for a driver to perceive and react to an object in the roadway and to brake to a complete stop before reaching that object. Stopping sight distance should be provided at every point within a roundabout and on each entering and exiting approach. At roundabouts, three (3) critical types of locations should be checked at a minimum:

i. Approach sight distance; to the yield line and to the crosswalk;

ii. Sight distance on circulatory roadway; and

iii. Sight distance to crosswalk on exit.

**Table 1.09.1**
**Suggested Roundabout Geometry Criteria**

| Design Element | Roundabout Category | | | | | |
|---|---|---|---|---|---|---|
| | **Mini** | **Urban Compact** | **Urban one-lane** | **Urban two-lane** | **Rural one-lane** | **Rural two-lane** |
| Max. entry design speed | 15 mph | 15 mph | 20 mph | 25 mph | 25 mph | 30 mph |
| Max. No. of entry lanes | 1 | 1 | 1 | 2 | 1 | 2 |
| Design Vehicle | SU-30 | B-40 | WB-67 | WB-67 | WB-50 | WB-67 |
| Inscribed circle diameter | 45-80' | 80-100' | 100-130' | 150-180' | 115-130' | 180-200' |
| Circulatory roadway width | 15-20' | 18-24' | 18-26' | 32-38' | 20-30' | 32-40' |
| Central Island diameter | 15-40' | 44-52' | 64-78' | 86-104' | 75-70' | 116-120' |
| Splitter island treatment (with cross-walk at grade) | Raised | Raised | Raised | Raised | Raised & extended | Raised & extended |
| Min. stopping sight distance | 80' | 80' | 115' | 155' | 155' | 200' |
| Daily service volumes (vpd) | 10,000 | 15,000 | 20,000 | >20,000 | 20,000 | >20,000 |

k. Intersection sight distance is the distance required for a driver without the right-of-way to perceive and react to the presence of conflicting vehicles. Intersection sight distance is achieved through the establishment of adequate sight lines that allow a driver to see and safely react to potentially conflicting vehicles. At roundabouts, the only locations requiring evaluation of intersection sight distance are the entries. Intersection sight distance is usually measured through the determination of a sight triangle, the “legs” of which should be measured not as straight lines but as distances along the vehicular path. For roundabouts, the sight distance triangle has two conflicting approaches that must be checked independently:

i. Approach leg of sight triangle – The length of the approach leg of the sight triangle should be limited to forty nine (49') feet. This value is intended to require vehicles to slow down prior to entering the roundabout, which allows the driver to focus on the pedestrian crossing prior to entry. If this approach leg is greater than forty nine (49') feet, it may be advisable to add landscaping to restrict sight distance;

ii. Conflicting leg of sight triangle – A vehicle approaching an entry to a roundabout faces conflicting vehicles within the circulatory roadway. Two conflicting traffic streams should be checked at each entry; 1) *Entering stream*, comprised of vehicles from the immediate upstream entry, and 2) *Circulating stream*, comprised of vehicles that entered the roundabout prior to the immediate upstream entry. These distances can vary from one hundred (100') feet to three hundred (300') feet, depending on the various design speeds.

In general, it is recommended to provide no more than the minimum required intersection sight distance on each approach. Excessive intersection sight distance can lead to higher vehicle speeds that reduce the safety of the intersection for all road users (vehicles, bicycles, pedestrians). Landscaping can be effective in restricting sight distance to the minimum requirements.

l. Vertical considerations – Elements of vertical alignment design for roundabouts include profiles, superelevation, approach grades, and drainage.

i. Profiles – The vertical design of a roundabout begins with the development of approach roadway and central island profiles. The development of each profile is an iterative process that involves tying the elevations of the approach roadway profiles into a smooth profile around the central island.

ii. Superelevation – For most roundabout design, a negative two (2%) percent superelevation (a cross slope of two percent away from the central island) should be used for the circulatory roadway. Where truck aprons are used, the slope of the apron should be three to four (3-4%) percent; greater slopes may increase the likelihood of loss-of-load incidents.

iii. Approach grades – Avoid locating roundabouts in areas where grades through the intersection are greater than four (4%) percent.

iv. Drainage – With the circulatory roadway sloping away from the central island, inlets will generally be placed on the outer curb line of the roundabout. Low points and inlets shall not be placed in crosswalk locations.

m. Bicycle considerations – The design of a roundabout should attempt, where practical, to provide bicyclists the choice of proceeding through the roundabout as either a vehicle or a pedestrian. In general, bicyclists are better served by treating them as vehicles; however, the best design provides both options to allow cyclists of varying degrees of skill to choose their more comfortable method of navigating the roundabout.

i. To accommodate bicyclists traveling as vehicles, bike lanes should be terminated one hundred (100') feet in advance of the roundabout to encourage cyclists to mix with vehicle traffic. This method is most successful at smaller roundabouts (speeds below twenty (20 mph) miles per hour) where bicycle speeds can more closely match vehicle speeds.

ii. To accommodate bicyclists who prefer not to use the circulatory roadway, a widened sidewalk or a shared bicycle/pedestrian path may be provided physically separated from the circulatory roadway (not as a bike lane within the circulatory roadway). Ramps or other suitable connections can then be provided between this sidewalk or path and the bike lanes, shoulders, or road surface on the approaching and departing roadways.

n. Sidewalk considerations – Where possible, sidewalks should be set back from the edge of the circulatory roadway in order to discourage pedestrians from crossing to the central island. A recommended set back distance of five (5') feet should be used with a

minimum of two (2') feet for safety purposes. The sidewalk should be designed so that pedestrians will be able to clearly find the intended path to the crosswalks.

4. Double-Lane Roundabouts. While the fundamental principles outlined above apply to double-lane roundabouts as well as single lane roundabouts, designing the geometry of double-lane roundabouts is even more complicated. Because multiple traffic streams may enter, circulate through, and exit the roundabout side-by-side, consideration must be given to how these adjacent traffic streams interact with each other. Design parameters that are best for singe-lane roundabouts may not necessarily be the most advantageous design consideration for double-lane design. The designer must include consideration to other variables, and their interactions, such as natural vehicle travel path, vehicle path overlap, design speed, entry and exit curves, and pedestrian safety, among others. For double-lane roundabouts the designer needs to balance these various conflicting and controlling parameters which can be done a variety of different ways that will vary significantly depending on site-specific conditions, and it is thus inappropriate to specify a single method for their design. Regardless of the specific design method employed, the designer should maintain the overall design principles of speed control and speed consistency.

5. Rural Roundabouts. Roundabouts located on rural roads often have special design considerations because approach speeds are higher than urban or local streets and drivers generally do not expect to encounter speed interruptions. The primary safety concern in rural locations is to make drivers aware of the roundabout with ample distance to comfortably decelerate to the appropriate speed.

    a. Visibility. Perhaps the most important element affecting safety at rural intersections is the visibility of the intersection itself. Roundabouts are no different from stop-controlled or signalized intersections in this respect except for the presence of curbing along roadways that are typically not curbed. The geometric alignment of approach roadways should be constructed to maximize the visibility of the central island and the general shape of the roundabout and/or additional treatments (signing, pavement markings, advanced warning beacons, etc.) similar to those that would be applied to rural stop-controlled or signalized intersections should be considered.

    b. Curbing. Rural highways typically have no outside curbs; however, for safety purposes, reducing shoulder widths and introducing curbs for roundabout installations on open rural highways shall be required. Curbs help to improve delineation, prevent "corner cutting", and help to confine vehicles to the intended design path. When setting curb locations, careful consideration should be given to all likely design vehicles, including farm equipment.

    c. Splitter islands. Another effective cross-section treatment to reduce approach speeds is to use longer splitter islands on the approaches. A minimum length of two hundred (200') feet is recommended.

6. Signing and Marking. All signage and marking shall conform to the *Manual on Uniform Traffic Control Devices* (MUTCD) as modified by the latest recommended roundabout guidelines and by these Standards. Additional specification on required signing and marking is given in **Section 1.23**, **Traffic Control Devices**.

7. Design considerations. Designing a roundabout is a process of determining the optimal balance between safety provisions, operations performance, and accommodation of over-sized vehicles. Achieving appropriate vehicular speeds through the roundabout, accommodating non-vehicular needs, providing for present and future capacity needs, and arriving at a proper geometric design is a long, iterative and complicated process. The designer often needs to revise and refine each layout attempt to enhance its capacity and safety. Roundabout design shall be completed with the aid of appropriate computer design software.

## 1.10 NON-CONNECTIVE ROADWAYS

### A. GENERAL

Through streets disperse traffic and provide for vehicle and pedestrian mobility in contrast to non-connective roadways that transfer vehicles onto collectors and arterials and discourage pedestrian transit unless they include a pedestrian outlet at the closed-end. Non-connective roadways consist of cul-de-sacs, hammerheads, eyebrows, knuckles, alleys and dead-ends.

Hammerheads and eyebrows are similar to cul-de-sacs; short, local streets having one end open to traffic and being permanently terminated by a turn-around (with some geometric variation to the cul-de-sac bulb) that allow for vehicle turnarounds, usually requiring at least one backing movement. Knuckles are expanded areas of roadway that allocate greater turning radii at sharp turns to make allowance for larger design vehicles. Alleys provide access to the side or rear of individual parcels and are characterized by a narrow right-of-way and pavement width. A dead-end is a short, local street that is planned to be extended with future development.

1. Permanent no-outlet streets shall be in the form of a cul-de-sac; allowed solely on local streets.

2. Most cul-de-sac design commonly uses a circular pavement symmetrical about the centerline of the street, sometimes with a central island. Although this type of cul-de-sac operates satisfactorily, better operation is obtained if the design is offset so that the entrance-half of the pavement is in line with the approach-half of the street. One steering reversal is avoided in this design.

3. Cul-de-sacs are a tool, that when used sparingly, can help developers build balanced and attractive developments, however, like any other tool, cul-de-sacs have benefits and disadvantages and need to be used only in the right circumstances.

4. Cul-de-sacs shall not be used to avoid connection with an existing street, to avoid the extension of a thoroughfare or Collector street, or to avoid connection to adjoining property. In general, cul-de-sacs shall not be used to provide access to development on the boundary of the development.

5. No-outlet streets without a cul-de-sac (temporary dead-ends) shall not be allowed unless planned and designed to connect with a future street.

    a. If the temporary no-outlet street is longer than one hundred fifty (150') feet, or serves as primary access to any lot, a temporary turn-around or a temporary paved connection to another street shall be provided.

    b. At least a ninety (90') foot temporary turn-around easement shall be provided when needed on temporary dead-end streets; the temporary turn-around pavement shall be an eighty (80') foot diameter, paved roadway. Any lots encumbered with a temporary turnaround easement and roadway, shall not be built on until the road is extended.

    c. Where a street is indicated to end into an adjacent unplatted area, the developer shall provide written approval from the adjacent landowner to discharge storm drainage from the street onto the adjacent land, and verification that the storm drainage will be properly detained.

    d. All stub streets (dead-ends) shall be constructed as a part of the development project. End of road markers, per Town of Windsor Standard Details, shall be installed on all stub streets that do not end on a cul-de-sac.

    e. Temporary dead-ends shall not exceed six hundred (600') feet in length.

### B. DESIGN CRITERIA

1. Cul-de-sac streets shall have a maximum length of six hundred (600') feet (measured along the centerline, from the centerline of the intersecting street to the center point of the bulb), or a maximum of twenty-five (25) lots on a Local Residential street. The right-of-way for a cul-de-sac shall conform to the right-of-way requirements for the specific street classification leading to the cul-de-sac. Where one cul-de-sac extends from another cul-de-sac, the end of each cul-de-sac shall be no more than six hundred (600') feet from a general circulation street as measured by the centerline of the streets.

2. Typical radii for a cul-de-sac with an entrance right-of-way width of fifty (50') feet shall be as follows:

    a. Right-of-way bulb radius shall be a minimum of fifty two (52') feet;

    b. Flow line radius of the cul-de-sac bulb shall be forty five (45') feet;

    c. Flow line radius where the entrance stem turns into the cul-de-sac bulb shall be thirty six (36') feet.

3. Surface drainage on a cul-de-sac shall be toward the intersecting street, or if that is not possible, a drainage outlet and right-of-way shall be provided from the cul-de-sac. The cul-de-sac turnaround shall have a maximum grade of three (3%) percent. The minimum grade around the curbing shall not be less than seven tenths (0.7%) percent.

4. Eyebrows shall be used only on Local streets and are allowed only upon approval by the Town Engineer. Eyebrows shall be a minimum of twenty eight (28') feet in width and a maximum of one hundred (100') feet in length measured along the flowline. Curb and gutter and sidewalks are required for all eyebrows.

5. Knuckles shall be used only on Local streets and are allowed only upon approval by the Town Engineer. Knuckles shall have a maximum extension beyond the original curb flowline of ten (10') feet and a maximum length of one hundred fifty (150') feet measured along the flowline of the curb and gutter, unless specifically waived by the Engineer. Curb and gutter and sidewalks are required for all knuckle designs.

6. Bulb-outs, or ox-bows, shall be used only on Local streets and are allowed only upon approval by the Town Engineer. Bulb-outs, or ox-bows, shall have a maximum extension beyond the original curb flowline based on a ratio of the length of ox-bow to depth of four to one (4:1) and a maximum length of one hundred fifty (150') feet measured along the flowline of the original curb and gutter, unless specifically waived by the Engineer. Curb and gutter and sidewalks are required for all bulb-outs/ox-bow designs.

7. Alleys should be aligned parallel to, or concentric with, the street property lines and situated in such a manner that both ends of the alley are connected either to streets or to other alleys.

8. New permanent dead-end streets are prohibited. Temporary dead-end streets are permitted only on streets that have no direct access from adjoining property and shall be planned to extend into neighboring property during a later development phase or project. They shall allow for the proper extension of the storm drains, sanitary sewer system, water lines, non-potable water lines and other utilities, where applicable. The road must be fully constructed to the property line, with a temporary paved turnaround. No curb and gutter is required on temporary turnarounds.

## 1.11 MEDIANS, ISLANDS, & CHANNELIZATION

### A. GENERAL

1. An island is a defined area between traffic lanes used for control of vehicle movements. A median island is the portion of a roadway separating opposing directions of the traveled way. Traffic entering an intersection is directed into definite paths by channelizing islands.

2. Islands serve three primary functions: 1) channelization – to control and direct traffic movement, usually turning; 2) division – to divide opposing or same direction traffic streams, usually through movements; and 3) refuge – to provide refuge for pedestrians crossing the street. Most islands combine two or all of these functions.

   The principal functions of a median are to separate opposing traffic, provide a stopping area in case of emergencies, allow space for speed changes and storage of left turning and U-turning vehicles, and provide width for future lanes. Additional benefits a median may offer are 1) an open green space; 2) a refuge area for pedestrians; 3) an excellent location for traffic control devices; and 4) control the location of intersection traffic conflicts.

3. An island may be designated by pavement markings, channelizing devices, raised curbs, pavement edges, or other devices. Raised curb medians, in contrast to flush medians, have an advantage of providing positive delineation during snowfall periods. The ends of islands first approached by traffic should be preceded by a gradually diverging marking on the roadway surface, to guide vehicles into desired paths of travel along the island edge.

4. Islands generally are either elongated or triangular in shape and are normally situated in areas unused for vehicle paths. Islands should be located and designed to offer little obstruction to vehicles, be relatively inexpensive to maintain, and occupy a minimum of roadway space; however, they should be commanding enough that motorists will not drive over them. Islands on undivided roadways at intersections should be aligned with the correct lanes on the opposite side of the intersection.

5. At unsignalized intersections on rural highways, any median should generally be as wide as practical while medians on Urban Arterial streets should not be wider than necessary. Where raised curbed islands are used, because they can be difficult to see at night, the intersection should have fixed-source lighting or appropriate delineations such as post mounted or curb-top reflectors or object markers. Under certain conditions, such as intersections with high speed approaches, little pedestrian traffic, and areas requiring significant snow plowing, etc., painted, flush medians and islands or traversable type medians may be preferable to the raised curb type island. At some intersections, both curbed and painted islands may be desirable.

6. Raised curb medians are required on low-speed urban arterial streets where it is desirable to regulate turn movements and provide an added increment of safety and improved operation between intersections. For Urban roadways, such medians should be located at the centerline of the intersected streets and should be of uniform width and common geometric design throughout the overall roadway alignment. For Rural roadways, elongated medians are typically used.

7. For Arterial streets and some Collector streets, the center lane between left turn bays may be used for a continuous center two-way left-turn lane (TWLTL) design, flush with the adjacent travel way. Continuous two-way left-turn lanes (TWLTL) should be identified by lane and arrow markings placed in accordance with the MUTCD.

8. Channelizing islands that control and direct traffic movements into the proper paths shall be designed and placed so that the proper course of travel is immediately obvious, easy to follow, and of unquestionable continuity. The corner triangular shaped island, commonly used to separate right turning traffic from through traffic, shall have their curved portions designed with radii equal to or greater than the minimum for the turning speed. Properly placed islands are advantageous where through and turning movements are heavy, however, at minor intersections on two-lane roadways, in rural areas, and at isolated locations, channelization and curbed islands generally should not be used.

9. Provision of a median or channelizing island as a deterrent to wrong-way movement can be a very effective design treatment in the design of large and complicated intersections.

## B. DESIGN CRITERIA

1. The design of medians shall include the evaluation for needed turn lanes and accesses. This need will be determined by a Traffic Impact Study (TIS), current AASHTO requirements and as required by the Town Engineer.

2. Prior to design of any medians on public streets, the Town shall be consulted for specific requirements; such as median dimensions and geometry, landscaping, median cover design, decorative concrete, etc. Generally, medians should be designed to meet the requirements of the AASHTO "Policy on Geometric Design of Highways and Streets" (latest revision).

3. Refuge islands for pedestrians and bicyclists crossing a wide street, and the wheelchair ramps accessing them, should match the existing sidewalk or trail width, be a minimum of six (6') feet in width and depth, and should have a clear path through the island not obstructed by poles, sign posts, utility boxes, etc.

4. The raised curb corner triangular shaped island is required for all Urban Major Arterial intersections to channelize traffic and where required by these Standards or the Town Engineer or as required to provide pedestrian refuge. It shall be designed as a raised island either for a right turn lane continuing to an exclusive lane condition or, for a right turn lane stop condition.

   Channelized median islands are used to facilitate traffic control, for speed-change lanes, and for high-volume movement. All islands and medians shall be designed in accordance with the specific requirements and design criteria of the National Cooperative Highway Research Program Report 279 (NCHRP 279) and these Standards.

5. Median islands are required at all Arterial/Arterial intersections. If raised curb median islands are not specifically required by these Standards, the median islands may be raised or flush design. The length of the island shall include the appropriate approach taper, bay taper and length of lane required by these Standards and as specified in **Section 1.08.B.5**. Alternative designs supported by another approved resource standard are subject to review and approval. The design shall be in accordance with the Standard Detail Drawings of the Town of Windsor and as follows:

   a. <u>No Obstruction</u>. Medians shall not obstruct the minimum left turn radius for the design vehicle(s).

   b. <u>Drainage</u>. Inflow curb and gutter with storm drainage inlets and piping system shall be provided to carry runoff unless drainage requirements are specifically waived and outfall curb and gutter allowed.

   c. <u>Refuge Islands</u>. Pedestrian refuge islands are required on all Urban Arterial road crossings.

6. The nose of the median on arterial streets should be a minimum of twenty (20') feet behind the flowline of the intersected street and shall not encroach on pedestrian crosswalks. Turning templates should be used to determine the shape of the median. The minimum radius for nose curbs should be two (2') feet to flowline. The minimum width of a median is recommended to be not less than four (4') feet except where refuge islands are planned which will require a minimum width of six (6') feet to provide for storage of bicycles, strollers, pedestrians or other non-vehicular traffic.

   Curbed corner islands and median noses should be ramped down and provided with devices to give advance warning to approaching vehicles. In rural areas, island curbs should usually be a sloping type.

7. Median islands may be allowed on Minor Arterial, Collector, and Local streets, where approved by the Town Engineer. If medians are included, they shall be placed in the public right-of-way and the design shall be in accordance with the Standard Detail Drawings of the Town of Windsor and as follows:

    a. No Obstruction. Medians shall not obstruct the design vehicle(s) turning radius.

    b. Visibility. The medians shall be placed and the landscape maintained such that the required visibility in the intersection is not hindered.

    c. Median Maintenance. These medians must be maintained by parties other than the Town of Windsor. The maintenance responsibility must be defined on all plans, including the Final Plat and Development Agreement.

    d. Public Use. The Town of Windsor may use these islands for roadway signing and may chose to remove the medians and/or landscaping if it is deemed necessary by the Town.

    e. Additional Right-of-way. Additional right-of-way necessary to include these medians shall be dedicated to the Town of Windsor prior to installation.

    f. Compliance with Standards. The median design must comply with all applicable median criteria in these Standards and any streetscape standards of the Town of Windsor.

8. Openings in medians should be situated only where there is adequate sight distance. The minimum length of median openings should be that of the projected roadway width of the intersecting cross street or driveway. Desirably, the length of median openings should be great enough to provide a fifty (50') foot turning radius. On urban Arterial and Collector streets with raised curb medians, openings should be provided only at intersections with other streets and at reasonably spaced driveways serving major traffic generators such as industrial plants and shopping centers. Median openings should be designed to include left turn lanes.

9. The continuous center two-way left-turn lane (TWLTL), flush with the adjacent travel way, design shall include the evaluation for needed turn lanes and accesses. This need will be determined by a Traffic Impact Study (TIS), current AASHTO requirements or as required by the Town Engineer.

10. The central area of large islands may be irrigated and landscaped whenever permitted. Landscaped medians shall be provided with drainage facilities to handle sprinkler runoff and nuisance flows. Irrigated/landscaped median design shall include an underdrain system design with an approved outlet to minimize seepage under the roadway to prevent damage to the base and wearing courses. When low maintenance landscaping is used in conjunction with trickle irrigation, outfall curb and gutter should be used; otherwise, inflow curb and gutter with a properly designed storm drain system shall be installed. The minimum width of landscaped medians shall be twelve (12') feet. For small curbed islands and in areas where conditions are not favorable, a concrete paved surface shall be used on the island. Patterned and colored concrete may be as required by the Town Engineer.

## 1.12 SIDEWALKS AND CURB TYPES

### A. GENERAL

1. Just as vehicles need roads, pedestrians need walkways, and roadways and walkways should be designed in concert with one another. Sidewalks benefit both pedestrians and motorists by creating separation between pedestrian and vehicular travel paths. Uncontrolled access across a sidewalk not only degrades the quality of the pedestrian environment, but also increases the potential for vehicle-pedestrian conflicts.

2. Sidewalks shall be designed to provide for the safety of pedestrians. All intersections shall be designed and constructed with sidewalks and pedestrian curb ramp access on all corners in accordance with all ADA requirements.

3. Sidewalks should be continuous; walking routes need to be obvious and should not require pedestrians to travel out of their way unnecessarily.

4. Sidewalk surfaces should be smooth and continuous. The surface shall be stable, firm, and slip-resistant. All sidewalks must be accessible to and usable by persons with disabilities.

5. Steep sidewalk grades create problems for all pedestrians, especially under adverse weather conditions. Sidewalks shall be designed with a maximum grade of five (5%) percent (1V:20H). In residential areas where a sidewalk runs along a roadway with a grade that exceeds five percent, the sidewalk grade may exceed five percent but must be less than or equal to the street grade.

**TABLE 1.12.1**
**Sidewalk Grade Criteria**

| **Adjacent to Public Right-of-way:** | |
|---|---|
| Maximum Sidewalk Grade Adjacent to Roadway | 5% but may be increased to 7% if it follows the grade of the street |
| Maximum Cross Slope | 2% (1V:48H) |
| **Not Adjacent to Public Right-of-way:** | |
| Maximum Grade without Railings | 5% (1V:20H) |
| Maximum Ramp Grade with Handrails and Landings | 8.3% (1V:12H) |

6. The cross slope of a sidewalk is the slope that is measured perpendicular to the direction of travel. Cross slopes are needed for drainage, however, sidewalks must be constructed with a maximum cross slope of two (2%) percent (1V:48H). At corners, sidewalks should have slopes of two percent or less in both perpendicular travel directions.

7. Meandering sidewalks shall be subject to special review and approval by the Town.

8. The minimum sidewalk width shall be four (4') feet. Wider sidewalks may be required by the Town where warranted by anticipated pedestrian traffic such as at or near schools and/or parks or designated trail systems. All detached sidewalks less than eight (8') feet in width and not within driveways shall be a minimum of four (4") inch thick concrete. All detached sidewalks eight (8') feet and greater in width shall be a minimum of six (6") inches thick. All sidewalks within a driveway shall be a minimum of six (6") inches thick. All attached sidewalks shall be a minimum of six (6") inches thick. Sidewalks shall be a minimum of eight (8") inches thick where crossed by commercial traffic.

## B. DESIGN CRITERIA

1. Rural and Urban Intersections. Most intersections shall be designed using the standard six (6") inch vertical face curb and gutter with pedestrian curb ramp access on all corners in accordance with all ADA requirements. Sidewalks may be either attached or detached, as appropriate.

2. Urban Local Residential. The standard curb and gutter for Urban Local Residential streets is the drive-over curb, gutter & attached four (4') foot sidewalk. Seven (7') foot wide on-street parking lanes shall be provided on both sides of the roadway.

3. Urban Local Commercial/Industrial. The standard curb and gutter for Urban Local Commercial/Industrial streets is the six (6") inch vertical face curb and gutter. Eight (8') foot wide on-street parking lanes shall be provided on both sides of the roadway. Sidewalks shall be attached

and at least four (4') foot wide; wider sidewalks may be required at the discretion of the Town Engineer.

4. Urban Minor Collector. The standard curb and gutter for Urban Minor Collector streets is the drive-over curb, gutter & attached four (4') foot sidewalk. Eight (8') foot wide on-street parking lanes shall be provided on both sides of the roadway.

5. Urban Major Collector. The standard curb and gutter for Urban Major Collector streets is the six (6") inch vertical face curb and gutter. Six (6') foot wide on-street bike lanes shall be provided on both sides of the roadway. Sidewalks shall be five (5') foot wide and detached, and the detached area shall have a minimum width of at least eight and a half (8½') feet.

6. Urban Minor Arterial. The standard curb and gutter for Urban Minor Arterial streets is the six (6") inch vertical face curb and gutter. Six (6') foot wide on-street bike lanes shall be provided on both sides of the roadway. Sidewalks shall be detached and five (5') foot wide, and the detached area shall have a minimum width of at least nine and a half (9½') feet.

7. Urban Major Arterial. The standard curb and gutter for Urban Major Arterial streets is the six (6") inch vertical face curb and gutter. Six (6') foot wide on-street bike lanes shall be provided on both sides of the roadway. Sidewalks shall be detached and five (5') foot wide, and the detached area shall have a minimum width of at least ten (10') feet.

## 1.13 SHOULDERS AND CURB GRADE & RADIUS

### A. GENERAL

Rural streets normally are designed with adjacent paved shoulders. A shoulder is that portion of the roadway contiguous with the traveled way that accommodates stopped vehicles, emergency use, and lateral support of subbase, base, and surfaced courses. In some cases, the shoulder can accommodate bicyclists. The width of outside shoulders should be at least six (6') feet and usable during all seasons. A shoulder should be continuous and on structures, should have the same width as the normal roadway section, including useable shoulders, except for long bridges (over one hundred (100') feet in length), which may require other design considerations.

Urban streets normally are designed with curbs to allow greater use of available width and for control of drainage, protection of pedestrians, and delineation. The curb should be six (6") inches high, with variations depending on drainage considerations, traffic control, and safety. Curbs can be either vertical or drive over and usually include a gutter, forming a combination curb and gutter section. Gutter sections may be required across intersections to transport stormwater runoff. The curb and gutter sections are not considered part of the traveled way.

1. At most Rural and all Urban intersections, pedestrian crossings shall be designed and constructed with sidewalks and pedestrian curb ramp access in accordance with ADA requirements.

2. Drive approaches shall be constructed in accordance with the Standard Details. Any deviation from these details shall be considered on an individual basis.

3. The foreslope away from a shoulder should be as flat as possible, dependent upon soil stability, topography, drainage issues, and other design considerations.

4. Minimum grade on gutter shall be one half (0.5%) percent. Particular attention shall be given to maintain a one half (0.5%) percent minimum grade especially on a sag vertical curve. The minimum allowable grade for flowlines around the perimeter of a curb return shall be seven tenths (0.7%) percent.

### B. DESIGN CRITERIA

1. Rural roads shall be designed using paved travel ways with shoulders, foreslopes and drainage swales with culverts for a typical cross-section. Design shall be in accordance with the Standard

Detail Drawings of the Town of Windsor. Foreslopes shall be designed with a four to one (4:1) ground slope for a distance of four to twelve (4' - 12') feet adjacent to the shoulder.

2. Urban roads shall be designed using paved travel ways with curb and gutter, sidewalks and storm drainage facilities for a typical cross section. Design shall be in accordance with the Standard Detail Drawings of the Town of Windsor. Curb types and minimum curb return radii shall be as shown in the following table:

**TABLE 1.13.1**
**Curb Return Radii Criteria**

| STREET CLASS | STANDARD CURB TYPE | RETURN RADII | INTERSECTING STREET |
|---|---|---|---|
| Arterials | Vertical | 35 ft<br>30 ft | Arterials<br>Collectors |
| Collectors | Vertical | 25 ft<br>20 ft<br>20 ft | Collectors<br>Locals<br>Driveways |
| Local Ind/Comm<br>Local Residential | Vertical<br>Drive Over | 20 ft<br>15 ft | Locals, Driveways and Alleys |

NOTES:
1. The minimum curb return radius is 35' for designated truck routes.
2. For curb returns on a State Highway, CDOT's curb radii requirements supersede these standards.

## 1.14 DRAINAGE

Drainage is an important consideration because of possible heavy rainfalls which can result in high runoff and flood potential. Surface flow from adjacent tributary areas may be intercepted by the street system, where it is collected within the roadway by curbs, gutters, and ditches, and conveyed to an appropriate drainage system. Where drains are available under or near the roadway, the flow is transferred at frequent intervals from the street cross section by gratings or curb-opening inlets to basins and from there by connectors to drainage channels or underground drains.

Drainage system design shall be in accordance with current Storm Drainage Design Criteria adopted by the Town of Windsor.

## 1.15 CROSS PANS

### A. GENERAL

Cross pans shall be designed and constructed in accordance with the Structural Design Criteria and the Standard Details section of this manual.

### B. DESIGN CRITERIA

1. Cross pans shall be a minimum of eight (8') feet wide, with eight (8") inch thick concrete, having a maximum flow depth of one (1") inch. Where greater stormwater depth is necessary, wider pans shall be required. On asphalt paved roadways, the pavement thickness adjacent to the cross pans shall be thickened to match the concrete pan thickness.

2. Most cross pans shall be located at intersections; mid-block cross pans, where permitted, shall be a minimum of ten (10') feet wide with one and one-quarter (1-¼") inches maximum depth. Larger widths may be required by the Town.

3. Cross pans are not permitted on Arterial or Major Collector streets or at signalized intersections.

4. Minimum grade on cross pans at flowline of pan shall be seven tenths (0.7%) percent.

5. Cross pan approaches shall be designed using the appropriate design speeds.

6. Cross pan approaches on Local streets at intersections shall be in accordance with the Standard Details.

## 1.16 INLETS

### A. GENERAL

1. Inlets shall not be installed in the curb return and shall not be in line with accessibility ramps. In residential developments inlets should be located at property lines where possible.

2. Inlets shall be designed and constructed in accordance with Storm Drainage Design Criteria adopted by the Town of Windsor.

3. The location of inlets shall be designed with consideration given to sunlight exposure so that potential icing of the roadway is minimized.

## 1.17 ROADWAY CROSS SLOPE

### A. GENERAL

Cross slope on a roadway is provided to drain water from the street surface. Roadways within the Town of Windsor shall be designed with a crown or high point in the middle and a cross slope downward toward both edges.

### B. DESIGN CRITERIA

1. The design of the cross slope shall consider driver comfort and safety. See **Section 1.07**, **General Design Elements (Horizontal & Vertical Alignment)**.

2. A minimum cross slope on all streets shall be two (2%) percent as measured from the lip of gutter, or edge of oil, to the street centerline.

3. On streets with raised medians, minimum cross slope of two (2%) percent shall be measured from lip of median gutter to lip of gutter at street edge.

4. Cross slopes steeper than two (2%) percent require a conscious effort in steering and increase the susceptibility of skidding on icy or wet pavements. Therefore, maximum allowable cross slope shall be four (4%) percent on all new construction.

5. Cross slope for widening an existing street or for adding turn lanes shall be a straight-line grade from crown to lip of new gutter adjacent to new pavement and the resulting cross slope of the widened portion shall be within the above limits. However, if the cross slope of the existing street exceeds the limits, then new curb and gutter shall be designed so that the existing pavement, when overlaid, will result in a straight line cross slope that meets these Standards. Alternatively, the existing pavement may be removed and reprofiled to comply with these Standards.

6. Cross Slopes other than two (2%) percent shall be indicated on plans and approved by the Town Engineer.

## 1.18 PAVEMENT DESIGN

Pavement design shall be in accordance with **Section 2 "Soils Investigation and Pavement Design"** of this manual.

## 1.19 TRANSITIONS

The design of transition sections includes consideration of: 1) transitions in the roadway cross slope, termed superelevation transition, and 2) possible transition curves incorporated in the horizontal alignment, termed appropriately alignment transition.

The superelevation transition section consists of the superelevation runoff and tangent runout sections. For reasons of safety and comfort, the pavement rotation in the superelevation transition section should be effected over a length that is sufficient to make such rotation imperceptible to drivers.

In the alignment transition section, a spiral or compound transition curve may be used to introduce the main circular curve in a manner that is consistent with the driver's steered path. For most curves, the average driver can follow a suitable transition path within the limits of normal lane width, however, combinations of high speed and sharp curvature lead to longer transition paths. In such cases, incorporation of transition curves between the tangent and the sharp circular curve, as well as between circular curves of substantially different radii, may be appropriate. A properly designed transition curve provides a natural, easy-to-follow path for drivers; a spiral transition curve simulates the natural turning path of a vehicle.

Design for lane and pavement transition length shall be in accordance with the latest AASHTO requirements.

## 1.20 RECOMMENDED DESIGN STANDARDS FOR BUS STOPS

### A. GENERAL

Bus travel is an increasingly important mode of mass transportation. The interference between buses and other traffic can be considerably reduced by providing turnouts on arterial roadways. Bus turnouts serve to remove the bus from the traveled way. The location and design of turnouts should provide ready access in the safest and most efficient manner practical. Bus stops are usually located in the immediate vicinity of intersections and may be located on the near-side (approach) or far-side (departure) side of the intersection; mid-block locations may be appropriate where blocks are exceptionally long.

The following minimum design standards are offered as guidelines for the design and construction of bus stops. The Town of Windsor may vary any of the following requirements as deemed appropriate for the site and its particular situation. It is important that the applicant contact the Town early in the review process to determine the exact location and proposed capacity of a bus stop in the proposed development.

### B. DESIGN STANDARDS

1. Bus Lane Width. Bus lanes and bus stops should be asphalt or concrete and at least ten (10') feet wide.

2. Bus Stop Lengths. Near-side bus stops should be concrete and at least fifty (50') feet long for a single bus, plus a thirty (30') to seventy (70') foot distance to the radius of intersection. A sixty (60') to eighty (80') foot long transition distance or deceleration lane shall be kept clear approaching the stop.

   Far-side bus stops should be concrete and provide a fifty (50') feet loading area plus a thirty (30') to seventy (70') feet distance to the radius of intersection. A forty (40') to sixty (60') foot long transition distance or merging lane shall be provided beyond the stop.

   Mid-block bus stops shall be paved and include transition lanes and should only be designed for long blocks. Minimum total impacted area for a single bus stop would be one hundred fifty (150') feet with a fifty (50') foot bus stop and two fifty (50') feet transitions before and after the bus stop. Design speeds above forty (40 mph) mile per hour will require greater distances. All bus stop locations shall be approved by the Town Engineer.

3. Bus Shelters. Shelters should be used at major bus stops to protect users from the weather. Locations with high passenger demands and low bus service frequency should be given priority.

The shelter should have maximum transparency and be highly visible from the surrounding area to assure users' safety. Shelters should be of vandal proof construction and materials, durable, and easily maintained. The appearance of the shelter should be visually pleasing and in natural tones. Openings should be at least thirty six (36") inches wide. Capacity should be based on maximum passenger accumulation at the stop, with approximately five (5 $ft^2$) square feet per person allowed to develop size requirements. They shall not obstruct pedestrian flow or motorists' sight distance. All bus shelters shall be lighted and approved by the Town Engineer.

## 1.21 STREET LIGHTING STANDARDS

### A. PURPOSE

Good visibility under both day and night conditions is fundamental to enabling motorists, pedestrians, and bicyclists to travel on the Town's roadways in a safe and coordinated manner. Properly designed and maintained streetlight installations should provide comfortable and accurate visibility at night.

### B. RURAL AREAS

Lighting of rural roadways may be desirable, but the need for it is much less than on urban streets and is seldom justified or required except in certain critical areas, such as intersections, railroad grade crossings, sharp curves, long or narrow bridges, and areas where roadside interferences are present. Whether or not rural at-grade intersections should be lighted depends on the layout and the traffic volumes involved. Intersections that do not have channelization are usually left unlighted, whereas intersections with substantial channelization, particularly multi-road layouts, are often lighted. The greater the volume of traffic, particularly turning traffic, the more important the fixed-source lighting at rural intersections becomes.

### C. RESIDENTIAL AREAS

Stray light on adjacent properties from luminaires installed on roadways can be characterized as both light trespass and light pollution. Light trespass is the shining of light produced by a luminaire beyond the boundaries of the property on which it is located. Light pollution or "skyglow" is the actual brightness of the fixture that can be seen miles away and causes domes of light over cities. Even though lighting provides increased safety and security, it should be applied in a manner sensitive to these environmental issues in order to minimize negative consequences. All lighting in residential areas shall be designed and installed to minimize light shining on or negatively affecting the neighboring residents. Low light trespass luminaires should be utilized whenever possible.

### D. GUIDELINES

Uniform lighting will be used on new roadway projects involving Arterial and Collector streets. The guidelines shall be the Illuminating Engineering Society (IES) Lighting Handbook, latest edition, and the Design Manual of the Colorado Division of Highways, latest edition and supplemental revisions or guidelines approved by the Town. All fixtures, poles, and designs will be reviewed and approved by the power provider and the Town. Drawings for installation will be prepared by the Developer/Owner with help from the local power provider and approved by the Town prior to installation. In new subdivisions, a street lighting plan will be required for approval of the subdivision. A street light will be required at all urban intersections and for all non-connective roadways, including cul-de-sacs. The Developer will be responsible for all costs involving the design, material, and installation of street lights and is responsible for coordinating with the appropriate utility companies for all aspects of design and installation.

### E. LAYOUT CRITERIA

1. Mounting Height. Streetlight mounting height shall not exceed twenty (20') feet in residential areas. In areas other than residential, the mounting height shall not exceed forty (40') feet. Refer to **Table 1.21.2**, **Street Lighting Requirements** for additional details.

2. Signalized Intersections. Signalized intersections will be lighted using combined streetlights and mast arms. Mounting of signals will be perpendicular to the flowline.

3. Railroad Crossing Lighting. Railroad crossing lighting will conform to the Railroad-Highway Grade Crossing Handbook (FHWA).

4. Lighting in Underpasses. All bridge underpasses, where vehicles, pedestrians, bicyclists, or equestrians may be present, shall require lighting.

5. Attached Sidewalks. Install street lighting behind sidewalks where they are attached to the curb.

6. Detached Sidewalks. For sidewalks detached from the curb, install street lighting with a minimum of two (2') feet clearance from back of curb to roadway side of support pole and two (2') feet clear from all walks (one foot on Local Streets).

7. Drawings. Drawings for installations will be prepared by the Developer with assistance from the power provider and approved by the Town prior to installation. In new subdivisions, a street lighting plan specifying the number, kind and location of street lights must be submitted with the final plat.

8. Minimum Illuminance. The Town of Windsor Municipal Code states that the minimum requirement shall be nine thousand five hundred (9,500) lumen lamps at a maximum spacing of five hundred (500') feet and at each intersection. More specific, detailed design data is given in **Table 1.21.1**, **Recommended Street Illumination Levels**.

9. Permission for Alternate Designs. Alternate designs for fixtures, if approved by the Town, may be used if more than twenty (20) installations are involved. Ornamental lighting may be required in certain Business districts and in areas of historical significance; such as Main Street corridor.

10. Fire Hydrant Conflicts and Property Lines. When locating proposed lighting, avoid possible conflicts with fire hydrants. Light poles shall be a minimum of ten (10') feet from fire hydrants. Light poles should be placed at property lines in residential areas where possible.

11. Roundabout Lighting. Lighting columns should be arranged around the perimeter of the roundabout in a simple ring, with the lights equidistant from the center and from each other. Lighting should extend at least two hundred (200') feet back along each approach road. Mounting height should be uniform throughout the intersection and not less than on any approach road. Minimum horizontal illuminance at the curb lines should be as given in **Table 1.21.4**, **Minimum Illuminance for Roundabouts**. The minimum illuminance required should not be less than the highest level of lighting for any of the approach roads.

## F. LIGHTING SYSTEMS DESCRIPTIONS

These lighting standards apply to all new street lighting systems.

1. Specific light types [High Pressure Sodium (HPS), Mercury, etc.] shall be as approved by the Town of Windsor and shall be installed according to the "Standard Specifications for Road and Bridge Construction", Colorado Department of Transportation, latest edition. Refer to **Table 1.21.2**, **Street Lighting Requirements** for additional details.

2. The 250-W, refractor style cobra with a Type-3 semi-cutoff distribution pattern mounted on poles shall be the standard construction for Major Collector streets and all Arterial streets.

3. A 100-W, traditional-style fixture with a Type-3 distribution pattern mounted on poles shall be used on Minor Collector and Local streets.

4. Luminaires shall be complete pre-wired lighting devices specifically manufactured for the purpose of roadway lighting. Luminaires, which are equivalent to those described, may be substituted upon approval by the Town.

5. Poles shall be fiberglass, aluminum or steel and shall meet the requirements given in "Standard Specifications for Road and Bridge Construction", Colorado Department of Transportation, latest edition.

6. Typical spacing of all street lighting shall meet the requirements of **Table 1.21.2**, **Street Lighting Requirements**; however, spacing shall be calculated and determined by Average Maintained Illuminance Value and Illuminance Uniformity Ratio given in **Table 1.21.1**, **Recommended Street Illumination Levels**.

7. Where possible, street lights shall be staggered on alternate sides of the roadway; however, for "T" intersections, the light should be located on either corner of the intersection of the street that ends.

## G. POSITIONING AT INTERSECTIONS

In general, the nighttime visibility of a pedestrian or hazardous object within an intersection is enhanced by increased contrast between the object and the surrounding street area. The optimum contrast (and hence safety) is achieved when the streetlights are situated to silhouette (or backlight) objects in the intersection. Therefore, streetlights at intersections are required to be placed on the downstream side of the intersecting street, as viewed by a motorist approaching the intersection in the lane directly beneath the luminaires. The positioning of light standards at intersecting streets shall be as noted in **Table 1.21.3**, **Intersection Light Locations**.

## H. LIGHT POLE OFFSET DISTANCES

Luminaire supports (poles) should be placed outside the roadside clear zones on Rural streets, whenever practical. When poles are located within the clear zone they shall be designed to have a suitable impact attenuation feature; normally a "break-away" design is used. On Urban Local residential streets with attached sidewalks, the distance behind back of walk shall be at least one (1') foot, and must be within easements or right-of-way. For Urban Collectors and Arterials with detached sidewalks, the street light must be offset at least two (2') feet from the back of curb and provide a clearance space between the light pole and edge of walk that equals or exceeds the required sidewalk width. Poles with "break-away" supports should be utilized whenever appropriate but generally should not be used on streets in densely developed areas, particularly with sidewalks.

## I. STREET LIGHTING IN MEDIANS

Street trees (full shade) shall not be placed within forty (40') feet of a street light. Ornamental trees shall be no closer than fifteen (15') feet to any street light.

## J. UNDERGROUND SERVICE

Street lighting shall be installed with underground electric service on all newly developed dedicated public streets in the Town. The Developer is responsible for coordinating with the appropriate utility company all aspects of design and installation. HDPE SDR 11 conduit or approved equal shall be used for all roadway crossing and may be used for electrical interconnect system if approved by the local electrical utility.

**Table 1.21.1**
**Recommended Street Illumination Levels**

| Street Classification | Area Classification | Average Maintained Illuminance Values | Illuminance Uniformity Ratio (Average to Minimum) |
|---|---|---|---|
| **Arterial** | Commercial<br>Intermediate<br>Residential | 17 lux (1.6 fc)<br>13 lux (1.2 fc)<br>9 lux (0.9 fc) | 3 to 1 |
| **Collector** | Commercial<br>Intermediate<br>Residential | 12 lux (1.1fc)<br>9 lux (0.9 fc)<br>6 lux (0.6 fc) | 4 to 1 |
| **Local** | Commercial<br>Intermediate<br>Residential | 9 lux (0.9 fc)<br>7 lux (0.7 fc)<br>4 lux (0.4 fc) | 6 to 1 |
| **Area Classification Definitions:** | | | |
| **Commercial:** | Business areas in the Town of Windsor where ordinarily there are many pedestrians during night hours. This definition applies to densely developed business areas outside, as well as within the central part of the Town. These areas contain land use which attracts a relatively heavy volume of night time vehicular and/or pedestrian traffic on a frequent basis. | | |
| **Intermediate:** | Those areas of the Town often with moderately heavy night time pedestrian activity; such as, in blocks having libraries, community recreation centers, large apartment buildings, industrial buildings, or neighborhood retail stores. | | |
| **Residential:** | A residential development or a mixture of residential and small commercial establishments, with few pedestrians at night. | | |
| **Note:** | Values in table assume typical asphalt roadway surface (pavement classification R2 or R3). Consult the IES document for other pavement surfaces. | | |
| **Source:** | Illuminating Engineering Society RP-8. | | |
| **Illuminance Definitions:** | | | |
| **Lux:** | An SI unit of illuminance; defined as the amount of light on a surface of one square meter all points of which are one meter from a uniform source of one candela. One lux equals 0.0929 footcandle. | | |
| **Footcandle:** | The illuminance of a surface one square foot in area on which there is uniformly distributed light flux of one lumen or the illuminance produced on a surface all points of which are at a distance of one foot from a directionally uniform point source of one candela. One footcandle equals 10.76 lumens | | |
| **Illuminance:** | The density of the luminous flux incident on a surface. It is the quotient of the luminous flux by the area of the surface when the latter is uniformly illuminated. | | |
| **Average Maintained Illuminance:** | The average level of horizontal illuminance incident on the roadway pavement when the output of the lamp and luminaire is diminished by the maintenance factors. Expressed in average lux or footcandles (fc) for the pavement area. | | |

**Table 1.21.2**
**Street Lighting Requirements**

| Street Classification | Luminaires | Mounting Height | Spacing |
|---|---|---|---|
| Major Arterial | 250-W Cobra | 32 foot height | 120–150 feet |
| Minor Arterial | 250-W Cobra | 32 foot height | 150–250 feet |
| Major Collector | 250-W Cobra | 32 foot height | 150-250 feet |
| Minor Collector | 100-W Pole Top | 20 foot height | 160–250 feet |
| Local/Residential | 100-W Pole Top | 20 foot height | 160–250 feet |

**Note:** Spacing to be determined by Average Maintained Illuminance Value and Illuminance Uniformity Ratio in **Table 1.21.1**

**Table 1.21.3**
**Intersection Light Locations**

| Intersection Classification | Street Light Locations |
|---|---|
| Major Collectors/Arterial | 4 lights, one on each corner |
| Arterial/Arterial | 4 lights, one on each corner |
| Collector/Collector | 2 lights, one on opposite corners |
| Local/Collector | 2 lights, one on opposite corners |
| Local/Local | 1 light on one corner |
| End of Cul-de-sac | 1 light at end (per Cul-de-sac) |

**Table 1.21.4**
**Minimum Illuminance for Roundabouts**

| Peak Hour Volume (Total Entering) | Minimum Horizontal Illuminance | |
|---|---|---|
| | Lux | Footcandles |
| 5,000 < PVH | 20 | 1.9 |
| 1,000 < PVH < 5,000 | 15 | 1.5 |
| PVH < 1,000 | 10 | 0.9 |

**Note:** Minimum horizontal illuminance values are to be measured at the curb line.

## 1.22 TRAFFIC CONTROL DEVICES

### A. GENERAL

Traffic control devices are employed to regulate, warn, and guide traffic and are a primary determinant in the efficient operation of intersections. Intersection design shall be accomplished simultaneously with the development of signal, signing, and pavement marking plans. Permanent signing, striping, and traffic control signals, shall be in place before new roadways are completely opened to the public.

This section describes general signal, signing, and striping design requirements for use in the Town of Windsor. All design and construction of signals, signing, and striping shall be in conformance with this section and the latest revision of the Manual on Uniform Traffic Control Devices (MUTCD), Colorado Supplements, and the Town's Standard Drawings and Specifications.

## B. TRAFFIC SIGNAL DESIGN REQUIREMENTS

The design, selection and use of traffic control signals should be based on an engineering study of roadway geometrics, capacity analysis, design hour volumes, vehicle and pedestrian traffic volumes and other considerations. A careful analysis of traffic operations, pedestrian and bicyclist needs, and other factors, coupled with good engineering judgment, define the minimum conditions or warrants, under which designing and installing a traffic control signal might be justified. Details on the design and location of most forms of traffic control signals, including the general warrants, are given in the MUTCD. A properly designed signal control system should be flexible and responsive to traffic fluctuations. The system should include detection and data processing components as well as control and signalization components.

The design of traffic signals shall be performed by a qualified traffic Engineer approved by the Town Engineer. The design should follow the Colorado Department of Transportation Standards for a standard mast arm type traffic signal installation. In general, the Design Engineer can use the current version of the CDOT Standard Specifications for Road and Bridge Construction, Section 614 "Traffic Control Devices" for guidance when preparing traffic signal plans.

## C. TRAFFIC SIGNS

Traffic signs are directly related to the design of a roadway and are features of traffic control and operation that should be treated as an integral part of design. The extent to which signs are used depends on the traffic volume, the type of facility, and the amount of traffic control appropriate for safe and efficient operation. Collector and Arterial roadways have relatively high traffic volumes and signs are employed extensively. Local roads usually have low volumes and speeds and the use of complex traffic control devices is limited.

Traffic signs are of three (3) general types: regulatory signs, used to indicate the rules for traffic movement; warning signs, used to indicate conditions that may involve risk to users; and guide signs, used to direct traffic along a route or toward a destination.

1. General.

   a. Conformity. All signs shall conform to current Manual on Uniform Traffic Control Devices (MUTCD), Colorado Supplements, and the Town's Standard Drawings and Specifications. Signs shall not have any company logos or decals on them.

   b. Type and Location. The Town Engineer shall make the final determination regarding the type and location of signage controls within the right-of-way. These controls shall include traffic control signs, street name signs, delineators, and permanent barricades.

   c. Sign posts. Sign posts and their foundations and sign mountings shall be constructed to hold signs in a proper and permanent position, to resist swaying in the wind or displacement by vandalism.

   d. Placement.

      i. Signs should be placed on structures, outside the clear zone, or behind traffic barriers and should not be placed to block sidewalks.

      ii. All signs, except STOP and YIELD signs, shall be placed near property lines and are not to intrude on driveways, doorways, or any type of entrance.

      iii. Signs shall be placed behind curbs to minimum specifications according to MUTCD. Signs preferably should be placed two (2') feet behind the curb or sidewalk whenever possible.

      iv. Signs shall be placed a minimum of five (5') feet from fire hydrants.

v. Placement of “STOP” signs shall be in accordance with Town Standards, behind curbs, ramps, or crosswalks with a minimum of three (3') feet behind the sidewalk at radius point or as approved by the Town Engineer.

vi. Signs placed in concrete islands shall be either core drilled with a four (4") inch hole or a piece of four (4") inch PVC pipe may be poured into the full depth of the concrete, flush with the top of the concrete.

vii. All sign placement shall call for current locates to the “CALL BEFORE YOU DIG” number, before sign installation. Current locates shall be established before the final inspection of sign installations.

e. Reflectivity. All traffic control signs must be fabricated with reflective materials and shall be 3M High Intensity Prismatic or Diamond Grade reflective sheeting with a ten (10) year guarantee, or approved equal. Legends and symbols shall be made with Electro Cut (EC) Film. The Town reserves the right to request material changes to signs.

f. Backing Plates. Aluminum blanks of .080 gauge are standard, except for signs larger than thirty six by thirty six (36" x 36") inches, which shall be .100 or .125 gauge aluminum. All backing plates shall have pre-punched holes.

g. Specifications. Because the Town will maintain the permanent traffic control devices on public rights-of-way, all traffic signs shall be fabricated and installed in accordance with the **Construction Specifications**, **Traffic Control Signing Standards**, **Section 02616**, of this manual.

2. Intersections.

a. Street Name Signs.

i. General. All street name signs shall conform to these standards. If the intersection has a traffic signal, street name signs will be designated as part of the signal.

ii. At Intersections. Nine (9") inch plates, up to thirty six (36") inches long, shall be used at all intersections, which include the intersections with Local, Collector, and Arterial Roadways.

iii. Sign Assembly. All nine (9") inch by thirty six (36") inch plates shall be installed with end bolts on all plates. There shall be two (2) plates for each road, with a minimum of four (4) plates per street sign assembly. For street name signs longer than thirty six (36") inches in length, back to back street name sign blanks shall used with two (2), two (2″) inch shims between the blanks. Street name assemblies can be combined and placed on top of Stop signs.

iv. Sign Face. Street name sign blanks shall be nine (9″) inches in height, green, with white lettering. All street names shall be composed of lower-case letters with an initial upper-case letter. For Minor Intersections, on roadways with posted speed limits of forty (40 mph) miles per hour or less, lower-case letters and numbers on the street name sign shall be a minimum of four and one-half (4½") inches high and the initial upper-case letter shall be a minimum of six (6″) inches high. At Major Intersections, on roadways with posted speed limits more than forty (40 mph) miles per hour, lower-case letters and numbers on the street name sign shall be a minimum of six (6") inches high and the initial upper-case letter shall be a minimum of eight (8″) inches. The white letters shall be on a reflective green background face. The colors shall not fade when exposed to an accelerated test of ultraviolet light equivalent to five (5) years of outdoor exposure. No silk screened signs are permitted. Borders on street name signs shall be per the MUTCD.

v. Street Name. Street name designations should be obtained from the approved plat.

vi. Change of Name. At the point where a street changes names from one section to the next, the change should be designated on the street name assembly by using directional arrows and will require two additional plates.

vii. No Outlet Signs. On any cul-de-sac, temporary dead-end street, or any other non-connective roadway, or any other streets with only one access point, a "No Outlet" sign is required. The "No Outlet" signs may be placed under the street name signs.

b. Stop Signs.

i. Location. The location and number of all stop signs shall be determined and discussed in the TIS. All four-way stops are required to meet warrants.

ii. Placement. Stop signs shall be placed in accordance with the TIS, approved construction plans, and the approval of the Town Engineer.

c. Warning Signs. Intersection warning signs may be required on four or six (4 or 6) lane Arterial Roadways and/or high-speed Rural Roadways, in advance of major intersections. An advisory plaque identifying the name of the intersecting side street shall be placed beneath the advance intersection warning sign.

3. Traffic Control Signs.

a. Design and Size. Sign specifications and diagrams are detailed in the latest revision of the Federal "Standard Highways Sign", available from the U.S. Department of Transportation, Federal Highway Administration and also the MUTCD.

b. Mounting. Signs should be mounted on existing streetlight and power poles, with new posts being used only if necessary. Streetlight locations should be checked for potential sign installation during the design process and shown on the signing and striping plan sheets. The use of stainless steel banding of signs is acceptable for fiberglass and steel poles.

c. Regulatory.

i. Reflectivity. All regulatory signs, except parking, shall be Diamond Grade reflectivity or greater, including the red series and black on white signs.

ii. Sheeting Material. All signs shall be fabricated with sheeting material, including letters. No silk-screened signs will be permitted.

iii. Stop Sign. Stop signs shall be a minimum of thirty (30") inches.

iv. Yield Sign. For minor, "Tee" intersections only, a yield sign may be used in lieu of a stop sign, at the discretion of the Town Engineer and according to MUTCD.

v. Speed Limit Sign. All Collectors and Arterials should have speed limit signs at approximately one-quarter (¼) mile intervals. All subdivisions shall have a speed limit sign at each entrance.

vi. Parking/No Parking Sign. Designated parking and "No Parking" zones shall be signed in accordance with MUTCD. No silk screened signs are permitted.

d. Warning.

i. Reflectivity Requirements. High intensity sheeting is required except for school crossing signs that shall have Diamond Grade sheeting.

ii. "No Outlet" Sign. On dead-end streets, cul-de-sacs, temporary dead-end streets, or any other non-connective roadway, a "No Outlet" sign will be required and mounted with standard mounting system under the street name sign. The sign shall be an MUTCD

#W14-1p, thirty (30") inch by six (6") inch minimum size black on yellow warning sign.

iii. "Road Closed" Sign.

A. All temporary dead-end streets shall have a "End of Road" marker with a "Road Closed" sign. A temporary dead-end street is anticipated to be a dead-end for less than a year and shall have a "Road Closed" (R11-2, 48 x 30 inches) sign mounted on both sides of the road.

B. All dead-end streets anticipated to be a dead-end for more than a year must use long-term barricades, as approved by the Town Engineer. Mount "Road Closed" signs directly on approved barricade with two (2) delineators each post.

iv. Crosswalk Sign. Crosswalks shall be signed where adjacent to a school and on an established school pedestrian route. There are usually a minimum of four (4) signs per crosswalk. The installation shall be completed according to MUTCD. The color shall be fluorescent yellow green. The diamond shaped sign shall have a minimum height and width of thirty six (36") inches in rural areas and thirty (30") inches in urban areas.

v. Bikeway Signs. Bicycle signs for bike lanes shall be provided. See MUTCD and AASHTO – *Guide for Development of Bicycle Facilities* for required signs and discuss in TIS.

4. Roundabouts.

a. Modern Roundabouts. The use of warning signs in advance of the circulating roadway shall be required as well as operating and directional signs to be discussed in the TIS and as approved by the Town Engineer.

b. Mini Roundabouts. The Town of Windsor does not permit the use of Mini Roundabouts.

## D. PAVEMENT MARKING AND STRIPING

Markings and markers, like signs, have the function of controlling traffic to encourage safe and efficient operation. Markings or markers either supplement regulatory or warning signs or serve independently to indicate certain regulations or warn of certain conditions present on the roadway. There are three general types of markings in use – pavement markings, object markings, and delineators.

Pavement markings include centerline stripes, lane lines, and edge striping as well as stop and crosswalk lines, and various word and symbol markings. Object markings include reflectorized painting and other high-visibility material for physical obstructions in or near the roadway. At night, post-mounted delineators are used to guide traffic. Reflector units installed at certain heights and spacings help delineate alignment changes and provide warning. Refer to the MUTCD for marking criteria, methods, and policies.

1. General.

a. All street markings shall be in compliance with the current Manual on Uniform Traffic Control Devices Standards and the following design criteria.

b. The Town Engineer shall make the final determination in regards to type, location, form, and application of pavement striping and marking within the right-of-way during the review of the project signing, striping, and traffic control plan.

c. Permanent striping and marking, unless otherwise approved by the Town Engineer, shall be completely in place before any new roadway is opened to the public.

2. Design Criteria.

a. Refer to **Construction Specifications**, **Pavement Marking and Lane Striping Standards**, **Section 02618** of this manual for information on materials and construction.

b. The Design Engineer may use the current version of the CDOT M&S Standards, Standard Plan No. S-627-1 "Typical Pavement Markings" for guidance when preparing roadway plans.

3. Striping.

a. Typical. Typical striping widths for lane lines are four (4") inches, unless otherwise noted. Double yellow centerline must have a four (4") inch minimum gap between stripes according to the MUTCD and shall be epoxy.

b. Layout. Before striping on a roadway to be sealcoated, a layout line with striping tabs shall be established prior to the sealcoat process.

c. Broken Line. All broken lines shall be striped with a four (4") inch wide white paint.

d. Turn Bay Line. All turn bay lines shall be striped with an eight (8") inch wide dotted line, as designated in the MUTCD; however, if a turn bay occurs on a horizontal curve, it shall be marked with short eight (8") inch wide dotted lines (two (2') foot long with four (4') foot gap).

e. Centerline. All centerline striping shall be double yellow, each four (4") inches wide, with a minimum four (4") inch gap between the two.

f. Bikeway. A four (4") inch wide white stripe shall be used for Bike lanes and edge lines.

g. Temporary Striping.

i. Only upon approval of the Town Engineer, temporary striping shall be allowed prior to the opening of a roadway for travel where pavement and/or permanent striping cannot be completed in time.

ii. Temporary striping shall conform to CDOT Standard Specifications and shall be the same color and width as for permanent striping.

iii. Temporary striping is permitted on Arterial roadways for no more than fifteen (15) days. All other roadways temporary striping is permitted for no more than thirty (30) days.

iv. Extensions must be requested in writing if weather does not allow installation of permanent striping.

4. Pavement Markings.

a. General. The Town requires the use of preformed thermoplastic on all pavement markings such as, but not limited to, arrows, "onlys," crosswalks, railroad crossings, school crossings, stop bars, and bike symbols.

b. Specification. Preformed thermoplastic pavement markings shall be one hundred twenty five (125) mils thick and consist of white or yellow pigmented plastic film with imbedded reflective glass spheres. Prefabricated legends and symbols shall conform to the applicable shapes and sizes as outlined in the MUTCD. Refer to **Construction Specifications**, **Pavement Marking and Lane Striping Standards**, **Section 02618** of this manual for material specifications.

c. Crosswalks. Crosswalks shall be used at all signalized intersections, approved crossings, school routes, adjacent to schools, and as directed by the Town Engineer and shall be "Continental" style bars that are nine (9') feet long and twelve (12") inches wide, white, thermoplastic symbols.

d. Stop Bars. All stop bars shall be white and a minimum of eighteen (18") inches wide. Stop bars are required at new signalized locations and where specified by the Town Engineer.

e. Symbols. Preformed thermoplastic pavement marking material for symbols shall be a minimum of one hundred twenty five (125) mils thick and the manufacturer shall be as approved by the Town. This material shall be used for all arrows, "onlys," bike symbols, bike diamonds, railroad crossing symbols, etc.

f. Bikeways. Bicycle markings are to be used on Collector and Arterial Roadways with designated Bike lanes to supplement any regulatory signs. The method and material to be used shall be as designated by the Town Engineer.

g. Roundabouts. Roundabouts require a "Yield" line at the point of entry into the circulatory roadway, marked across each entry roadway. The yield line shall consist of a row of solid white isosceles triangles pointing toward approaching vehicles, extending across approach lanes to indicate the point at which the yield is intended or required to be made. See MUTCD for further information.

## 1.23 LANDSCAPE STANDARDS FOR STREETSCAPE AND MEDIANS

The Town shall approve all tree and shrub plantings on new and existing streetscapes and medians.

## 1.24 BIKE PATHS OR TRAILS CROSSING UNDER ROADWAYS

To accommodate both bicycle and pedestrian traffic on the existing and proposed bike path or trail system, the following shall be considered minimum clearances for bridges where the bike path or trail crosses under a roadway:

| | |
|---|---|
| Horizontal: | Twelve (12') feet from abutment to curb or edge of water. |
| Vertical: | Eight (8') feet from bike path or trail surface to underside of bridge. |
| Note: | The bike path or trail surface elevation should be at or above the high water mark for the two (2) year storm. |

## 1.25 ACCELERATION, DECELERATION, AND TURNING LANES

### A. GENERAL

A Traffic Impact Study (TIS), along with the Town Engineer in conjunction with specific requirements in the standards in this section, shall determine the need for acceleration lanes, deceleration lanes, and turning lanes for all roadways within the Town and its GMA, except for highways regulated by the State of Colorado, in which case CDOT regulations shall apply. Within this section, the terms speed change lanes and auxiliary lanes are interchangeable for deceleration lanes, acceleration lanes, and turning lanes.

### B. DESIGN CRITERIA

1. The design of all speed change lanes shall meet the design requirements of the State of Colorado, State Highway Access Code, dated August 31, 1998, or the latest revision, and/or these Standards, whichever is the most restrictive.

2. Speed change or auxiliary turn lanes shall be installed according to the following criteria:

   a. A left turn lane is required for any access with a projected peak hour left ingress turning volume greater than twenty five (25 vph) vehicles per hour. If the posted speed is greater than forty (40 mph) miles per hour, a left turn lane is required for any access with a projected peak hour left ingress turning volume greater than ten (10 vph) vehicles per hour.

b. A right turn lane is required for any access with a projected peak hour right ingress turning volume greater than fifty (50 vph) vehicles per hour. If the posted speed is greater than forty (40 mph) miles per hour, a right turn lane is required for any access with a projected peak hour right ingress turning volume greater than twenty five (25 vph) vehicles per hour.

c. The Town Engineer may require an auxiliary lane when it is specifically identified and documented that the lane is necessary to prevent or correct an operational or safety condition. A raised median may be required.

3. The required deceleration lane lengths, including stored vehicles and tapers, are based on both the posted speed for the Arterial and the projected peak hour number of turning vehicles. The required acceleration lane lengths are based on only the posted speed. The required minimum lengths for both types of speed change lanes are given in **Table 1.25.1**, **Speed Change Lane Lengths**, below:

**Table 1.25.1**
**Speed Change Lane Lengths**

| Posted Speed (mph) | Accel. Lane length (ft) | Right & Left turn Decel. Lane length (ft) | | | |
|---|---|---|---|---|---|
| | | Number of turns (vehicles per hour) | | | |
| | | <100 | 100-200 | 200-300 | >300 |
| 25 | N/A | 140 | 190 | 290 | 390 |
| 30 | 190 | 150 | 200 | 300 | 400 |
| 35 | 270 | 170 | 220 | 320 | 420 |
| 40 | 380 | 195 | 245 | 345 | 430 |
| 45 | 550 | 435 | 435 | 435 | 435 |
| 50 | 760 | 500 | 500 | 500 | 500 |
| 55 | 960 | 600 | 600 | 600 | 600 |
| 60 | 1170 | 700 | 700 | 700 | 700 |

4. The lengths given in the table above include the taper length. On some Arterials, the full deceleration length may not be capable of being provided due to existing conditions. Coordination of the design with the Town Engineer will be necessary in such instances.

5. Acceleration lane lengths shown in **Table 1.25.1**, above, shall be adjusted for any grade of three (3%) percent or more, using the factors given in **Table 1.25.2**, **Grade Adjustment Factors for Acceleration Lanes**, below:

**Table 1.25.2**
**Grade Adjustment Factors for Acceleration Lanes**

| Roadway Grades in Excess of 3% | Posted Speed (mph) | | | |
|---|---|---|---|---|
| | 25 to 45 | 50 | 55 | 60 |
| 3 to 4.9% Upgrade | 1.3 | 1.4 | 1.5 | 1.5 |
| 5 to 7% Upgrade | 1.5 | 1.8 | 2.0 | 2.3 |
| 3 to 4.9% Downgrade | 0.7 | 0.65 | 0.65 | 0.6 |
| 5 to 7% Downgrade | 0.6 | 0.55 | 0.5 | 0.5 |

6. Deceleration lane lengths shown in **Table 1.25.1**, **Speed Change Lane Lengths**, shall be adjusted for any grade of three (3%) percent or more, using the factors given in **Table 1.25.3**, **Grade Adjustment Factors for Deceleration Lanes**, below:

**Table 1.25.3**
**Grade Adjustment Factors for Deceleration Lanes**

| Upgrade | Factor | Downgrade | Factor |
|---|---|---|---|
| 3 to 4.9% | 0.9 | 3 to 4.9% | 1.2 |
| 5 to 7% | 0.8 | 5 to 7% | 1.35 |

7. In **Table 1.25.1**, **Speed Change Lane Lengths**, the lane lengths that have been calculated and shown are based on standard automobile lengths. To allow for the impact of larger trucks, buses and recreational vehicles, "passenger car equivalents" shall be determined and applied as directed in the State Highway Access Code and the minimum lengths of Deceleration turning lanes shall be recalculated and increased accordingly.

8. On Deceleration lanes where it is necessary to store stopped vehicles (such as at traffic signals), additional lengths shall be provided to accommodate the average number of vehicles anticipated at the peak hour, per signal cycle, if indicated from the most recent traffic impact analysis. In such cases, the "additional storage length" shall be added to the "deceleration length" to arrive at the total length.

9. Redirect Tapers. Where it is necessary to establish a left turn lane or median island, or otherwise redirect the vehicles on the main traveled way, redirect tapers required for directing through travel lanes shall be installed according to the requirements outlined in the State Highway Access Code. The beginning and ending point of all tapers shall be rounded.

10. Speed change lanes shall normally be twelve (12') feet wide exclusive of gutter pan or shoulder. When necessary to redirect the traveled way or install a speed change lane, a paved shoulder adjacent to the lane shall be provided where no curb and gutter is present. Shoulders adjacent to the traveled way should be a minimum of six (6') feet in width but no less than the width of the current shoulder. Shoulders adjacent to a speed change lane shall be a minimum of four (4') feet in width.

11. The total storage length is a function of the probability of occurrence of events and should usually be based on one and one-half to two (1½ - 2) times the average number of vehicles that would store per cycle. This length should prove sufficient to serve heavy surges that occur from time to time. As in the case of unsignalized intersections, provision should be made for storing at least two (2) vehicles.

12. This section relies on general design techniques. The use of more exact geometric engineering standards and methods is permissible provided the design meets the intents of these standards, is based upon nationally accepted standards, and is subject to review and approval of the Town Engineer.

## 1.26 TRAFFIC IMPACT STUDY (TIS)

### A. PURPOSE

The Traffic Impact Study (TIS) will determine and analyze the traffic impact a development imposes on the existing and 20-year transportation system affected by the development. Site and background traffic should be analyzed as to safety and efficiency in traversing the impacted street system leading up to, entering, circulating within the site, as well as the site and back through the system during the peak hour (PH) traffic period. All intersections, streets, adjacent drives and site access affected by the traffic will be analyzed with consideration given to adjacent land use, traffic generations, and improvements to the system, existing, committed and planned and as covered in comprehensive plans. Recommendations as to improvements and phasing should be given.

At some point, the development traffic and background traffic growth may trigger the need for an additional travel lane, a signal, or an exclusive turn lane at a signalized intersection or into the development. This may be when the first phase is done, at build out, or within twenty (20) years when the increased background and site traffic will require the improvements. It is the intent of the study to determine if the first phase, build out phase, or twenty (20) year traffic will require improvements on the existing system.

### B. RESPONSIBILITY FOR TRAFFIC IMPACT STUDIES

The developer provides a TIS prepared by a Professional Engineer experienced in transportation planning.

## C. CONDITIONS FOR REQUIREMENT

Not all developments will generate the traffic required to do a study. The Town will determine if a study is required and the specific scope of the study. In general, a TIS is required when:

1. The site is estimated to generate fifty (50) or more build-out peak hour trips on an arterial or major collector, or one hundred (100) or more on a minor collector or local street.
2. A capacity or safety issue exists or will exist before the proposed site is built out.
3. The expansion of an existing development or change in use increases traffic to that stated in number 1, or will add peak hour traffic to the existing background traffic on the adjacent main street or signalized intersections that will decrease Level of Service (LOS) to "D" or lower.
4. A new location or relocation of an access point may create a traffic problem.
5. Estimated traffic will have a negative impact on local streets or intersections.
6. Capacity, sight distance or safety will be compromised.

## D. SCOPE MEETING

It is recommended that the developer and Traffic Engineer meet with the appropriate Town staff and present a conceptual map (to scale) with planned use (housing, commercial, office, industrial, etc.), surrounding land use and estimated access points. More detailed information such as the number of employees or homes, hours of operation, and daily and peak hour trip generation can be supplied later. If the project is on a State route, CDOT shall be involved. The following should be agreed upon:

1. Existing, build-out, and twenty (20) year daily traffic volumes.
2. Existing and twenty (20) year, twenty four (24) hour traffic count source.
3. Build-out and twenty (20) year trip distribution.
4. Number of travel lanes for collectors and arterials in the build-out and twenty (20) year period.
5. If a grade-separated interchange will be built.
6. Any planned Town streets or improvements.

Twenty four (24) hour volumes (existing, build-out, and twenty (20) year) and peak-hour distribution should be in written form and used as reference during the TIS review. The peak-hour traffic percent of the daily traffic should be around ten (10%) percent.

## E. STUDY AREA BOUNDARIES

The study boundary should include the network impacted by the new development which would include streets, signalized intersections, and those to be signalized in the future, and all commercial and private drives within four hundred (400') feet of the project property boundary.

## F. STUDY AREA MAP

A scaled map should include:

1. Site location.
2. All streets and street names internal and adjacent to proposed site.
3. All drives within four hundred (400') feet of the proposed site boundary, including drives & streets on opposite side of roads.
4. All existing and proposed site access drives and spacing dimensioned between them.
5. Footprints, with square footage, of all buildings and their use, if known.
6. Project parking and drive aisles.
7. Adjacent existing land uses.
8. Existing traffic control devices.
9. Existing lanes including turn lanes and dimensions.
10. A north arrow and map scale.

## G. TIS REQUIREMENTS

Summary of Major Requirements

1. Project description.
2. Existing twenty four (24) hour counts, intersection turn moves and LOS.
3. Use of each building, square footage, and traffic generated.
4. Site build-out and background traffic (daily and peak hour), distribution, peak-hour turning movements, LOS, signal warrants, queuing analysis, and traffic progression analysis.
5. Twenty (20) year site and background traffic, distribution, peak-hour turning movements, LOS signal warrants, queuing analysis and traffic progression analysis.
6. Turn lane improvements or new turn lanes resulting from the development.
7. Number all pages including the appendix.

## H. TRIP GENERATION

A Trip Table of proposed land uses is required and includes both twenty four (24) hour and peak-hour generated traffic for total build-out. Peak hour traffic is the most critical determinate of signal, access point, and turn lane needs. It is not always highest during the usual 4:30 to 5:30 weekday period. Commercial area impact is typically greatest on Saturday afternoon, and homes in the weekday morning or evening. A special generator (stadium, school, library, movie theater, etc.) may have a peak-hour traffic demand different from the usual afternoon peak-hour traffic, and not on weekdays. If these uses will produce the greatest total demand, then use them, along with the other uses, in the Trip Generation Table, and state the reason. The table should include:

1. Land use category and number from the ITE Trip Generation Manual.
2. The square feet of each building, or number of housing units, employees, etc.
3. ITE Trip Generation Rates and Trips for the morning and afternoon peak-hours producing the highest number of trips.
4. Total daily traffic, and total morning and afternoon entering and exiting traffic.
5. If development is proposed in phases, and any phase will produce need for a signal, turn lanes, or degrade the existing LOS to a “D” or lower, then show that phase as a separate Trip Table from the total Trip Table, and the year it may happen, if not within the default five (5) year span.
6. Pass-by and internal trip reduction, if any.
7. Document the source of trip rates, pass-by, and internal trip reduction rates.

## I. EXISTING CONDITIONS

1. Describe the existing zoning, land use, surrounding road names and number of lanes. Include a scale map of the above, with driveway access points within four hundred (400') feet.
2. Prepare a map of the twenty four (24) hour daily traffic counts, peak-hour turning movements (AM, PM, and noon if noon is the highest, or Saturday PM counts, if highest). All counts should have existing morning traffic counts on top, and evening on bottom.
3. A map of the peak hour LOS for each turn movement impacted by the development shall be included.

## J. BUILD-OUT AND TWENTY (20) YEAR CONDITIONS

For build-out and twenty (20) year conditions, provide the following. State the source of all traffic counts. If previous TIS counts are used, reference the study.

1. A map of twenty four (24) hour estimated traffic on adjacent streets. The methodology for determining the counts should be included. Twenty (20) year traffic analysis zones should account for estimated build-out.
2. Peak-hour project traffic distribution map with arrows and percent at all major intersections and drives.
3. A map of background peak-hour turning movement counts at all major intersections and LOS.
4. A map of total (background and site traffic) peak-hour turning movement counts for all intersections, and site drives with morning on top, evening on bottom.

5. Turning movement LOS table for background and peak-hour traffic for the build-out and twenty (20) year period at intersections and site drives along arterial. Show LOS for intersections needing signals, and after signalization.
6. Map of signalized intersection lanes (new or improved) and adjacent street lanes needed as a result of site and background traffic. Provide a scaled turn lane layout of taper, deceleration, and storage lengths. Turn lane design is part of the TIS. They should be designed for the highest peak-hour turn demand which can be the morning, noon or afternoon to evening weekday or Saturday peak period. Existing turn lanes, or turn lanes needed in phased, or build-out construction, should be shown. Sometimes the greatest impact, and the need for turn lanes, is in the morning period on a collector as large amounts of traffic enter an arterial from side street, or at a signal. A large housing development will have the greatest impact in the morning on the minor street turn lane approach to an arterial, or on a turn lane at a signal. These turn lanes should be addressed in the study and the peak period used mentioned. All turn lanes needed or modified by the development must be shown to scale on a map showing all business and residential drives to determine the impact of the turn lanes on existing or planned development. Development left turn lanes that are back-to-back with another left turn lane should show, through layout, how they will accommodate the twenty (20) year peak-hour turning traffic. Any traffic estimated backing into the through lane and/or through the next intersection should be mentioned.
7. Map of existing, build-out, and twenty (20) year ADT should be provided for all adjacent streets.
8. Signal warrant analysis and LOS at intersection, and site drives should be shown in a table.
9. Stochastic Queuing Analysis results in a table for all site and signalized intersection turn lanes. If the peak-hour queue backs into a through lane, this must be stated, and a design to accommodate the queue drawn to scale.
10. Traffic progression analysis is required for signals spaced closer than one half (½) mile. Place measures of effectiveness (MOE) in a separate table for all signalized intersections and name the intersection.

## K. STUDY CONCLUSIONS

TIS Report conclusions shall include:

1. Total traffic generated from the site.
2. Intersections with a LOS higher than "D" in the build-out and twenty (20) year period.
3. If the development and background traffic resulted in a poor LOS, or if the background traffic resulted in a poor LOS, mention which turn moves will be affected, their LOS, and recommendations for improvements.
4. Any through lanes or intersections operating in over saturated conditions.
5. Turn lanes that will experience backing into the through lanes, and through lanes backing into the next intersection.
6. Poor progression resulting from project generated traffic.
7. Through band traffic progression efficiency on all adjacent arterials.
8. Which intersections need traffic signals and when (build-out or in twenty (20) years).

## L. RECOMMENDED SITE AND AREA OF INFLUENCE IMPROVEMENTS

Summary of recommendations shall include:

1. Improvements needed at build-out.
2. Improvements needed in twenty (20) years.
3. Needed right-of-way for improvements.
4. Need for traffic signals and additional turn lanes resulting form the increased traffic.
5. Turn lane geometry at signalized or future signalized intersections, and all site accesses.
6. Pedestrian and wheel chair access.
7. Cost estimates for major improvements generated by the development.

**END OF SECTION**

## SECTION 2

## SOILS INVESTIGATIONS AND PAVEMENT DESIGN

### 2.01 SOILS INVESTIGATIONS

#### A. GENERAL REQUIREMENTS

Three (3) categories of soils testing and reports are required for all projects requiring right-of-way grading and paving. Soils Report, final Pavement Design Report, and extra testing (e.g., imported fill). All sampling and testing of soils shall be performed under the direct supervision of a Professional Engineer. All required reports shall be prepared and signed by a Professional Engineer.

1. Soils Report. This report evaluates the characteristics of the soils and the general issues of groundwater, soil stability, and swells potential. If groundwater is found to be an issue per the Geotechnical Report, measures to mitigate ground water impacts to the proposed use must be provided in the development plans. (See **Section 2.03**) A Soils Report is required for street and related improvements within the right-of-way and/or public easements. This report is required as part of the preliminary plat submittal. The Soils Report is valid for three (3) years. If construction has not begun three (3) years following the date the Soils Report is accepted by the Town, an updated Soils Report will be required.

2. Final Pavement Design Report. This report is required for all projects with roadway improvements. The soil investigation associated with this report will occur after grading for public roadways is complete to within six (6") inches of anticipated final subgrade elevation, and sanitary sewer lines have been installed. This report must be submitted and approved prior to any concrete or paving installation. The Final Pavement Design Report is valid for one (1) year. If paving construction has not begun one (1) year following the date the report is accepted by the Town, an updated report will be required.

3. Extra Testing. If imported fill material is required for the project, this material shall also be tested to meet Town standards before placement.

#### B. TIMING OF SOIL BORINGS

1. Initial Borings. The information from the initial soil borings must be summarized in the Soils Report. The entire site shall be sampled for initial testing. This requirement exists because street locations may not yet be determined or may change. A minimum of one (1) sample for every five (5 ac) acres shall be taken to establish general site grading recommendations, preliminary foundation recommendations, and preliminary pavement section design. In areas where groundwater is suspected within five (5') feet of the original ground surface, borings shall be taken during the time of year that the groundwater table is likely to be highest in elevation. Generally, evaluation for groundwater shall be done between May 1st and October 1st.

2. Structures. Soil borings for design of structures shall be taken prior to the design of the structure.

3. Imported Fill. All fill material shall be tested by the Geotechnical Engineer and approved by the Town prior to its use in the public right-of-way and easement. (See **2.01G**)

#### C. FREQUENCY OF SOIL BORINGS

1. Basic Requirements. A minimum of two (2) borings shall be provided for each project. The number of borings should be dependent on project size and Geotechnical Engineer's recommendations, but shall not be less than a minimum of one (1) boring per five (5 ac) acres.

2. Structures. Testing frequency for structures shall satisfy AASHTO Bridge Design requirements and CDOT Materials Testing requirements.

## D. LOCATION AND DEPTH OF BORINGS

1. Basic Requirements. Borings shall be taken to a minimum depth of ten (10') feet below the proposed grade or existing grade, whichever is deeper. The original ground elevation at the top of each boring shall be clearly identified. If preliminary plans exist, borings shall be taken at the location of future roads, buildings, etc.

2. Structures. Borings for structures shall be taken to a minimum depth of ten (10') feet below the footing elevation.

3. Piers or Piles. Initial borings shall extend deeper than ten (10') feet if it is anticipated that piers or piles will be used within the development as a construction method. In such cases, the depth of borings shall extend to a depth of ten (10') feet below the anticipated piers or pile depth or to a depth at which sound bedrock is encountered.

## E. SOIL GROUPING AND SUBGRADE SUPPORT TESTING

To simplify subgrade support testing (R-Value), soil samples may be combined to form soil groups consistent with the AASHTO classification, group index, and location for the area investigated. Groupings shall not mix samples with different AASHTO classifications. Soil groupings shall not be used to reduce swell potential of the in situ subgrade soils. An adequate number of tests should be performed for the Geotechnical Engineer to determine whether or not the subgrade soil is capable of supporting the proposed construction and design loads, but shall never be less than a minimum of two (2) per Soils Report. If the subgrade soils are not suitable, then the Geotechnical Engineer shall provide a specific recommendation for subgrade stabilization. The Final Pavement Design Report shall contain construction details related to the specific mitigation measures recommended in the Soils Report.

## F. REQUIRED TESTS

The tests listed in **Table 2.01.1**, **Test Required for Each Boring**, are required for each boring described in the Soils Report. Soils shall be described in the Soils Report. Soils shall be described visually and then tested in a laboratory to determine the AASHTO Classification of each soil type.

## G. IMPORTED FILL MATERIAL TESTING

All imported fill material shall be tested for swell potential, Atterberg limits, and R-value (one test for each soil type) and approved by the Town Engineer prior to use in the right-of-way. All imported fill shall have an R-value equal to or greater than the on-site subgrade materials. Imported fill shall not have liquid limit greater than forty (40) and a plasticity index greater than twenty (20). The swell potential shall be less than two (2.0%) percent at one hundred fifty (150 psf) pounds per square foot load.

**Table 2.01.1**
**Test Required for Each Boring**

| Test | Testing Frequency | Notes / Exceptions |
|---|---|---|
| Visual | Each Soil Type | Described in the Field |
| Liquid Limit | Each Soil Type | Passing No. 40 Sieve |
| Plastic Limit | Each Soil Type | Passing No. 40 Sieve |
| Moisture | Each Soil Type | |
| Percent Passing 200 | Each Soil Type | |
| Gradation | Each Granular Soil | A-1 through A-4 soils |
| AASHTO Classification | Each Soil Type | |
| R-Value | See Section 2.01E | |
| Swell/Consolidation Test | Each Clay Soil Type | A-6 through A-7 soils |
| Percentage of Soluble Sulfates | Each Clay Soil Type | A-6 through A-7 soils |
| Standard Penetration Test | Each Soil Type | |
| Groundwater | Elevation | If encountered |
| Bedrock Level | Elevation | If encountered |
| Corrosion Potential Resistivity | Each Soil Type | |

## 2.02 SOILS REPORT

### A. REPORT REQUIREMENTS

A Soils Report shall be submitted with the preliminary plat. The report shall show results from all required testing. The report shall also include a description of site characteristics, e.g., location, topography, drainage features, etc. A checklist (see appendix) has been developed to assist in preparation of Soils Reports. It includes items pertinent for the Town's review and reflects established professional engineering practice for Soils Reports. The final version of the Soils Report, which has been accepted by the Town, must be clearly identified and dated as such.

The following acceptance block must be on the title page of the submittal:

ENGINEERING REVIEW, TOWN OF WINDSOR

Review is for general compliance with Town of Windsor Standards and Requirements. The Town of Windsor is not responsible for the correctness of design, dimensions, details, quantities, and design safety.

☐ No Exceptions Taken
☐ Make Corrections Noted
☐ Rejected - See Checklist

Review Engineer_____ Date_____

In addition to the basic report requirements, each Soils Report shall include the following items:

1. Site location and description.

2. Laboratory test reports conducted using the most current AASHTO test methods, for the tests listed in **Table 2.01.1**.

3. Boring logs with ground elevation, of each soil type, plus or minus five tenths (±0.5') feet.

4. Depth to bedrock, if encountered.

5. Mitigation plans and recommendations for unsuitable or swelling soils.

6. Additional tests. These may be required for trench backfill evaluation, fill evaluation, slope stability, imported soils, etc.

7. Elevation of groundwater encountered in each boring.

## 2.03 SUBSURFACE WATER INVESTIGATION

### A. CONDITIONS FOR REQUIREMENT

If groundwater is encountered within five (5') feet of the original ground surface, a Subsurface Water Investigation Report shall be submitted for approval by the Town Engineer, unless the Town Engineer has waived this requirement. This report is required to ensure mitigation of high groundwater effects upon public improvements within the right-of-way or easements. This information may be a separate report or may be included in the Soils Report.

Exception for Buried Utility Construction: This report is not required for temporary dewatering activity needed to facilitate construction of buried utilities. However, all applicable State requirements must be followed.

### B. REPORT REQUIREMENTS

The report shall include recommendations and proposed methods of dealing with groundwater, including proposed methods for dewatering utility trenches and proposed methods for protecting foundations and structures.

The subsurface water investigation report shall include, at a minimum, the following information:

1. Site location and description. Include locations of any on-site or nearby irrigation ditches and wetlands.

2. Lowest and highest elevations of water table and likely direction of flow. Elevations for high water to be taken between May 1$^{st}$ and October 1$^{st}$.

3. Potential sources of groundwater. Include proximity to irrigation ditch systems.

4. Other relevant subsurface information, such as, water ownership (water rights), groundwater quality (contamination or other undesirable characteristics).

5. Potential future groundwater conditions and cone of influence.

6. Subsurface drainage recommendations, including its effects on all conditions, including sensitive habitat and wetlands.

7. Subsurface drains: If subsurface drains are recommended, the drains must have a gravity discharge without any possibility of backflow or blockage of the outlet. Any subsurface drain system shall be owned and maintained by the Developer or the Developers assigned successor(s). These drains may discharge into the Town's storm drainage system, including inlets or detention ponds, upon

approval of the Town Engineer. Anticipated impacts to the groundwater table on adjacent properties must be quantified. Subsurface drains may be located in the public right-of-way or easements, but shall be maintained by the Developer or the Developers assigned successor(s). Subsurface drains shall have properly designed clean-outs and be designed to prevent any possibility of backflow or blockage from occurring.

## 2.04 UNSUITABLE SOIL MITIGATION

Mitigation plans for unstable or swelling soils (unsuitable for construction) revealed by the soils investigation shall be submitted by the Geotechnical Engineer. The following specific factors shall be addressed:

### A. MITIGATION PLANS AND APPROVAL

All special problems found in soils investigation (e.g., expansion, frost, soluble sulfates, shallow bedrock, groundwater, soil instability, erosion, etc.) shall be addressed in the mitigation plans. All mitigation procedures must be approved by the Town Engineer prior to their implementation. If soils mitigation is required, the approved soil treatment shall extend to the back of curb, or to the back of sidewalk for attached or rollover (monolithic) sidewalk. If the soils beneath the curb, gutter, and attached sidewalk have passed required proof-rolling and compaction tests, then these items may be constructed. In such cases, if soils mitigation is required under the pavement, the approved soil treatment shall extend from lip of gutter to lip of gutter.

### B. MITIGATION FOR SWELL

If the swell potential is two (2.0%) percent or greater at one hundred fifty (150 psf) pounds per square foot (ASTM D 4546), the final Pavement Design Report must provide mitigation measures. The mitigation measures shall reduce destructive swell potential under the public improvements to less than two (2.0%) percent. The swell test report shall specify sample conditions, surcharge pressures, and other key testing factors. Limits of mitigation shall be clearly identified in the Final Pavement Design Report and shall be based on tested samples.

Possible measures for mitigation may include the following:

1. Over-Excavation. Over-excavation and replacement with suitable non-expansive or low-expansive material to a depth sufficient to mitigate expansion is a common and acceptable mitigation method.

2. Chemical Treatment. Chemical treatment may be used to mitigate expansive characteristics of the soil, when approved by the Town Engineer.

3. Subsurface Drains. Subsurface drains may be effective at reducing the groundwater, thereby reducing swelling.

4. Moisture Treatments. Soils may be conditioned with moisture and compacted to an appropriate level of compaction for the expansive condition, including stability requirements.

5. Other Procedures. Other procedures may be proposed for review and approval by the Town Engineer. The chosen method must work for the full life expectancy of the roadway.

### C. SPECIFIC MITIGATION REQUIREMENTS

Specific mitigation requirements and methods generally accepted by the Town of Windsor are described in **Section 3, Street Construction Specifications, Section 02225 – Grading, Compaction, and Unimproved Area Preparation** of this manual.

## 2.05 FINAL PAVEMENT DESIGN REPORT

### A. GENERAL

All streets in the Town of Windsor or its GMA, are required to use the Street Structural Design Criteria presented herein. These criteria shall be used in conjunction with **Section 1, Minimum Design Criteria.** Soils Investigations and Report requirements are outlined in **Section 2, 2.01 through 2.04.** The Final Pavement Design Report shall include follow-up testing for subgrade soil expansion, subsurface water, and R-value.

1. Existing Streets. For existing streets the Town Engineer may require deflection tests or other testing of the existing pavement and base structure to determine if an overlay is feasible, or if reconstruction is necessary.

2. AASHTO Design. The design criteria and procedures presented follow American Association of State Highway and Transportation Officials (AASHTO) 1993 Guide for the Design of Pavement Structures.

3. Pavement Type. Streets shall be constructed of either hot bituminous asphalt pavement (HBP) or Portland Cement concrete pavement (PCCP), on top of compacted aggregate base course material and subgrade.

4. Treated Subgrade. The use of treated subgrade, or treated base may be acceptable when designed and submitted by the Geotechnical Engineer, and approved by the Town Engineer in accordance with these standards. The subgrade must be within six (6") inches of final subgrade elevation prior to any soil tests and borings.

5. Roundabouts. The pavement thickness design for the circulatory roadway shall be based on the sum of the twenty (20-yr) year design volumes from all legs. A separate pavement design is required. The minimum asphalt sections listed in **Table 2.08.1** shall also apply to roundabouts.

6. Approval. A preliminary pavement design may be submitted with final construction plans, but will not be approved until subgrade soil samples are analyzed after preliminary grading and sanitary sewer construction. Town's approval is required prior to subgrade treatment, placement of aggregate base course, or pavement (including curb and gutter) construction.

7. Pavement Design Updates. A new, revised Pavement Design investigation and report shall be required if the following conditions occur:

   a. Phases. If it has been more than one (1) year since the original design was completed, or if the roadway design or location has been changed.

   b. Imported Fill Material. If imported fill material is used, tests must be taken to prove that the properties of the imported material meets or exceeds the properties (R-Value) of the on-site materials. If this condition is not met, the Pavement Design shall be updated.

## 2.06 FINAL PAVEMENT DESIGN – SOILS SAMPLING

### A. SOIL INVESTIGATION REQUIREMENTS

1. Timing. Soil borings shall be taken in the existing or proposed street right-of-way. Subgrade samples shall be taken after the installation of the sanitary sewer, waterline, or other utilities on which the final in situ subgrade strength characteristics may be affected by their installation. The subgrade shall be with-in six (6") inches of final subgrade elevation. Any required fill material shall be placed to the sub-grade elevation prior to sampling. The final Pavement Design Report shall be approved by the Town, prior to installation of curb and gutter, sub-bases, bases, or pavement.

2. Frequency of Testing. A minimum of two (2) borings shall be obtained per project, or a minimum of one (1) boring per five hundred (500') lineal feet of new roadway, whichever is greatest. One

(1) of the borings shall be required in the trench of any installed utilities and one (1) in compacted subgrade. Multiple samples shall be taken alternately among lanes and shall be evenly spaced. The Geotechnical Engineer or the Town may require more frequent testing, especially on sites that have high groundwater, or contain soils that could be unstable or might have swell potential.

3. Depth of Borings. Borings shall be taken to a minimum depth of four (4') feet below the proposed subgrade elevation. The Geotechnical Engineer or Town may require deeper borings, especially when related to high groundwater levels, utility trenches, soils with swell potential, or other design concerns.

## 2.07 FINAL PAVEMENT DESIGN – SOILS TESTING

Soils shall be classified visually and tested in a laboratory to determine the properties listed in **Section 2.01 Soils Investigations**. A Boring Log and the following tests are required for each sample for Final Pavement Design.

**TABLE 2.07.1**
**Tests Required for Each Boring**

| Test | Testing Frequency | Notes / Exceptions |
|---|---|---|
| Visual | Each Soil Type | Described in the Field |
| Liquid Limit | Each Soil Type | Passing No. 40 Sieve |
| Plastic Limit | Each Soil Type | Passing No. 40 Sieve |
| Moisture | Each Soil Type | |
| Percent Passing 200 | Each Soil Type | |
| Gradation | Each Granular Soil | A-1 through A-4 Soils |
| AASHTO Classification | Each Soil Type | |
| R-Value | See **Section 2.01.E** | |
| Swell / Consolidation Test | Each Clay Soil Type | A-6 through A-7 soils |
| Percentage of Soluble Sulfates | Each Clay Soil Type | A-6 through A-7 Soils |
| Standard Penetration Test | Each Soil Type | |
| Groundwater | Elevation | If encountered |
| Bedrock Level | Elevation | If encountered |

### A. SUBGRADE SUPPORT TESTING

Subgrade samples shall be tested for subgrade support value (R-Value). The Final Pavement Design Report shall clearly state whether or not the subgrade soil is capable of supporting the proposed construction and design traffic loads. Recommendation for subgrade stabilization (See **Section 2.04**), if required, shall also be provided.

### B. HVEEM STABILOMETER

The subgrade support value shall be determined using Hveem Stabilometer (R-Value). The design R-value shall be for three hundred (300 psi) pounds per square inch (2070 kPa) exudation pressure. Reported data shall be contained in the Final Pavement Design Report and shall include the following:

1. Test procedure reference.
2. Dry density and moisture content for each sample.
3. Expansion pressure for each sample.
4. Exudation Pressure. Corrected R-value curve showing the three hundred (300 psi) pounds per square inch (2070 kPa) design R-value.

## C. SWELL TESTS

Swell tests shall be conducted for all A-6 through A-7 soils. The following table provides a guideline for expansion potential. Surcharge pressure shall be one hundred fifty (150 psf) pounds per square foot. At least two (2) samples shall be required per soils report, with one (1) test sample within trench backfill and one (1) outside of trench backfill; thereafter, continue with one (1) swell test every fourth ($4^{th}$) sample unless waived by the Town Engineer.

**Table 2.07.2**
**Expansion Potential of Subgrade Soils**

| Percent Passing No. 200 Sieve | Liquid Limit (percent) | Standard Penetration Resistance (Blows/Ft) | Volume Change Estimate (% of Total) | Expansion Classification |
|---|---|---|---|---|
| >95 | >60 | >30 | >10 | Very High |
| 60-95 | 40-60 | 20-30 | 4-10 | High |
| 30-60 | 30-40 | 10-20 | 1-3 | Medium |
| <30 | <30 | <10 | <1 | Low |

# 2.08 PAVEMENT THICKNESS DESIGN CRITERIA

Pavement design procedures in this section provide for a twenty (20-yr) year service life of pavement when normal maintenance is provided to keep the roadway surface in an acceptable condition.

## A. DESIGN FACTORS

1. Equivalent Daily Load Applications (EDLA). Equivalent Daily Load Applications (EDLA) and Equivalent Single Axle Loads (ESAL) units are based on eighteen (18k) kip (80 KN) axle loading on each design lane. All data and design procedures in this section use EDLA or ESAL units for pavement loading repetitions. Minimum EDLA and ESAL criteria for each roadway classification are given in **Table 2.08.1**, **Flexible Pavement Design Criteria**. The values shall be increased for roadways with a traffic study showing higher traffic numbers.

2. Design Serviceability. The Serviceability Index to be used for all Town Roadways dedicated for public use is given in **Table 2.08.1**, **Flexible Pavement Design Criteria**.

3. Minimum Pavement Section. **Table 2.08.1**, **Flexible Pavement Design Criteria**, provides the minimum acceptable pavement sections for each roadway classification based on assumed subgrade support and traffic values. These pavement thicknesses may be used for preliminary planning purposes, cost estimates, or final pavement designs when approved by the Geotechnical Engineer and the Town. All pavement thickness designs must be based on actual subgrade support test results and traffic projections for the specific project, but shall not be less than the minimum per **Table 2.08.1**, **Flexible Pavement Design Criteria**.

4. Flexible Pavement Strength Coefficients. **Table 2.08.2**, **Pavement Strength Coefficients**, contains the standard design coefficient for various pavement materials. Nonstandard design coefficients may be used, only if approved in advance by the Town Engineer. In addition, design values must be verified by pre-design mix test data and supported by daily construction tests.

5. Portland Cement Concrete Pavement. PCCP roadways shall have a minimum thickness of six (6") inches, and shall meet the requirements of **Section 02585, Portland Cement Concrete Pavement** in this Manual. The working stress ($f^t$) to be used in the design shall be seventy five (75%) percent of that provided by third-point beam loading, which shall have a minimum laboratory twenty eight (28) day strength of six hundred (600 psi) pounds per square inch based on actual tests of materials to be used.

## TABLE 2.08.1

## Flexible Pavement Design Criteria

| ROAD CLASSIFICATION | 20-Year Design Traffic Information | | Serviceability Index (psi) | | | Reliability | Aggregate Base Thickness, (inches) Class 5 or 6 | | Asphalt Thickness, (inches) | | Grading S[1] (¾ inch aggregate) | | Grading SG (1½ inch aggregate) | | Minimum Structural Number[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min. EDLA[2] | Min. ESAL | $S_i$ Init | $S_t$ Final | D (psi) | (percent) | Layer, inches | | Layer, inches | | Layer, inches | | Layer, inches | | |
| | | | | | | | Min | Max | Min | Max | Min | Max | Min | Max | |
| LOCAL | | | | | | | | | | | | | | | |
| Residential two lane | 5 | 36,500 | 4.5 | 2.0 | 2.5 | 75 | 6 | NA | 3.5 | 5.5 | 2 | 3 | 3.0 | 4.0 | 2.39 |
| Residential one lane[4] | 10 | 73,000 | 4.5 | 2.0 | 2.5 | 80 | 6 | NA | 3.5 | 6.0 | 2 | 3 | 3.0 | 4.5 | 2.49 |
| Industrial/commercial | 50 | 365,000 | 4.5 | 2.3 | 2.2 | 75 | 6 | NA | 5.0 | 7.5 | 2 | 3 | 3.0 | 6.0 | 3.29 |
| COLLECTOR | | | | | | | | | | | | | | | |
| Minor | 25 | 182,500 | 4.5 | 2.3 | 2.2 | 75 | 8 | NA | 5.0 | 7.0 | 2 | 3 | 3.0 | 5.5 | 2.97 |
| Major | 50 | 365,000 | 4.5 | 2.3 | 2.2 | 85 | 8 | NA | 6.0 | 8.0 | 2 | 3 | 3.0 | 6.5 | 3.48 |
| Industrial/commercial | 100 | 730,000 | 4.5 | 2.3 | 2.2 | 85 | 8 | NA | 6.0 | 9.0 | 2 | 3 | 3.0 | 7.5 | 3.85 |
| ARTERIAL | | | | | | | | | | | | | | | |
| Two lane | 100 | 730,000 | 4.5 | 2.5 | 2.0 | 90 | 10 | NA | 6.0 | 9.5 | 2 | 3 | 3.0 | 8.0 | 4.08 |
| Four lane | 200 | 1,460,000 | 4.5 | 2.5 | 2.0 | 90 | 10 | NA | 6.5 | 10.5 | 2 | 3 | 3.0 | 9.0 | 4.51 |
| Six lane | 300 | 2,190,000 | 4.5 | 2.5 | 2.0 | 90 | 10 | NA | 6.5 | 11.0 | 2 | 3 | 3.0 | 9.5 | 4.77 |

**NOTES:**

1. Wearing surface course shall be Grading S or SX for residential roadway classification and Grading S for collectors, arterials, and all industrial/commercial roadways.
2. EDLA shall be calculated based on projected traffic uses. Minimum EDLA values are as given for the design lane. Greater EDLA values may be required if warranted.
3. Minimum structural numbers are based on subgrade R-value = 5 and MR (Resilient Modulus) =555 x R + 1000.
4. Single lane refers to a paved surface less than 20 feet wide, including residential alleys.
5. Min/Max lift thicknesses: Grade SX - 1½"/2½"; Grade S - 2"/3"; Grade SG - 3"/5" (2" minimum wearing course).
6. See **Section 02575, Bituminous Paving – SuperPave Method**, for additional requirements.

Sep't, 2009

## B. SPECIAL CONSIDERATIONS

1. Staged Construction. Staged construction is an alternative for the Developer to provide a minimum thickness pavement (bottom lift) during construction, and after repairs, construct the final lift of asphalt, providing for a new finished pavement surface. If the full pavement section is not to be placed during the same construction season, a pavement design for staged construction may be required by the Town Engineer. The staged construction design must include asphalt thickness for each proposed stage. Calculations, traffic numbers, and construction truck traffic numbers supporting the staged design must also be submitted. For staged construction, accommodations must be provided for the paved surface to drain with no water left standing on the pavement, and all manhole and valve boxes shall be set at grade for the interim paving surface. Manholes and valve boxes shall later be adjusted to final grade, including concrete collars, after placement of the top lift of asphalt. The Town shall inspect the bottom lift(s) of asphalt prior to placement of the top lift. The Town will not accept maintenance responsibilities for any new roadway prior to the full design depth of asphalt being completed.

2. Full Depth Sections. Full depth asphalt pavement sections are not allowed. All new asphalt roadways require a minimum of six (6") inches depth of aggregate base course.

3. Rehabilitating Existing Asphalt Streets. Prior to overlaying existing asphalt, the Town Engineer may require nondestructive testing to determine the amount of overlay necessary to bring the street to current standards. The method of nondestructive testing and the data obtained must be in a form compatible with the Town's pavement management system. All "potholes", utility trench settlement, cracking, and any similar imperfections shall be repaired to the Town Engineer's satisfaction prior to overlaying. The Town shall inspect the existing asphalt street prior to placement of any overlay. Asphalt pavement grading SX may be used for mill/overlay work on local streets only.

4. Special Requirements. The Town Engineer may require Portland Cement Concrete Pavement (PCCP) in locations where traffic, utilities, type of construction, subsurface drainage, or time of construction requires special consideration.

## C. PAVEMENT STRUCTURE COMPONENTS

The Pavement Structure Components shall be a combination of one or more of the following courses placed on a subgrade to support the traffic load and distribute it to the roadbed; however, the pavement section must be composite in nature.

1. Subbase. The layer(s) of specified or selected material of designed thickness placed on a subgrade to support a base course, surface course, or both.

2. Base Course. The layer or layers of specified or selected material of designed thickness placed on a subbase or a subgrade to support a surface course.

3. Surface Course. One or more layers of a pavement structure designed to accommodate the traffic load; the top layer of which resists skidding, traffic abrasion and the disintegrating effects of climate. For asphalt pavement, the top layer is sometimes called the "wearing course".

**Table 2.08.2**
**Pavement Strength Coefficients**

| Pavement Structure Component Conventional Materials | Design Strength[1] Coefficients (Per Inch of Material) | Limiting Test Criteria |
|---|---|---|
| Plant Mix Seal Coat | 0.25 | |
| New Bituminous Pavement | 0.44 | R 90+ |
| Existing Bituminous Pavement | 0.24 | See Note 1 |
| New Aggregate Base Course | 0.11 | R>72 |
| Existing Aggregate Base Course | 0.10 | R>69 |
| Granular Subbase Course | 0.07 | R>50 |
| Recycled Asphalt Pavement | 0.07 | R>78 |
| **Chemically Treated Subgrades[2] (or Approved Substitute)** | | **Compressive Strength of Field Specimen** |
| Cement Treated Subgrade | 0.23 | 7 day, 650 - 1000 psi |
| Fly Ash Treated Subgrade | 0.10 | 7 day, 150 psi @ 70°F ± |
| Lime Treated Subgrade | 0.14 | 7 day, 160 psi, PI<6 |
| Kiln Dust Treated Subgrade | 0.10 | 7 day, 160 psi, PI<6 |

**NOTES:**

1. Greater strength coefficient may be considered if derived from deflection data collected on the existing street.
2. Strength coefficient is only acceptable if material is properly mixed and field tests correlate with laboratory results. Strength Coefficient shall be reduced by fifty (50%) percent if field test correlations is not performed.
3. Provide the Town with test results for items tested in the above **Table 2.08.2**.

## 2.09 PAVEMENT DESIGN PROCEDURES

### A. FLEXIBLE PAVEMENT DESIGN

1. General. Flexible pavements are those pavements that have sufficiently low bending resistance to maintain continuous contact with the underlying structure, yet have sufficient stability to support a given traffic loading condition. An example is asphaltic concrete pavement.

2. Procedure. Computer generated printouts and/or other design calculations must be included with the design submittal. The following procedure should be used in determining the structural number and thickness of the pavement being designed:

   a. Confirm the roadway classification and corresponding EDLA. The predicted volumes in the Traffic Impact Study (TIS) must be used whenever they exceed the minimum EDLA values given in **Table 2.08.1.**

   b. Determine the serviceability index (SI) and reliability for the roadway classification (**Table 2.08.1**).

   c. Convert the R-value using the AASHTO conversion for the subgrade to resilient modulus; MR = 1,000 + 555(R-value).

d. Determine the structural numbers using AASHTO pavement design software or nomographs from AASHTO along with soil support test results and EDLA values previously determined. If used, copies of the nomograph determinations must be included with the design submittal.

e. Once the structural number (SN) has been determined, the design thickness of the pavement structure can also be determined by the software that uses the general equation:

$$SN = A1D1M1 + A2D2M2 + A3D3M3 + ...$$

A1 = Hot Bituminous Pavement (HBP) Strength Coefficients.
A2, A3, ... = Strength Coefficients of Additional Pavement Components
The strength coefficients for various components of the pavement structure are given in **Table 2.08.2**.

D1 = Thickness of HBP (inches).
D2, D3, ... = Thickness of Additional Pavement Component Sections.

M1, M2, ... = Drainage Coefficient of Additional Components.
These values are available in AASHTO Design Criteria or from Colorado Asphalt Pavement Association. Designers should use a value of one (1.0) unless specific drainage information indicates otherwise.

Total HBP thickness selected shall not be less than the minimum specified in **Table 2.08.1**, and the aggregate base course thickness selected shall not exceed two (2.0) times the total HBP thickness selected.

f. The standard deviation for design of asphalt pavement shall be 0.44.

g. The design must reference any mitigation measures required when the subgrade contains swelling soils. Design reports recommending permeable layers in the pavement system must present the measures to be used to ensure adequate drainage of such layers and to maintain separation of the layers from the swelling soils. See **Section 3, Street Construction Specifications**, **Section 02575, Bituminous Paving – SuperPave Method**.

## B. RIGID PAVEMENT DESIGN

1. General. Rigid pavements are those that possess a high bending resistance and distribute loads over a large area of foundation soil. Examples include Portland Cement Concrete Pavement (PCCP) which shall have a minimum thickness of six (6") inches and shall meet the requirements of **Section 3, Street Construction Specifications**, **Section 02585, Portland Cement Concrete Pavement**.

2. Procedure. Computer generated printouts and/or other design calculations must be included with the design submittal.

   The design of rigid pavement is a function of structural quality of the subgrade soil (R-value), traffic (EDLA), and the strength of the concrete (working stress). In comparison to the strength of the concrete pavement, the structural contributions of underlying layers to the capacity of the pavement are relatively insignificant. However, to ensure proper drainage, PCCP shall not be placed directly on fine-grained soils.

   The following procedure should be used in determining the structural number and thickness of the pavement being designed:

a. Confirm roadway classification and corresponding EDLA. The predicted volumes in the Traffic Impact Study (TIS) must be used whenever they exceed the minimum EDLA values given in **Table 2.08.1**.

b. Determine the serviceability index of the roadway classification from **Table 2.08.1**.

c. The reliability factor for design of all concrete pavements shall be ninety (90%) percent.

d. The working stress of the concrete is to be obtained from laboratory tests or design tables, and verified during construction.

e. The standard deviation for design of concrete pavements shall be between 0.30 and 0.40.

f. Determine the structural numbers using **AASHTO** pavement design software or nomographs. Printouts from software or copies of the nomographs shall be included with the design submittal.

g. Determine the pavement section thickness. A minimum thickness of six (6") inches of concrete slab must be provided. If fine-grained subgrade exists, a minimum of six (6") inches of aggregate base course shall be provided beneath the slab.

h. Design must reference any mitigation measures required when the subgrade contains sulfates.

### C. RIGID PAVEMENT JOINT DESIGN

The rigid pavement joint designs shall conform to CDOT M & S Standards. A Joint Layout Plan shall be prepared by the Design Engineer and approved by the Town prior to construction.

## 2.10 PAVEMENT DESIGN REPORT

### A. REPORT FORMAT

1. The pavement design report shall be prepared by or under the supervision of and signed and stamped by a Professional Engineer registered in the State of Colorado.

2. The report shall make a recommendation for a typical pavement structural section based on known site soil conditions and the valid traffic impact study.

3. Show original submittal date, and revision dates (if applicable).

### B. REQUIRED INFORMATION

The appendix includes a Pavement Design Report checklist which includes the following items:

1. Vicinity map to locate the investigated area.

2. Scaled drawing showing the location of final boring test holes.

3. Final layout with street names.

4. Scaled drawings showing the estimated extent of subgrade soil types and EDLA for each street classification.

5. Pavement design alternatives for each street classification.

6. Tabular listing of sample designation, depth, group number, liquid limit, plasticity index, percent passing the No. 200 sieve, AASHTO classification, group index, and soils description.

7. R-value test results of each soil type used in the design.

8. Swell/consolidation test results.

9. Identification of any samples consolidated to create composite sample for testing purposes.

10. Borrow source identification (on-site or imported).

11. Pavement design nomographs or computer software printouts.

12. Design calculations and coefficients used for all pavement design section materials.

13. Mix design test results if chemical subgrade stabilization methods have been approved by Town.

14. A discussion of any potential unsuitable subgrade issues including; heave or settlement, frost, ground water, drainage issues, cold weather construction, organics, etc.

15. Recommendations to alleviate or mitigate the impacts of identified unsuitable subgrade soils.

**END OF SECTION**

# TOWN OF WINDSOR

## DIVISION I - STREETS

### SECTION 3

### STREET CONSTRUCTION SPECIFICATIONS

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## SECTION 01010

## SUMMARY OF WORK

### PART 1 - GENERAL

### 1.1 SCOPE

**A.** General.
All pavement and street construction within the Town of Windsor, in Town right-of-ways or on Town owned property shall be constructed in accordance with the requirements of these specifications, Colorado Department of Transportation Standard Specifications for Road and Bridge Construction as referenced herein and as related to Town Ordinances. All standard specifications, i.e. ASA, AWWA, ASTM, ACI, ISSA etc. are made a portion of these specifications by reference and shall be the latest edition and revision thereof. The Town of Windsor standards, specifications, and special provisions shall take precedence over conflicting provisions in the CDOT Standard Specifications and other referenced standards.

Whenever the provisions of these Standards are found to be inconsistent with any other regulations or codes, the Engineer (as defined below) shall determine the standard to apply. The provisions of these regulations are minimum requirements that do not preclude imposition of more restrictive standards by agreement or by law.

**B.** Accepted Plans.
Pavement and street construction shall be done in accordance with engineered construction plans for the work, prepared under the direction of a Professional Engineer and approved by the Town of Windsor Engineering Department. Plans shall conform to the Street Design Criteria section of these specifications and shall show all the information called for on the "Construction Plans Check List" shown in Appendix A. Construction shall conform to the standard detail drawings of the Town of Windsor.

Prior to the Contractor/Owner beginning work, an accepted set of plans and specifications must be on file with the Town of Windsor Engineering Department. All contracts, bonds, insurance, permits, and licenses must be fully executed by the Contractor/Owner before beginning work. Contractor/Owner shall have a copy of the approved plans and specifications, along with the Town's "Design Criteria and Construction Specifications", on the site at all times during construction.

**C.** Preconstruction Conference.
A preconstruction conference shall be held prior to the issuance of any permits for construction. Attendance should include representatives from the Town's Engineering Department, the Public Works Department, Developer/Owner, Design Engineer, General Contractor and Subcontractors including earthwork, utilities, curb and gutter, paving and signing.

### 1.2 GENERAL CONDITIONS

**A. DEFINITIONS**

In addition to the definitions given in **Section 1, MINIMUM DESIGN CRITERIA**, **1.02.D**, wherever the following words, phrases, or abbreviations appear in these specifications they shall have the following definition and meaning:

1. ABILITY – that which a person can do on the basis of present development and training.

2. AGENCY – shall mean the Town of Windsor.

3. BASE COURSE – the layer or layers of specified or selected material placed on a sub-base or a subgrade to support a surface course.

4. CDOT STANDARD SPECIFICATIONS – Colorado Department of Transportation, "Standard Specifications for Road and Bridge Construction" latest edition.

5. CERTIFICATE OF FINAL ACCEPTANCE – At the expiration date of the warranty period and after all deficiencies are corrected to the satisfaction of the Town Engineer, a Certificate of Final Acceptance will be issued.

6. CERTIFICATE OF SUBSTANTIAL COMPLETION – shall constitute the initiation of the warranty period.

7. COMPETENT – a person who has the natural powers, physical or mental, to meet the demands of a situation or work; the word is widely used to describe the ability to meet all requirements, natural, legal, or other of a given task.

8. CONSTRUCTION DRAWINGS – Detailed and working drawings, including plan, profile, and detail sheets of proposed utility improvements, approved by the Town Engineer which graphically shows the scope, extent, and character of the Work to be performed by the Contractor.

9. CONSULTANT – the partnership, corporation, or individual who is a Registered Professional Engineer in the State of Colorado hired by the Owner and is empowered to act as his agent for the project.

10. CONTRACTOR – the corporation, association, partnership, or individual who has entered into an Agreement with the Owner to perform the work, and who is bonded in the Town of Windsor in accordance with the requirements of the Town Code, for public right-of-way work.

11. DAYS – intended as calendar days, not normal working days, unless stipulated as working days.

12. DESIGN ENGINEER – the partnership, corporation, or individual who is registered as a professional engineer, according to Colorado statutes, and who is hired by the Owner, and is empowered to act as his agent for the project.

13. DIVISION – when referred to in the CDOT Standard Specifications shall mean the Town of Windsor Engineering Department.

14. ENGINEER – A term used in situations where a decision or action may be required by the Town Engineer of the Town of Windsor, or his designated representative.

15. LIFT – The maximum specified thickness of material that may be placed at one time.

16. MAY – a permissive condition. No requirement for design or application is intended.

17. NORMAL WORKING DAYS – Monday through Friday. Saturdays, Sundays, and legal Holidays shall not be considered normal working days.

18. OR AN APPROVED EQUAL – as approved to being acceptable by the Engineer.

19. OWNER – the developer, corporation, association, partnership, or individual who has entered into an Agreement with the Town and has entered into an agreement with the Contractor to perform the work.

20. PAVEMENT STRUCTURE – The combination of one or more of the following courses placed on a subgrade to support and distribute the traffic load to the roadbed.

    a. <u>Subbase</u> – The layer or layers of specified or selected material placed on a subgrade to support a base course, surface course, or both. Subgrade that has been treated with lime, fly ash, cement kiln dust, or combination thereof for stabilization is considered subbase.

b. Base Course – The layer or layers of specified or selected materials placed on a subbase or a subgrade to support a surface course.
c. Surface Course – One or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion, and the disintegrating effects of climate. The top layer is sometimes called "Wearing Course."

21. PROJECT AS BUILT RECORD DRAWINGS – Detailed drawings which have been prepared by the Design Engineer, upon completion and at the time of the certificate of substantial completion, and show actual construction and contain field dimensions, elevations, details, changes made to the construction drawings by modification, details which were not included on the construction drawings, and horizontal and vertical locations of underground utilities which have been impacted by the utility installation.

22. PROJECT REPRESENTATIVE – shall mean an authorized representative of the Engineer assigned to complete project observation and review for contract performances, standards, and contract compliance.

23. PROVIDE – furnish and install complete in place.

24. QUALIFIED – acquired abilities: skill, knowledge, experience, that fits a person for a position, office, or profession.

25. REMOVE – remove and dispose of legally.

26. SHALL – a mandatory condition.

27. SHOULD – an advisory condition. Where the word "should" is used, it is considered to be advisable usage, but not mandatory. Deviations may be allowed when reasons are given which show that the intent of the standard is met.

28. STANDARD STREET SPECIFICATIONS – the current Town of Windsor Design Criteria and Construction Specifications for Streets.

29. STREET – as used in this specification shall include the pavement section, right-of-way, sidewalks, driveways, bikeways, alleys and alley approaches.

30. SUBBASE – the layer or layers of specified or selected material placed on a subgrade to support a base course, surface course, or both. Subgrade that has been treated with lime, fly ash, cement kiln dust, or combination thereof for stabilization is considered subbase.

31. SUBGRADE – the bed of ground or lowest level of a roadway section upon which the subbase is placed to enable the pavement structure, shoulders, and/or curbs and sidewalks to be constructed.

32. SURFACE COURSE – one or more layers of a pavement structure designed to accommodate the traffic load, the top layer of which resists skidding, traffic abrasion, and the disintegrating effects of climate. The top layer is sometimes called "Wearing Course."

33. TESTING – shall mean tests that shall be performed by a qualified engineering testing firm, for the Town of Windsor Engineering Department, to verify compliance with these specifications. Acceptance tests shall include but not be limited to the following: CONCRETE - slump, compressive strength, air content, and aggregate sieve analysis tests, SOILS -moisture density relationship and density tests, AGGREGATE BASE COURSE -moisture-density relationship and density tests, HOT BITUMINOUS PAVEMENT tests.

34. TOWN – The Town of Windsor, Colorado, or an individual employed by the Town of Windsor whom is authorized to make the applicable decisions on behalf of the Town.

35. UTILITIES – shall mean all utilities on site prior to the time of any design; such as but not limited to water lines, sanitary sewer lines, drainage lines, electric lines, gas lines, telephone lines, and cable television lines.

36. WORK – the entire completed construction or the various separately identifiable parts required to be furnished for the project. Work is the result of performing services, furnishing the labor and furnishing and incorporating materials and equipment into the construction.

37. WORKING DAYS – Any day, exclusive of Saturdays, Sundays, and holidays, on which weather and other conditions not under the control of the Contractor will permit construction operations to proceed with the normal working force engaged in performing those items controlling the completion of the work.

38. WORKING HOURS – The Contractor shall restrict working hours to between 7:00 a.m. and 6:00 p.m. on normal Town of Windsor business days unless prior approval has been obtained from the Town Engineer.

## B. ABBREVIATIONS

1. AASHTO – American Association of State Highway and Transportation Officials.

2. ACI – American Concrete Institute.

3. APWA – American Public Works Association.

4. ASTM – American Society for Testing and Materials.

5. AWG – American Wire Gauge.

6. AWS – American Welding Society.

7. CDOT – Colorado Department of Transportation.

8. CMP – Corrugated Metal Pipe.

9. EPA – United States Environmental Protection Agency.

10. HDPE – High Density Polyethylene (pipe).

11. ITE – Institute of Transportation Engineers.

12. ISSA – International Slurry Seal Association.

13. MGPEC – Metropolitan Governments Pavement Engineers Council.

14. MUTCD – Manual on Uniform Traffic Control Devices.

15. OSHA – Occupational Safety and Health Administration.

16. PVC – Polyvinyl Chloride (pipe).

17. RCP – Reinforced Concrete Pipe.

## C. INTERPRETATIONS

1. These Specifications contain many command sentences which are directed at the Contractor/Owner unless otherwise stated.

2. The Contractor/Owner shall request clarification of all apparent conflicts by contacting the Engineer. The Engineer will not be responsible for any explanations, interpretations, or supplementary data provided by others.

## D. VARIANCES FROM STANDARDS

These standards and construction plans are intended to supplement each other. When conflicts and/or questions arise between the accepted plans, specifications, development standards, referenced standards or other contract documents, the Engineer shall make the final decision concerning such matters. If administrative changes are made after approval of the plans, the variance from these standards must be approved in writing by the Engineer. Work shall be completed according to the design accepted by the Engineer. Written clarification shall be obtained from the Engineer for acceptance of omissions, conflicts, or revisions prior to construction.

## E. OMISSIONS

1. Any work not specifically set forth in the construction plans or these standards, but which is necessary as determined by the Engineer, shall be completed.

2. The Standards and Specifications are complementary; what is called for by one is as binding as if called for by all. It is the intent of the Standards and Specifications to require a functionally complete Project (or part thereof) to be constructed in accordance with these Standards and Specifications. Any work, materials, or equipment that may reasonably be inferred as being required to produce the intended result will be provided whether or not specifically called for. When words which have a well-known technical or trade meaning are used to describe work, materials, or equipment, such words shall be interpreted in accordance with that meaning.

## F. GENERAL QUALIFICATIONS

The provisions of the Standards and Specifications apply to the construction, enlargement, removal, alteration, relocation, repair, trenching, and restoration of any Public Improvement or common facilities regulated herein.

1. Exceptions – Requests for exceptions shall be submitted in writing to the Town's Engineering Department. The request shall state the variance requested, the justification and supporting data for the variance, and the requested change to the standards or specifications for the specific project. The Engineer may require that exceptions be signed by a professional engineer registered to do work in the State of Colorado and bear their seal.

2. Exceptions to the Construction Specifications for Streets as outlined in this document shall be reviewed by the Town Engineer, or his designee, and shall meet the following criteria for approval:

   a. Special circumstances or conditions exist which limit the ability of the design to meet the design standards outlined in the document. Financial difficulties, loss of prospective profits, and previously approved exceptions in other developments shall not be considered special circumstances; or,

   b. The exception represents an alternative design that will meet the intent of the standards and requirements set forth in this document.

   c. In either case, if granted, the exception will not be detrimental to the public interest or other property, nor in conflict with the Town's Comprehensive Plan, and will not endanger the public safety, health or welfare.

3. All exceptions for construction specifications must be reviewed and acted on prior to construction. The Town shall respond promptly and in writing to such requests but reserves a minimum of five (5) working days for review and response. When additional review time is required, the Town shall notify the submitter of the need for additional time within two (2) working days of the submittal.

## 1.3 REGULATIONS FOR STREET CONSTRUCTION

### A. LICENSES AND PERMITS REQUIRED

1. All paving and street construction, including required cuts and fill in Town rights-of-way shall be done as provided for in the Town of Windsor's Municipal Code. No person, firm, or corporation may perform any work in the public right-of-way without first obtaining the appropriate permit through the Engineering Department. Once the permit is secured, the permittee shall notify the Town's Engineering Department twenty four (24) hours prior to initiating construction.

   Every applicant shall agree in making application for a permit to be bound by all provisions of the Town of Windsor's Municipal Code. The following is required to complete a construction permit:

   a. 8 ½" x 11" Site Plan
   b. Signed and accepted construction plans
   c. Project Schedule
   d. Project Quantities

   A Traffic Control Plan and cover sheet must be submitted and reviewed by the Town Engineer before permit for excavation or construction will be issued.

   A permit for excavation or construction in public right-of-way/easement is required for the following:

   a. Street Paving. Any new street construction, reconstruction, overlays, crack sealing and seal coats.
   b. Curb, Gutter and Sidewalk. Any new, reconstruction, and repair of curbs, gutters, sidewalks, valley gutters, bikeways, driveway and alley approaches, and other various concrete appurtenances in the public right-of-way.
   c. Utility Construction Any new, reconstruction, expansion, and repair of water, sewer, storm sewer, power, gas, telephone, and cable TV lines and other various appurtenances related to these projects in the public right-of-way/easements. This permit also covers Emergency Street Cuts.

2. Other Fees and Permits. The Contractor/Owner shall obtain all necessary permits for construction, unless otherwise directed by the Town Engineer. All permits must be in accordance with Town, County, State, and Federal requirements. Town review and approval of all permits must be accomplished prior to the start of any construction. Examples of permits that might be required and locations where initial contact is to be made are as follows:

| Partial List of Permits | Initial Contact |
|---|---|
| State's Utility Permit | CDOT |
| State's Access Permit | CDOT |
| Railroad Use of Right-of-Way | Railroad Company |
| Railroad Work in Right-of-Way | Railroad Company |
| E.P.A. N.P.D.E.S. Permit | Colorado Dept. of Health |
| Corps of Engineer's Permits | Corps of Engineers |
| Air Quality | Weld and/or Larimer County |
| Work in Ditch Right-of-Way | Individual Ditch Companies |

   This list is provided as an aid, and shall not be interpreted as a complete list of all permits required. It shall be the responsibility of the Contractor/Utility to determine the type of permits required by the specific development. The Town shall make every effort to assist the Contractor/Owner in determining, and obtaining permits required. A copy of all permits must be available for inspection on the job site at all times.

All required fees must be paid in advance, prior to issuance of permit and commencement of any construction.

## B. PROJECT OBSERVATION AND REVIEW

1. All construction and installations shall be subject to observation and review by the Engineer or his authorized Project Representative. Certain types of work may have continuous observation and review.

2. It shall be the responsibility of the person performing the work authorized by the permit to notify the Town that such work is ready for observation and review. The Town requires that every request for observation and review is to be received one (1) working day before such service is desired. Such requests shall be made by telephone to the Town's Construction Inspector at 970-686-7476, Monday through Friday between 8:00 A.M. and 4:30 P.M.

   The Contractor/Owner wishing to work outside of these hours and requiring observation and review of such work shall be assessed an observation and review fee based upon the actual costs to the Town associated with supplying a project representative for overtime hours. Additionally, there will be a two (2) hour minimum for observation and review work outside of the normal work hours. The Contractor/Owner is responsible for notifying the Construction Services of his intent to work overtime hours, weekends, or holidays. Such notice shall be given as soon as possible, but, in no case less than twenty four (24) hours prior to the overtime work. The Engineer or his representative shall have total control when determining the need for observation and review of any work.

3. The Engineer may make or require other observations and reviews of any work as deemed necessary to ascertain compliance with the Town's Development Standards, Design and Construction Standards, or other standard specifications and codes.

4. The Project Representative is authorized to check all work performed in connection with street construction, including but not limited to clearing and grubbing, compaction of subgrade, placement of sub-base, base and asphalt, forms, concrete work, signage, pavement markings, and materials to be used.

5. The Project Representative is present on the site to advise contractors on these standards. He has authority to reject defective materials and workmanship, until any questions of issue can be resolved by the Engineer, and advise the Contractor/Owner in complying with construction plans and standards.

6. The Project Representative shall, in no case, act as foreman or perform other duties for the Contractor/Owner, nor interfere with the management of the work done by the Contractor/Owner. The presence or absence of the Project Representative shall not relieve in any degree, the responsibility or the obligation of the Contractor/Owner to perform the work in accordance with the plans or specifications.

7. The Engineer and Project Representative shall, at all times, have reasonable and safe access to the work whenever it is in preparation or progress and the Contractor/Owner will provide proper facilities for such access for observation and review. The Project Representative has the authority to select locations for tests.

8. The Engineer and/or Project Representative may suspend or stop the work, wholly or in part, until defective workmanship has been corrected for any of the following reasons; 1) for such period of time deemed necessary due to unsuitable weather conditions; 2) for Contractor's/Owner's failure to perform according to these standards; or 3) for Contractor's/Owner's failure to provide safe working conditions.

9. Whenever any portion of these specifications are violated, the Town Engineer, by written notice, may order that portion of construction which is in violation of these specifications or other approved plans, specifications, and materials to cease until such violation is corrected. A copy of the notice

shall be filed with the Contractor's license application for future review. If deficiencies are not corrected, performance shall be required of the Contractor's Surety. A re-inspection of constructed facilities shall occur at the end of the warranty period.

## C. QUALITY ASSURANCE

1. The Town shall make periodic checks to verify the quality and progress of the work. The authorized agents and their representatives of the Town shall be provided safe access to the work, whenever it is in preparation or progress. The Contractor/Owner shall provide for such access and for inspection, including maintenance of temporary and permanent access.

2. Materials and equipment rejected by the Town shall be identified and marked for removal.

3. The Contractor/Owner shall supply geotechnical services for verification that concrete, asphalt, granular and geotextile materials, moisture and compaction requirements are being met in accordance with the frequencies and methods specified in this manual. All quality control test results shall be made available to the Engineer immediately after testing. Copies of all tests shall be provided to the Town on a periodic basis and all test results will be submitted prior to a certificate of substantial completion being issued by the Town of Windsor.

4. The Town will review all acceptance testing. Acceptance testing may include but not be limited to tests associated with placing of concrete, asphalt, and base course subgrade preparation, and trench compaction. The Contractor/Owner shall coordinate with the Project Representative as to when he or she is ready for acceptance tests. See Appendix (Schedules For Quality Control and Acceptance Sampling and Testing).

5. The Contractor/Owner shall be responsible for the costs associated with re-testing due to failed quality control and acceptance tests.

6. Conflicts. In case of a conflict or disagreement between codes, standards, laws, ordinances, rules, and regulations or within any document itself, the more stringent requirements, as determined by the Engineer, shall govern. Where work required by drawings or specifications is above the standard required by local regulations or recommended standards, it shall be completed as shown and/or specified.

7. Soil Compaction Tests.

   a. All utility trenches within the street right-of-way (including service lines) must be mechanically compacted to not less than ninety five (95%) percent of maximum density within plus or minus two (± 2%) percent of optimum moisture content as determined by AASHTO T-99. Alternatively, utility trenches can also be backfilled with flowable fill to within one (1') foot of finished grade. This includes gas, electric, TV cable, telephone and other utility lines serving the development. All water and sewer services, including water and sewer main stub-outs, shall be installed prior to street construction. Trench backfill in utility easements within twenty (20') feet of right-of-way shall be mechanically compacted to ninety five (95%) percent maximum density or backfilled with flowable fill to within one (1') foot of finish grade. Trench backfill in utility easements beyond twenty (20') feet from right-of-way shall be compacted to ninety (90%) percent maximum density. Water settlement and/or jetting of trenches shall not be permitted.

   b. Quality Assurance shall comply with ASTM D 698 or AASHTO T-99 – Standard Method of Test for Moisture Density Relations of Soils using a five and a half (5.5 #) pound hammer and a twelve (12") inch drop.

      i. Use method A, B, C, or D, as appropriate, based on soil condition and judgment of the testing laboratory.
      ii. Sample tests shall be representative of materials to be placed.
      iii. Determine and provide optimum density curve for each type of material encountered or utilized.

iv. Include Atterberg Limits, grain size determination, and specific gravity.

c. Quality Assurance shall comply with ASTM D 2049 – Test for Relative Density of Cohesionless soils.

d. Quality Assurance shall comply with ASTM D 2844 or AASHTO T-90 - Test for R-value to determine load-bearing capacity of materials.

e. Test results shall be basis for Field Quality Control.

8. Submittals.

a. Submit test certificates with the following information to enable the Engineer to determine compliance with the Specifications for imported materials from each proposed source or supplier.

i. ASTM D 698 or AASHTO T-99.
ii. ASTM D 2049.
iii. ASTM D 2844 or AASHTO T-90.

b. All testing shall have been completed within six (6) months prior to incorporating the material into the Project.

9. Pavement Testing. See **Section 02575, Bituminous Paving**, **and Section 02585**, **Portland Cement Concrete Pavement**, for testing and quality assurance specifications.

## D. PRODUCT DELIVERY, STORAGE, AND HANDLING

1. Select transportation schedule and truck routes with approval of the Town to keep impacts on the public to a minimum.

2. Do not stockpile excavated materials against existing structures or work.

3. If any material is stockpiled on the job site, it shall be done in an orderly manner and kept a sufficient distance from banks, open trenches, or excavations to avoid overloading and prevent slides or cave-ins.

4. Maintain adequate drainage and erosion control efforts during construction.

## E. MATERIALS, MANUFACTURER'S CERTIFICATES AND RECOMMENDATIONS

1. All materials and equipment shall be new and of a quality acceptable to the Town's Engineer.

2. If required by the Town's Engineer, the Contractor/Owner shall furnish satisfactory evidence (including reports of required tests) as to the kind and quality of materials and equipment. All materials and equipment shall be applied, installed, connected, erected, used, cleaned, and conditioned in accordance with the instructions of the applicable supplier except as otherwise provided in the Contract Documents; but no provision of any such instructions will be effective to assign to the Town, or any of Town's representatives, any duty or authority to supervise or direct the furnishing or performance of the work.

3. When deemed necessary by the Engineer, the Contractor/Owner shall submit a certificate to the Engineer, secured from manufacturer of all the material used as a permanent part of the project, certifying that their product as used on the project, conforms to all Town specifications. No material shall be used until the certificates are approved by the Engineer.

4. All manufacturer's recommendations, instructions, or specifications regarding installation and use of products shall be considered a part of these Standards and Specifications and of equal force. Any

conflict between the manufacturer's instructions and these Standards and Specifications shall be decided and settled by the Engineer and shall not be open for arbitration. All such manufacturer's instructions and submittals shall be presented to the Engineer for approval prior to scheduling a pre-construction meeting.

## F. TRAFFIC CONTROL

A Traffic Control Plan (TCP) shall be submitted and reviewed by the Town Engineer prior to commencing any work. If the proposed work is in the State Highway right-of-way, then a construction traffic control plan approved by CDOT must be submitted to the Traffic Division prior to commencing any work. The Contractor/Owner shall be responsible for all types of traffic, including pedestrians, in the construction area. SPECIAL ATTENTION SHALL BE GIVEN TO INDIVIDUALS UNDER THE AMERICANS WITH DISABILITY ACT. Any person who makes pavement cuts, excavations, places an embankment, or does any work in public right-of-way, including but not limited to areas along a public street, alley, or sidewalk, shall place barricades, lights, warning signals, detour signs as appropriate, and/or other safety devices at the location, sufficient to warn the public of the hazard, the cut, excavation or embankment. Safety devices must be in compliance with the Manual on Uniform Traffic Control Devices (MUTCD) and the "Colorado Supplement" to the MUTCD.

The Contractor/Owner shall appoint a Traffic Control Supervisor who shall be responsible for traffic control and who shall be certified by the American Traffic Safety Services Association (ATSSA) and/or the Colorado Contractor’s Association (CCA). The Supervisor must be available twenty four (24) hours per day to resolve traffic control problems during construction. All Traffic Control Supervisors shall have in their possession a current T.C.S. card. A current copy of the T.C.S. card must be on file at the Traffic Operations Division one (1) week in advance of job setup. Provide a Traffic Control Supervisor on job site at all times during job set-up.

All work areas including but not limited to open cuts, trenches, ditches, manholes, and/or other hazards shall be completely surrounded by approved fencing and other appropriate controls to protect and warn pedestrians and persons using bicycles, wheel-chairs, and other vehicles. Temporary walk ways must be provided, with all weather surfacing.

The Contractor/Owner shall maintain fencing to completely surround open cuts for trenches, manholes, or other hazardous sites.

Intersections and driveways shall be closed only for a minimum amount of time. The Contractor/Owner shall coordinate driveway closures with property owners, one (1) week prior to construction by written notification with final approval by the Engineer.

Removal of any and all signs shall be coordinated with the Engineering Division. It will be the responsibility of the Contractor/Owner to replace/repair said signs until job project is final with Town’s acceptance of the project after the warranty period.

Developments with private streets shall also adhere to these same guidelines; except their traffic control devices shall be permanently maintained by their Homeowner’s Association Group.

The Contractor shall maintain responsibility to change or adjust traffic control devices if conditions warrant.

All flaggers shall be properly trained according to State and Federal guidelines. The Contractor/Owner shall submit copies of flagger's certifications card to the Engineer, and/or Traffic Operations prior to construction.

The Contractor/Owner shall repair and replace damaged or missing traffic control devices immediately.

The Contractor/Owner shall maintain all necessary barricades, signs, permanent signs, temporary signs, pavement markings, and other traffic control devices between phases of construction even if construction activity ceases for a year or more.

After the streets are constructed, the new streets must be controlled with either construction traffic control barricades or approved temporary or permanent traffic control signage (stop signs, street signs, etc.) and pavement markings. Building permits cannot be issued until appropriate traffic control is in place because of construction traffic into, out of, and throughout the development site. Also, other traffic which is not construction related frequently drives through these sites. Street signs are included as required signage during the building construction phase to insure that emergency services and building inspection staff can find building addresses.

Prior to issuing building permits for any buildings within a phase of development construction, approved permanent traffic control signage and pavement marking must be in place and approved by Town Engineering Division personnel.

All traffic control signage (temporary or permanent) must be in accordance with MUTCD, CDOT Standards, and Town of Windsor standards.

The Town of Windsor will not be responsible for the maintenance of traffic signs or pavement marking as part of a new subdivision until Final Acceptance. At that time Public Works will complete an inspection of the development to assure all the signs and pavement markings were installed in accordance to approved plans.

If there are deficiencies, the Contractor/Owner or other party shall be responsible, at no cost to the Town, to bring Traffic Control signs and pavement markings back in compliance with approved plans.

If the traffic control is deemed insufficient, notice will be given to rectify. If after one (1) hour, the deficiencies have not been corrected, the Town reserves the right to temporarily suspend operations until compliance.

The Contractor/Owner shall hold harmless the Town of Windsor and Town staff against claims resulting from accidents involving construction work or construction traffic control.

The Owner/Contractor shall schedule and expedite the work to cause the least inconvenience to the public. Construction or repair work will not be permitted at or near the vicinity of signalized intersections or on any Arterial and Collector streets that have major traffic volumes between the hours of 7:00 a.m. to 8:30 a.m. and 3:30 p.m. to 6:30 p.m. during the rush hours and school term (except in the case of an emergency or with approval from the Engineer). When the work is stopped for the day, all traffic lanes of an Arterial or Collector Street shall be opened to traffic unless extended closure is authorized by the Engineer. A traffic lane shall be considered satisfactory for opening to traffic only if it is paved, patched, or plated in conformance with **Section 02595, Utility Cuts, Backfill, and Pavement Patching**. No full street closures will be allowed except in special conditions. No work will be permitted on holidays except in case of an emergency. Construction may not begin until all traffic control devices are in place.

The Contractor/Owner shall remove all traffic control devices immediately upon completion of work or when they are no longer needed (take off job site or move to designated holding area).

## G. CONSTRUCTION STAKES

1. Stakes, which are the responsibility of the Contractor/Owner unless other arrangements are made with the Engineer prior to initial construction, shall be provided as required for pavement structure sections, curb, gutters, sidewalks and structures and furnish all necessary information relating to lines and grades. The Contractor/Owner shall be responsible for the reasonable preservation of all such stakes. Stakes shall not be removed until at least three (3) working days after placement of concrete unless approved by the Engineer.

2. Curb stakes shall be placed at twenty five (25') foot intervals and at the lowest and highest elevations along the vertical curve to minimize flat grades at the high and low points.

3. All vertical control shall be based on the Town's monumentation and current datum. Proposed reference monumentation shall be approved by the Engineer prior to survey.

4. All horizontal control shall be based on the State Plane Coordinate system.

5. A forty eight (48) hour notice shall be given to the Town by the Contractor/Owner prior to providing construction staking.

## H. PRESERVATION OF SURVEY MONUMENTS

It shall be the policy of the Town of Windsor to preserve and perpetuate survey monuments existing within the Public Right-of-Way and at all other locations.

1. Definitions:

   a. "Aliquot Corner" means any section corner or quarter section corner and any other corner in the Public Land Survey System created by subdividing land according to the rules of procedure set forth in Section 38-50-101, "Laws of the State of Colorado regulating the Practice of Land Surveying".

   b. "Acceptable monumentation of aliquot corners" means a monument meeting the physical standards for similar monuments set by the United States Bureau of Land Management (Chapter 1V, Manual of Instructions for the Survey of Public Lands, 1973) pursuant to Colorado State Law. Where any aliquot corner falls within the traffic area of a street, road, or highway, the top of the monument shall be placed one-half foot below the surface of the roadway, and if such surface is any form of pavement, the monument shall be provided with a monument box marked "SURVEY", the top of which shall be set one-quarter (¼") inch below an existing pavement surface and one-half (½") inch below the surface of new pavement.

   c. “Bench Mark” means a permanent or semi-permanent physical mark of known elevation. Benchmarks should include a complete description of the monument with reference ties and the vertical datum with respect to which its elevation is established.

   d. "Professional Land Surveyor" means any individual who practices professional land surveying and is currently registered with the State Board of Licensure for Architects, Professional Engineer and Professional Land Surveyors to practice in the State of Colorado.

2. All existing aliquot corner monuments and benchmarks in the Public Right-of-Way shall be preserved whenever possible. Monuments that must be disturbed during construction shall be referenced by a Professional Land Surveyor before being disturbed and be replaced with acceptable monumentation at the completion of construction.

3. All construction plans or drawings shall show the location of aliquot corner monuments and benchmarks known to be in existence in the area of construction. Should an undiscovered or previously unknown monument be found during construction, it shall be preserved or referenced in compliance with the “Laws of the State of Colorado regulating the Practice of Land Surveying Title 38, Articles 1-101 and Title 38, Articles 53-103” and be replaced with acceptable monumentation at the completion of construction.

4. Should an aliquot corner monument or benchmark be destroyed by construction or utility repair, the Town shall have authority to cause such monument to be legally replaced and monumented at the Contractor/Owner's expense.

## I. JOB CONDITIONS AND CONFORMITY OF WORK AND MATERIALS

1. <u>Underground Obstructions</u>.

a. Known underground obstructions are as shown on the drawings; however, locations shown may prove inaccurate and other obstructions not known may be encountered. Contractor shall field locate and verify all obstructions whether or not shown on the drawings.

b. Notify each utility owner and request utilities to be field located by surface reference at least forty eight (48 hrs) hours prior to excavation.

c. Expose and verify size, location, and elevation of underground utilities and other obstructions where conflicts might exist, sufficiently in advance to permit changes in the event of conflict. Notify Engineer in case of a conflict.

d. Maintain, protect, and support by shoring, bracing, or other means, existing utilities and appurtenances.

e. If Contractor elects to remove underground obstructions, the following shall apply:

   i. Replace all underground obstructions which are still in use with new materials.
   ii. Restore to original conditions or better.

f. Maintain drainage culverts and/or irrigation channels during construction and clean culverts and channels so they are free of all sediment and debris after construction.

2. Blasting. The use of explosives will not be permitted without a blasting permit issued by the governing fire authority and only upon approval by the Town Engineer.

3. Drainage and Groundwater.

   a. Maintain excavations free from water during construction.

   b. Remove and dispose of surface water and groundwater entering excavations, trenches, or other parts of the work.

   c. In addition to good, positive drainage to eliminate standing water, conduct dewatering operations when necessary.

   d. Divert surface runoff and use pumps, gravel blankets, well points, drainage lines, or other means as necessary to accomplish the above.

   e. Maintain excavations free from water during subgrade preparation and continuously thereafter until the work is completed to the extent that no damage will result from hydrostatic pressure, flotation, or other causes.

   f. Where applicable, based on Soil Reports, excavations shall be maintained in a dry condition to minimize swell potential.

4. Weather.

   a. Do not backfill structures or trenches or construct fills, embankments, stabilization courses or pavement courses during freezing weather.

   b. Do not place backfill, fills, embankments, stabilization courses or pavement courses on frozen surfaces.

   c. Do not deposit, tamp, roll, or otherwise mechanically compact backfill, embankments, stabilization courses or pavement courses on submerged subgrade.

5. Conformity.

All work performed and all materials furnished shall be within the lines, grades, cross sections, dimensions, and material requirements, including applicable tolerances, shown on the plans or indicated in these criteria and specifications.

6. Worksite Maintenance. All Contractor/Owners, Permittees, etc., shall maintain the work site so that:

   a. Trash and construction materials are contained and not blown off the work site.

   b. Trash is removed from a work site often enough so that it does not become a health, fire, or safety hazard.

   c. Trash dumpsters and storage or construction trailers are not placed in the street without specific prior approval of the Town.

   d. As the work progresses, all public rights-of-way and other property shall be cleaned of all rubbish, excess dirt, rock, and other debris, at the sole expense of the Permittee.

   e. Utilize best efforts to eliminate the tracking of mud or debris upon any street or sidewalk. Streets and sidewalks shall be cleaned of mud and debris at the end of each day.

   f. Utilize erosion control measures to prevent erosion and degradation of water quality.

   g. Utilize dust control measures to prevent the blowing and spreading of dust borne material from the work site. Dust control measures may include applying water to soils or aggregates, pre-wetting an excavation area, and dust palliatives.

   h. Provide employee and construction vehicle parking so that there is no parking in the neighborhood adjacent to the work site. There shall be no unauthorized parking on sidewalks.

   i. Provide necessary sanitary facilities for workers, the location of which shall be approved by the Town Engineer and set forth in the permit.

7. Clean-up.

   It shall be the responsibility of each individual Contractor/Owner to keep the work area clean during the prosecution of the work. On a daily basis the Contractor/Owner shall clean up all refuse, mud and dirt on streets, rubbish, scrap materials and debris so that at all times, the site of the work and surrounding area shall present a neat and orderly appearance. Refuse containers shall have lids or covers which shall be closed at the end of each workday and shall not be overfilled so that lids may be tightly closed at all times.

## J. FIELD QUALITY CONTROL

1. Field Compaction Control. Field tests shall be conducted to determine compliance of compaction methods with specified density in accordance with:

   a. ASTM D 2922 (AASHTO T-238) – Tests for Density of Soil and Soil-Aggregate In-Place by Nuclear Methods, or,

   b. ASTM D 1556 (AASHTO T-191) – Tests for Density of Soil In-Place by the Sand Cone Method.

   c. ASHTO T-205) – Tests for Density of Soil In-Place by Rubber-Balloon Method.

2. R-value. Field tests shall be conducted to determine compliance of the load-bearing capacity of materials as specified herein in accordance with ASTM D 2844 (AASHTO T-90) and as otherwise specified herein.

3. Gradation. The dry-sieve analysis method of determining the relative proportions of aggregate shall be in accordance with ASTM C 136 (AASHTO T-27) and as otherwise specified herein.

4. Moisture Content. Compact soils and other materials within plus or minus two (±2%) percent of optimum moisture content.

5. Geotechnical Engineer.

   a. Contractor/Owner shall retain the services of a Geotechnical Engineer and Testing Laboratory, which shall be approved by the Town Engineer, to perform all required geotechnical testing and sampling.

   b. Contractor/Owner shall permit the Geotechnical Engineer access to the job site at all times and shall furnish any labor or equipment required to assist the Geotechnical Engineer in obtaining and handling samples at the source of material and at the Project.

   c. Contractor/Owner shall provide and maintain, for the sole use of the Geotechnical Engineer, adequate facilities for safe storage of equipment and test specimens on the Project site.

   d. Contractor shall not prepare subgrade, sub-base, stabilization materials or base materials or place any additional paving courses until such testing, inspection and approval thereof has taken place (or waived by the Town Engineer) and resulting recommendations of Engineer have been carried out.

   e. The Geotechnical Engineer personnel are not authorized to stop work, to revoke, alter, relax, enlarge, or release any requirements of the Standards, nor to approve, accept, or reject any portion of the Work on behalf of the Town of Windsor.

## K. LOAD RESTRICTIONS

The Contractor/Owner shall comply with CDOT Section 105 of the latest edition of the Standard Specifications for Road and Bridge Construction for Truck-Load Weights.

## L. UTILITY COORDINATION

1. During construction the Contractor/Owner shall keep inlets, junction boxes, manholes, control valves, and fire hydrants clear at all times. For all street construction which impacts utilities, the Contractor/Owner shall provide a Town-approved means of temporary service during the approved construction time and properly reconnect such utility service immediately following construction.

2. In the event that a manhole frame, valve box, or other fixture is covered up during construction, it shall be made accessible within twenty-four (24) hours and raised to the proper alignment and grade prior to the issuance of the Certificate of Substantial Completion unless otherwise approved by the Engineer.

3. Locating or moving existing utilities or coordinating the installation of new utilities is the responsibility of the Contractor(s)/Owner performing the work. Relocation of utilities which are in a public right-of-way or easements shall be the responsibility of the permittee.

4. The Contractor/Owner shall, at all times, take proper precautions for the protection of utilities, the presence of which are known or can be determined by field location of the utility companies. The Contractor/Owner shall be responsible for all expenses relating to damage to utilities. Hand-excavation shall be used whenever necessary. It is the Contractor/Owner's responsibility to call for utility locates and abide by those requirements as outlined by State Statutes. Call UNCC at 1-800-922-1987 for locates

## M. SAFETY AND PROTECTION

The Contractor/Owner shall be responsible for initiating, maintaining and supervising all safety precautions and programs in connection with the work. Contractor/Owner shall take all reasonable and necessary precautions for the safety of, and shall provide the necessary protection to prevent damage, injury or loss to:

1. Employees and other persons onsite who may be affected.

2. The work and materials or equipment to be incorporated therein, whether in storage on or off the site

3. Other property at the site or adjacent thereto, including, but not limited to trees, shrubs, lawns, walks, pavements, roadways, structures and utilities not designated for removal, relocation or replacement in the course of construction.

Contractor/Owner shall comply with all applicable laws, ordinances, rules, regulations and orders of any public body having jurisdiction for the safety of persons or property or to protect them from damage, injury or loss; and shall erect and maintain all necessary safeguards for such safety and protection.

## N. ARCHAEOLOGICAL

If the Contractor's excavating operations encounter remains of historical or archaeological significance, the operations shall be temporarily discontinued. The Contractor/Owner shall notify the Engineer, who will contact the proper authorities, to determine the disposition of the remains and artifacts. The Contractor/Owner shall protect the site in such a manner as to preserve the artifacts encountered.

## O. PRESERVATION OF PROPERTY

Existing improvements, adjacent property, utilities, trees and plants that are not to be removed shall be protected from injury or damage resulting from the Contractor/Owner's operations.

## P. PROTECTION OF PUBLIC AND PRIVATE INSTALLATIONS

The Contractor/Owner shall at all times take proper precautions for the protection of driveway culverts, street intersection culverts or aprons, irrigation crossings, mail boxes, driveway approaches, valve boxes, manholes, survey monuments, underground or overhead utility lines, temporary or permanent street markings, signage, and all other identifiable installations that may be encountered during construction. The Contractor/Owner shall be responsible for all expenses relating to damage to public and private installations.

## Q. PREVENTION OF WATER & AIR POLLUTION AND DUST CONTROL

1. The Contractor/Owner shall comply with all applicable Federal, State and Local laws, orders, and regulations concerning the control and abatement of water pollution.

2. The Contractor/Owner shall comply with all applicable Federal, State and Local laws, orders, and regulations concerning the prevention and control of air pollution. Unless otherwise indicated on the approved plans, material to be disposed of shall not be ignited or burned, either inside or outside the project boundaries.

3. The Contractor/Owner shall comply with all applicable Federal, State and Local laws, orders, and regulations concerning the prevention and control of dust abatement. A dust abatement plan shall be submitted to the Town Engineer. The Contractor/Owner shall have all necessary equipment and labor readily available to control errant dust due to unexpected winds.

## R. TIMELINESS OF REPAIRS

Repairs, which are not termed a hazard to pedestrians, vehicles, or structures, shall be completed within thirty (30) days after receipt of notice to repair from the Public Works Department.

## S. SEQUENCE OF CONSTRUCTION

All curb, gutter, crosspans, and sidewalk shall be constructed after the sanitary sewer, water, non-potable water, and storm sewer mains and services have been installed in accordance with these standards. All street grades shall be within six (6") inches of finished pavement subgrades prior to curb, gutter and sidewalk installation. Water valve boxes, manholes, and associated appurtenances shall be adjusted to final grade after installation of the pavement. Electrical, telephone, cable TV lines, and all other conduit which are in the public right-of-way shall be installed after sewer, water, non-potable water, and storm sewer mains. Conduit for dry utilities shall be installed prior to curb, gutter, and sidewalk. Tunneling under existing sections of curb, gutter and sidewalk is not allowed. Utility easements shall be brought to final grade prior to installation of utilities. New signage and pavement markings must not be installed until after all road work and utilities have been installed.

## T. COMPLETION AND WARRANTY

Upon written request of the Contractor/Owner, the Engineer and Project Representative shall, in accompaniment with the Contractor/Owner or his representative, physically examine the work and/or phase of the work. One reproducible set of project as-built record drawings shall be prepared by the Contractor/ Owners' Design Engineer and issued to the Town prior to request for Substantial Completion. The Project Representative shall issue a "punch list" of deficiencies to be completed prior to Substantial Completion. If no deficiencies are found, a Certificate of Completion will be issued. The Certificate of Substantial Completion shall constitute the initiation of the warranty period. The Contractor/Owner shall warranty the completed work to be free of defects in workmanship or materials for a period of at least **one (1) year**. All work that fails or deteriorates during the warranty period shall be replaced. The Contractor/Owner shall be responsible for all costs of material, equipment, labor, and/or traffic control for warranty work. Warranty work shall be completed in accordance with these specifications within thirty (30) days of written notification by the Town, or agreed upon by the Engineer.

The determination of the necessity during the warranty period for the repair or replacement in whole or in part of the work shall rest entirely with the Town Engineer.

## U. ACCEPTANCE

Upon written request of the Contractor/Owner, the Engineer and Project Representative shall, in accompaniment with the Contractor/Owner, physically examine the work and/or phase of the work. The Engineer or his designee shall issue written partial acceptance of the work with a "punch list" of deficiencies to be completed within thirty (30) days and prior to final acceptance. After all deficiencies are corrected to the satisfaction of the Town Engineer, a Certificate of Final Acceptance will be issued. If no deficiencies are found, the Town Engineer will issue a Certificate of Final Acceptance. The issuance of a Certificate of Substantial Completion and/or Certificate of Final Acceptance shall not relieve the Contractor/Owner from the responsibility or liability of conforming to the approved plans and specifications.

Such written request shall not be made more than sixty (60) days from the end of the warranty period nor less than thirty (30) days.

## V. PAYMENTS

When the CDOT Standard Specifications refers to payment or basis of payment, it shall be disregarded unless specifically referred to in other contract documents associated with the work. The Town of Windsor has no responsibility for payments unless the work was contracted by the Town.

## W. CONFLICTS/QUESTIONS

When conflicts and/or questions arise between the accepted plans, specifications, development standards, referenced standards, or other contract documents, the Town Engineer shall make the final decision concerning such matters.

## X. LIABILITY

The Town, the Engineer, or Engineer's authorized representatives charged with the enforcement of these Standards and Specifications, acting in good faith and without malice in the discharge of their duties, will not thereby be rendered personally liable for any damage that may accrue to persons or property as a result of any act or by reason of any act or omission in the discharge of their duties.

## Y. NO WAIVER OF LEGAL RIGHTS

The Town will not be precluded or stopped by any measurement, estimate, or certificate (made either before or after the completion and acceptance of the work) from showing the true amount and character of the work performed and the materials furnished by the Contractor/Owner, or from showing that any such measurement, estimate or certificate is untrue or is incorrectly made.

**END OF SECTION**

## SECTION 02220

## EXCAVATION, REMOVALS AND EMBANKMENT

### PART 1 – GENERAL

### 1.1 SCOPE

The Work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials necessary to perform clearing, grubbing, removal, and disposal of objectionable materials from the right-of-way prior to excavations, placement of embankment including borrow, utility installations and grading operations pertaining thereto for roadways, and the preparation of subgrade, as directed, in conformity with lines, grades, and typical sections as shown on the plans or as staked.

### 1.2 QUALITY ASSURANCE

Quality Assurance shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.C.

### 1.3 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I.

### 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.D.

### PART 2 – MATERIALS

### 2.1 SOIL MATERIALS

A. Generally, soil materials for roadway construction shall be as recommended in the approved Soil Report. The following soils materials are the minimum requirements for the materials to be used for embankment material in the construction of roadways.

B. Embankment and fill material shall consist of soil, granular sand, gravel, and cobble material, free from frozen material, organic material, trash, glass, broken concrete, asphalt chunks, and other corrosive or deleterious material. The Contractor shall import approved material as necessary. Approval of embankment and fill material is contingent on the material having a resistance value when tested by the Hveem Stabilometer, or equivalent resilient modulus value, of at least that specified in the approved plans or pavement design and a maximum dry density of not less than ninety (90pcf) pounds per cubic foot. The material must be stable and have a liquid limit less than forty (40) and a plastic index less than twenty (20) when tested in accordance with AASHTO T-89 and T-91, respectively. Size restrictions are as follows:

1. No material shall have a dimension larger than six (6") inches. If old concrete pieces are used, they shall be crushed. If old asphalt pieces are used, they shall be milled. Where the subgrade layer is less than six (6") inches, the maximum size shall not exceed two thirds (2/3) the depth of the layer. For stabilization material, larger sizes may be permitted, with prior approval.

2. These size restrictions are contingent upon the material being evenly distributed in finer material such that uniform soil consolidation is achieved. If uniform soil consolidation is not being achieved, the Engineer may reduce the size of materials allowed or change the embankment and fill material requirements.

3. Where unstable subgrade is encountered, the Contractor shall take steps necessary to stabilize the material by techniques such as over-excavation and backfill with imported material, use of geotextile reinforcement, chemical stabilization or other methods. The Contractor shall notify the Engineer of

the proposed solution to stabilize the subgrade. If required by the Town, the Owner's Design Engineer will make recommendations on stabilization techniques and materials. See Geotextile Reinforcement Placing, Street Construction Specifications, **Section 02225** subsection 3.4.

4. If tests or observations reveal that material being placed is not of suitable quality and structural value, or in the event that sufficient material is not available for embankment construction or filling excavations from which unsuitable material is removed, the Contractor shall import other material (select borrow) as specified below and as approved by the Engineer.

C. Select borrow material shall be a well graded mixture of sound mineral aggregate particles containing sufficient proper quality bonding material to secure a firm, stable foundation when placed and compacted on the roadway. When tested with laboratory sieves, the material shall meet the following gradation requirements:

**Table 02220-1**
**SELECT BORROW MATERIAL**

| SIEVE DESIGNATION | % BY WEIGHT PASSING LAB SIEVES |
|---|---|
| 4 inch | 100 |
| No. 10 | 80 |
| No. 200 | 5 - 15 |

The Contractor/Owner will be required to provide a screen or other means to eliminate fines passing the No. ten (10) sieve if such fines prove to be objectionable at any time during construction. If tests reveal that material being imported is not of suitable quality for the purpose for which it is intended, Contractor/Owner shall provide alternative material.

## PART 3 – EXECUTION

### 3.1 CLEARING AND GRUBBING

The Contractor/Owner shall establish the construction limits in accordance with the plans and Town requirements. The natural ground surface shall be cleared of all vegetation; such as, trees, logs, upturned stumps, roots of downed trees, brush, grass, weeds, and all other objectionable materials within the limits of construction. All surface objects and all trees, roots, and other protruding obstructions not designated to remain shall be cleared and/or grubbed, including mowing, as required, except stumps and roots and nonperishable solid objects which will be removed a minimum of two (2') feet below subgrade or slope of embankments. In streets, stumps and root systems shall be completely removed, even if it extends below the two (2') foot level. Except in areas to be excavated, all cavities resulting from the removal of obstructions shall be backfilled with suitable material and compacted in accordance with subsection 3.6 - Embankment.

Trees which are to be removed shall be removed in such a manner as not to injure standing trees, plants, and improvements which are to remain. Any object that is designated to remain and is damaged shall be repaired or replaced as directed by the Engineer at the Contractor's expense.

Before the start of any overlot grading, stockpiling of soil, or clearing or grubbing operation, the Contractor/Owner shall file and obtain approval for a State of Colorado permit for Erosion and Sediment Control. The Contractor/Owner shall also file and obtain approval for an Erosion Control Plan (ECP) which shall be approved by the Town. See the Town's Storm Drainage Design Criteria Manual for details of the ECP. Contractor/Owner shall check with the Town Engineer and verify if a Floodplain Development Permit is required. The installation of those items required on the ECP shall be installed and functional prior to the start of any land disturbing activities. Additionally, the Contractor/Owner shall post with the Town a letter of credit (or other sufficient surety) in an amount to be determined by and as required by the development agreement. All disturbed soil, on or off-site and related to work at the project site, is required to be protected

from wind and storm water erosion. To mitigate erosion, the contractor shall use standard erosion control techniques described in " A Guide for Erosion and Sediment Control in Urbanizing Areas of Colorado," published by the Natural Resources Conservation Service, U.S. Department of Agriculture.

## 3.2 REMOVAL AND DISPOSAL OF MATERIALS

All materials removed shall be legally disposed of outside of the right-of-way. No accumulation of flammable material shall remain on or adjacent to the right-of-way. The roadway and related work areas shall be left with a neat and finished appearance. In no case shall the material removed from the right-of-way and temporarily stockpiled be left in such a manner as to pose an erosion, weed, or hazard to the public; they shall be left with long sloping sides (minimum slope of 3:1) and in such a manner as to accommodate the use of mechanical mowing equipment. Temporary stockpiles shall be removed prior to construction acceptance, unless otherwise approved by the Town Engineer. The Contractor shall make all arrangements to obtain written permission from property owners for disposal locations outside the limits and view of the project. Broken concrete and asphalt shall be separated (mingling of materials is prohibited) and disposed of properly.

The Contractor shall legally dispose of all material that is deemed unusable by the Engineer, off of the project site within thirty (30) days of notification.

## 3.3 REMOVAL OF EXISTING IMPROVEMENTS

A. Bituminous Pavement.

Bituminous pavement shall be removed to clean, straight lines by such methods as cutting, drilling, or other methods that will insure the breaking of pavement in a straight line in accordance with **Utility Cuts, Backfill, and Pavement Patching**, **Section 02595** of this manual. All saw cutting shall not extend past the construction limits by more than the depth of the structure and such overcut shall be sealed by a method approved by the Engineer.

Pavements which are to be overlaid shall be repaired as required by **Section 02595, Utility Cuts, Backfill, and Pavement Patching**.

Also see **Section 02595**, **Utility Cuts, Backfill, and Pavement Patching**, for restrictions on cutting and patching bituminous pavement.

B. Concrete Pavement.

Crosspans, Alley Intersections, and Concrete pavement shall be removed to the nearest construction joint or saw cut to full depth. See Standard Details. Sections shall be saw cut in straight lines either parallel with the curb or perpendicular to the alignment of the sidewalk or curb. All over sawing shall not extend more than the depth of the structure past the construction limits and shall be sealed in the same manner as joints. If the removed portion falls within less than five (5') feet of a construction joint, cold joint, expansion joint, edge, crack, or existing patch, the concrete shall be removed to the joint, crack, edge, or patch.

See **Section 02595**, **Utility Cuts, Backfill, and Pavement Patching**, for restrictions on cutting and patching concrete pavement.

C. Concrete Curb, Gutter, Sidewalk, and Driveways.

Concrete shall be removed to edges neatly sawed to full depth. Sidewalks and driveways shall be saw cut in straight lines either parallel with the curb or perpendicular to the alignment of the sidewalk or curb. Concrete shall be cut full width, at the midpoint of the concrete section, or no less than five (5') feet long. If the saw cut in the sidewalk or driveway falls within less than five (5') feet of a construction joint, expansion joint, or edge, the concrete shall be removed to the joint or edge. The sawing of concrete shall be done carefully, and all damages to concrete to remain in place due to Contractor's operations shall be repaired at the expense of the Contractor. All saw cutting shall not extend past the construction limits by more than three (3") inches and such overcut shall be sealed in the same manner as cracks.

See **Section 02595**, **Utility Cuts, Backfill, and Pavement Patching**, for restrictions on cutting and patching concrete curb, gutter, sidewalks, driveways, etc. See Standard Details.

D. Miscellaneous Obstructions.

In addition, removal of fences, old pavement, abandoned pipelines, irrigation structures, etc., and excavation of every description and of whatever substances encountered within the limits of the project shall be included.

## 3.4 TREE REMOVAL

The Town of Windsor Parks Department shall be notified and approval obtained prior to excavation, removal, and/or modification of any tree within the public right-of-way.

## 3.5 EXCAVATION

A. Excavation of all materials shall be performed in conformity with the lines and grades indicated on the drawings and as staked. Suitable material removed from the excavations may be used in the formation of embankments and backfilling or any other areas within the right-of-way as permitted by the Engineer. Where material encountered within the limits of the work is considered unsuitable by the Engineer, such material shall be excavated as directed by these standards, the plans, or the Engineer and replaced with suitable material.

B. Grading shall be done as necessary to prevent surface water from entering the excavation. Any other water accumulation therein shall be promptly removed. Earthwork construction shall be performed in a manner that does not obstruct surface drainage or prohibit access to operational driveways, fire hydrants, manholes, and water valves.

C. Foundations and the pavement structure shall be founded on original, undisturbed soil or on structural backfill extended to the undisturbed soil. Foundations and the pavement structure shall not be founded on existing fill if encountered at the project site. If existing fill is encountered at the subgrade, the Contractor shall either provide certified proof from a geotechnical engineer that the existing fill material is adequate and free of organics and other deleterious materials, or shall excavate to original undisturbed soil and bring the grade to the required elevation with approved material and methods. Existing fill may be stockpiled for reuse in backfills and embankments if it meets the requirements of the specifications. The Contractor shall remove unsuitable soil material as directed by the Engineer. The disposal of unsuitable soil material is the responsibility of the Contractor.

D. Excavate rock that is encountered at the site to a minimum depth of twelve (12") inches below subgrade within the limits of the roadbed. The use of explosives will not be permitted without prior approval by the local fire authority and only upon approval by the Town Engineer. All blasting methods and technologies shall meet all applicable local, county, state, and federal guidelines and recommendations.

E. The Contractor/Owner shall provide all stakes and grade locations to enable finish subgrade elevations for roadways and curb and gutter within a tolerance of plus or minus four one hundredths of a foot ($\pm$ 0.04'). For sidewalks, a tolerance of plus or minus eight one hundredths of a foot ($\pm$ 0.08') is permitted.

F. The Contractor shall blend the intersection of cut slopes with the slopes of adjacent natural ground surfaces in a uniform manner. The tops of cut slopes shall be flattened and rounded in accordance with the approved plans.

G. All excavated material shall be stockpiled in a manner that does not endanger the work or workers and does not obstruct sidewalks, streets, alleys, and/or driveways. Maximum permissible slope on stockpiles shall not exceed three to one (3:1). The work shall be done in a manner that will minimize interference with traffic and/or drainage of the street. The Contractor at the end of each day shall barricade all excavations and ditch lines, remove excess excavated material from travel ways, and thoroughly clean all streets, alleys, and/or sidewalks affected by the excavation.

H. Materials encountered during excavation; such as, rubbish, organic, or frozen material, and any other material which is unsatisfactory for use as backfill in the opinion of the Engineer, shall be removed from the site and legally disposed of at the Contractor's expense. Stones, concrete, or asphalt chunks larger than six (6") inches or frozen material shall be considered unsatisfactory backfill and removed by the Contractor. Frozen material, however, may be thawed out and used at a later date.

## 3.6 EMBANKMENT

This work shall consist of the construction of embankments by depositing, placing, and compacting material of acceptable quality and structural value above the natural ground or other surface in conformance with the lines, grades, and cross-sections shown on the drawings or as established in the field. Before any embankment is placed, clearing, tree removal, sod and topsoil removal over the entire area shall be performed in accordance with paragraphs 3.1 through 3.5 above.

When an embankment is to be placed on slopes, it shall be continuously benched in horizontal layers to key into the existing slope. Each layer of the embankment material shall not exceed eight (8") inches in loose depth. The Contractor shall thoroughly mix and insure uniform density and moisture for proper compaction.

Cut areas shall be thoroughly compacted for a depth of eight (8") inches below finished subgrade. Each layer in fill and cut areas shall be thoroughly compacted by static roller, vibratory equipment, or other preapproved methods. See **Section 02225, Grading, Compaction, Subgrade, and Unimproved Area Preparation**, Subsection 3.1, for details of grading, compaction, and subgrade preparation. The base of fill areas should be scarified to a depth of not less than eight (8") inches and compacted to not less than ninety five (95%) percent of maximum density within plus or minus two ($\pm$2%) percent of optimum moisture content as determined by AASHTO T99, prior to placement of embankment material. Each layer, or lift, shall be wetted or aerated, if necessary. No embankment material shall be placed upon soft, spongy, or frozen material or other material, the stability of which is, in the opinion of the Engineer, unsuitable for the placement thereof.

## 3.7 FIELD QUALITY CONTROL

Field Quality Control shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.J.

**END OF SECTION**

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**SECTION 02223**

**STRUCTURAL BACKFILL**

## PART 1 – GENERAL

### 1.1 SCOPE

The Work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials and includes the material and construction specifications, necessary to perform structural excavation and structural backfill and filter materials and/or the placement of flowable backfill around structures within the right-of-way, as directed, in conformity with lines, grades, and typical sections as shown on the drawings or as staked in the field. Unless otherwise specified, structure excavation and backfill shall include all pumping, bailing, draining, sheeting, bracing, and incidentals required for proper execution of the Work.

### 1.2 QUALITY ASSURANCE

Quality Assurance shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.C.

### 1.3 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I.

### 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.D.

## PART 2 – MATERIALS

### 2.1 STRUCTURAL BACKFILL

A. Structural Backfill shall comply with **CDOT Standard Specifications** for Class 1 material and meet the following requirements from laboratory sieves:

**Table 02223-1**
**CLASS 1 MATERIAL**

| SIEVE DESIGNATION | % BY WEIGHT PASSING LAB SIEVES |
|---|---|
| 2 inch | 100 |
| No. 4 | 30 - 100 |
| No. 50 | 10 - 60 |
| No. 200 | 5 - 20 |

Class 1 Structural Backfill shall be used on all bridges, box culverts, or where otherwise specified. In addition this material shall have a liquid limit not exceeding thirty five (35) and a plasticity index of not over six (6) when determined in conformity with AASHTO T 89 and T 90.

B. Class 2 Structural Backfill, permitted only upon approval of the Engineer, shall be composed of suitable materials developed on the project. To be suitable for use under this classification, backfill shall be free of frozen lumps, wood, or other organic material. If the material contains rock fragments or other materials that, in the opinion of the Engineer, will be injurious to the structure, the native material shall not be used for backfilling, and the Contractor shall be required to furnish "Class 1 Structural Backfill" material.

C. Flowable backfill may be substituted for Structure Backfill (Class 1) and (Class 2) where it is used to backfill culvert pipes, storm sewer pipes and utility cuts. It shall not be used to backfill abutments.

## 2.2 FLOWABLE BACKFILL

A. Flowable backfill meeting the following requirements shall be used to backfill all open cuts in portions of public right-of-way beneath existing paving, curb, gutter, or sidewalk improvements. Alternate backfill methods for large excavations will be considered on an individual review basis with the Town Engineer.

B. Flowable backfill shall consist of a controlled low-strength, self-leveling concrete material composed of various combinations of cement, fly ash, aggregate, water, and chemical mixture. It shall have a design compressive strength between fifty (50 psi) and one hundred fifty (150 psi) pounds per square inch at twenty eight (28) days when tested in accordance with ASTM D 4832. The mix shall result in a product having a slump in the range of seven (7") to ten (10") inches at the time of placement. The Contractor shall submit a mix design for approval by the Town prior to placement. The mix design shall be supported by laboratory test data verifying compliance with the twenty eight (28) day compressive strength requirements.

C. Compaction of flowable backfill will not be required.

D. Flowable backfill shall not be allowed to freeze.

E. Flowable fly ash backfill shall be a thoroughly mixed combination of the following ingredients:

**Table 02223-2**
**FLY ASH BACKFILL**

| Ingredients | Lbs./C.Y. |
|---|---|
| Class C Fly Ash | 200 – 400 |
| Class F Fly Ash | 1600 – 1800 |
| Water (96 gallons) | 800 (or as needed for proper consistency) |

F. Compaction of flowable fly ash backfill will not be required.

G. Flowable fly ash backfill shall be delivered and placed from volumetric mobile mixers.

H. The maximum lift thickness for flowable backfill shall be five (5') feet. Additional lifts shall not be placed until the flowable backfill has lost sufficient moisture to be walked on without indenting more than two (2") inches. Damage resulting from placing flowable backfill in lifts or layers that are too thick or from not allowing sufficient time between placements of lifts shall be repaired at the Contractor's expense.

I. Flowable backfill will be used on all utility-locate pot holes and/or cores in right-of-way. This flowable fill may be mixed on job site.

J. For locate potholes and/or cores, a cap of non-shrink grout with thickness of five and a half (5½") inches is to be used on all local and minor collector streets, or a cap of non-shrink grout with thickness of seven and a half (7½") inches is to be used on all arterial and major collector streets. This material also may be mixed on job site.

## 2.3 FILTER MATERIAL

Filter material shall consist of free draining sand, gravel, slag, or crushed stone. The following gradations are taken from the CDOT Standard Specifications, Subsection 703.09.

The grading requirements are set forth in the following table:

**Table 02223-3**
**GRADATION SPECIFICATION**
**FOR FILTER MATERIAL**

| Sieve Size | Percent by Weight Passing Square Mesh Sieves | | |
|---|---|---|---|
| | Class A | Class B | Class C |
| 3" | 100 | --- | --- |
| 1 ½" | --- | 100 | — |
| 3/4" | 20 - 90 | --- | 100 |
| No. 4 | 0 - 20 | 20 - 60 | 60 - 100 |
| No. 16 | --- | 10 - 30 | --- |
| No. 50 | --- | 0 - 10 | 10 - 30 |
| No. 100 | --- | --- | 1 - 10 |
| No. 200 | 0 - 3 | 0 - 3 | 0 - 3 |

During progress of construction, the Engineer will determine the class of filter material to be used. The following table is intended to be a guide:

**Table 02223-4**
**RECOMMENDED FILTER CLASSES**

| Sieve Size or Designation | Percentage of Soil Passing Designated Sieves | | |
|---|---|---|---|
| | *Use Class A, B or C | **Use Class B or C | Use Class C |
| No. 10 | less than 85, and | ---- | ---- |
| No. 40 | less than 24 | less than 85 | more than 85 |
| * Based on the minus three (-3") inch portion of the soil adjacent to the filter material. | | | |
| ** To drain large quantities of water, use the most open grading recommended. | | | |

# PART 3 – EXECUTION

## 3.1 STRUCTURAL EXCAVATION

A. Unsuitable foundation material shall be removed and wasted in a manner acceptable to the Engineer. Unsuitable foundation material which is suitable for embankments and suitable surplus excavated material shall be used in the construction of embankments. Unsuitable material removed below designed elevation shall be replaced with approved material.

B. Rock, hardpan, or other unyielding material encountered in trenches for culvert pipe or conduit shall be removed below the designed grade for a minimum depth of twelve (12") inches. This extra depth excavation shall be backfilled and compacted with Class 1 or other approved material. The type of compaction shall be the same as that required for structure backfill (Class 1), as specified below.

## 3.2 STRUCTURAL BACKFILL

A. Backfill shall consist of approved materials uniformly distributed in lifts brought up equally on all sides of the structure. Each lift of backfill shall not exceed six (6") inches before compacting to the required density and before successive lifts are placed. Structural backfill (Class 1) shall be compacted to a density of not less than ninety five (95%) percent of maximum density within plus or minus two (± 2%) percent of optimum moisture content as determined by AASHTO T99.

B. Required density for structural backfill (Class 2) shall conform to **Section 02225 Grading, Compaction and Subgrade Preparation**, Subsection 3.1.

C. Compaction methods that produce horizontal or vertical earth pressures, which may cause excessive displacement or overturning, or may damage structures, shall not be used.

D. Backfill material shall not be deposited against newly constructed masonry or concrete structures until the concrete has developed a field compressive strength of equal to the design compressive strength.

E. Shape the surface of the subgrade under structures such that they are not more than zero inches above or one and one quarter (1-1/4") inches below the required subgrade elevation.

F. Unless otherwise indicated in the Contract or directed by the Engineer, all sheeting and bracing used in making structure excavation shall be removed by the Contractor prior to backfilling.

## 3.3 FLOWABLE BACKFILL

A. Compaction of flowable backfill will not be required.

B. The maximum lift thickness for flowable backfill shall be five (5') feet. Additional lifts shall not be placed until the flowable backfill has lost sufficient moisture to be walked on without indenting more than two (2") inches. Any damage resulting from placing flowable backfill in lifts that are too thick or from not allowing sufficient time between lifts shall be repaired at the Contractor's expense.

## 3.4 FILTER MATERIAL AND PLACEMENT

A. Construction requirements for filter material for subsurface drains shall conform to the applicable requirements of CDOT Standard Specifications Section 605.

B. Filter material shall be placed behind bridge abutments, wingwalls, and retaining walls as provided in the Drawings or specifications and in accordance with the following requirements:

1. Wall drain outlets shall be backed with sacked filter material conforming to the gradation requirements for course aggregate No. 3 or No. 4 set forth in CDOT Standard Specifications Table 703-1.

2. Filter material shall be placed in horizontal lifts along with and by the same methods specified for structural backfill.

## 3.5 FIELD QUALITY CONTROL

Field Quality Control shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.J.

**END OF SECTION**

# SECTION 02225

# GRADING, COMPACTION, SUBGRADE, AND UNIMPROVED AREA PREPARATION

## PART 1 – GENERAL

### 1.1 SCOPE

The work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials needed for grading, import of approved fill material, scarifying, soil stabilization, compaction, and proof-rolling, to perform preparation of the subgrade for roadways within the public right-of-way.

### 1.2 QUALITY ASSURANCE

Quality Assurance shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.C; except sub-section 1.3.C.8.a. shall be modified to include: iv. ASTM C 977

### 1.3 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I.

### 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.D; except subsection 1.3.D. shall be modified to include the following:

A. Lime material, if stockpiled on the job site, shall be protected against weather and drainage, placed in an orderly manner and stored to assure the preservation of its quality and fitness for the work. Fly ash will not be permitted to be stored on the site.

B. Geotextile rolls shall be furnished with suitable wrapping to protect against moisture and extended ultraviolet exposure prior to placement. Each roll shall be labeled to provide product identification sufficient for inventory and quality control purposes. Rolls shall be stored in a manner which protects them from the elements. If stored outdoors, they shall be elevated and protected with a waterproof cover.

## PART 2 – MATERIALS

### 2.1 FILL MATERIALS

For embankment, select borrow, and structural fill materials, see **Sections 02220 and 02223** Subsection Part 2 - Materials.

### 2.2 LIME

The material for lime treated subgrade shall be applied in slurry form. Dry application of lime will not be allowed unless otherwise approved by the Engineer. Commercial lime slurry shall be a pumpable suspension of solids in water. Lime for lime treated subgrade shall conform to the requirements of ASTM C 977 and rate of slaking test for moderate reactivity per ASTM C 110 and shall be the product of a high-calcium limestone as defined by ASTM C 51.

### 2.3 WATER

Water used for mixing or curing shall be reasonably clean and free of oil, salt, alkali, sugar, vegetable, or other substance injurious to the finished product and shall meet the suggested requirements of AASHTO T 26. Water known to be of potable quality may be used without testing. Where the source of water is relatively shallow, the intake shall be so enclosed & monitored as to exclude silt, mud, grass, or other foreign materials.

### 2.4 FLY ASH

The material for Fly Ash treated subgrade shall be applied in dry form and shall conform to the requirements of ASTM C 618 for Class C fly ash. The fly ash shall be from a preapproved source.

## 2.5 GEOTEXTILE REINFORCEMENT

Geotextile Reinforcement shall be as recommended by an experienced Geotechnical Engineer retained by the Owner and who is a Registered Professional Engineer in the State of Colorado, but shall meet or exceed the specifications given below.

Paving geotextile material shall be constructed of nonwoven synthetic fibers; resistant to chemical attack, mildew, and rot; and shall meet or exceed the physical requirements given in **Table 02225-1, Physical Requirements for Paving Geotextiles**, below:

**Table 02225-1**
**Physical Requirements for Paving Geotextiles**

| Property | Requirements | Test Method |
|---|---|---|
| Tensile Strength, N (lbs.) | 450 (100) | ASTM D 4632 |
| Mass per Area, g/m² (oz./sq. yd.) | 140 (4) | ASTM D 3776 |
| Elongation-at-break, %, min. | 50 | ASTM D 4632 |
| Asphalt Retention, L/m² (gal./sq. yd.) | 0.9 (0.2) | Texas DOT Item 3099 |
| Melting Point, ºC (ºF) | 149 (300) | ASTM D 276 |

Securing pins shall be made from galvanized steel wire or other approved wire material, ninety one thousandth (0.091") inch or larger in diameter. They shall be U-shaped, with legs six (6") inches long and a one (1") inch crown.

# PART 3 – EXECUTION

## 3.1 PREPARATION OF SUBGRADE

A. General. Subgrade material shall conform to the lines, grades, cross-sections, and thickness shown on the approved plans and shall be finished and maintained in an acceptable condition at least one day's progress in advance of sub-base and base construction.

B. Preparation Conditions. Work shall not occur on the subgrade in freezing conditions, or when the subgrade is frozen. In cut sections, the material shall be removed from the full width of the roadbed to the designated depth. In fill sections, the material shall be placed and compacted as directed in **Section 02220, Excavation, Removals and Embankment**, to the designated width and depth. The subgrade shall be free of organic and other deleterious material.

C. Scarification. The material below the designated subgrade depth shall be thoroughly scarified to a minimum depth of twelve (12") inches, wetted or aerated as needed and compacted until the required density and stability is obtained unless otherwise approved by the Engineer. Such scarification shall be done in such a manner as to achieve a uniform mixture of the subgrade soils. Pockets of clay, sand, dry, wet, or stratified soil layers are to be thoroughly mixed, creating a soil blend of uniform consistency.

   Scarification shall mean a thorough mixing of the subgrade soils to the required depth either by equipment mounted ripper teeth or turning the soil with a construction disc. If the scarified soil does not exhibit sufficient subgrade strength for roadway construction, the Owner's Geotechnical Engineer shall be consulted and alternate methods of construction may be approved by the Engineer. Application of geotextile reinforcement may be accepted if recommended by the Owner's Geotechnical Engineer.

D. Compaction. This scarified layer shall be moisture treated to within two (2%) percent (or as specified on the plans or Soils Report) of optimum moisture content, disked or sheep-foot rolled, and replaced and compacted to the specified relative compaction. For improved areas, field compaction densities for embankments and subgrade soils shall be as indicated in the Soil Report but not less than ninety five (95%) percent of maximum density or within plus or minus two (± 2%) percent of optimum moisture content as determined by AASHTO T99. For unimproved areas, field compaction densities for embankments and soils shall be not less than ninety (90%) percent of maximum density within plus or minus two (± 2%) percent of optimum moisture content as determined by AASHTO T99.

Do not compact topsoil.

Soft and yielding material and other portions of the subgrade which will not compact when rolled or tamped shall be removed as directed by the Engineer and replaced with suitable material. The Contractor/Owner shall, when requested by the Engineer, furnish the necessary equipment to proof roll a questionable area even though density tests may indicate compliance with density requirements. If, based on proof rolling, the Engineer determines that the questionable area exhibits any visible deflection in the form of weaving or pumping and/or the soil cracks, the Contractor/Owner shall be required to correct the problem to the satisfaction of the Engineer. One such method of stabilizing the subgrade is the use of geotextile reinforcement as given in subsection 3.4 below.

If the required compaction is not obtained, it shall be the responsibility of the Contractor to re-compact the material. In cases where there is a failure to achieve the required compaction, the Engineer may require that the backfill be removed and replaced with Town approved backfill material.

If the Contractor's scheduling of work, methods, or inclement weather caused a naturally suitable subgrade to become unstable, the area shall be sub-excavated and stabilized as described above at the Contractor's expense.

Acceptable compaction test results shall not relieve the Contractor from correction or repairing of any substandard work before or during the warranty period.

E. Final Proof-Rolling. After the subgrade has been compacted, tested, shaped to the required cross-section, and found to meet specifications, the entire subgrade shall be mechanically proof-rolled with a heavily loaded vehicle to ensure uniformity of the subgrade. The vehicle must have a loaded GVW of fifty thousand (50,000 #) pounds with a loaded single axle weight of a least eighteen (18,000 #) pounds and a tire pressure of ninety (90 psi) pounds per square inch. Subgrade which is pumping or deforming under loading must be reworked, replaced or otherwise modified, to from a smooth, stable, non-yielding base for subsequent paving courses. The Town Engineer shall be notified at least twenty four (24 hrs) hours before final proof-rolling. All proof rolls shall be observed and approved by the Town.

Upon approval of the proof-rolling, the sub-base, base course, or initial pavement course shall be placed within forty eight (48 hrs) hours. If the Contractor fails to place the sub-base, base course, or initial pavement course within forty eight (48 hrs) hours or the condition of the subgrade changes due to weather or other conditions, proof-rolling and correction shall be performed again at the Contractor’s expense.

## 3.2 SUBGRADE PROTECTION

During construction, subgrades and excavations shall be kept shaped and drained. Ditches and drains along the subgrade shall be maintained to drain effectively at all times. Where ruts occur in the subgrade, the subgrade shall be brought to grade, reshaped, and recompacted prior to placing of sub-base material. The storage or stockpiling of materials on the subgrade will not be permitted. No base course shall be laid until the subgrade has been inspected and approved. Under no circumstances shall base material be placed on a muddy or unstable subgrade.

## 3.3 SOIL STABILIZATION

Subgrade soils stabilization shall be as specifically recommended in the Soils Report (see **Section 2, Soil Investigations and Pavement Design** of this manual) for subgrade stabilization. If subgrade stabilization is not intended to be part of pavement design (no changes are proposed to final pavement design), but instead is proposed as a remedy to soft subgrade or subgrades failing proof-rolling, then a letter with site specific recommendations for subgrade stabilization methods, prepared by a Professional Engineer registered in the State of Colorado, shall be submitted to the Town for approval prior to any stabilization work. At a minimum the letter shall contain the following information:

- The type of stabilizing agent proposed.
- Percent of stabilizing agent to be used.

- Depth and extent to which subgrade will be treated.
- Moisture requirements if different than that specified.
- Soluble sulfate content of subgrade (only if lime is to be used).
- Swell potential of proposed mix shall be tested and shall be less than 1% at 150 psf, ASTM D4546

A. Lime Stabilization.

1. General. Lime stabilization shall conform to the recommendations contained in the Soil Report and shall consist of treating the earth subgrade by combining lime and water with the pulverized soil subgrade material to the specified depth and compaction requirements.

2. Purpose. The purpose of lime stabilization is to improve the subgrade quality of fine-grained soils (clays and silts only; it is not applicable to sands and gravels) by increasing its strength and reducing its swell-shrink potential during wet-dry cycles.

3. Construction. The Contractor shall construct one or more compacted courses of treated material to the depth specified in the Soils Report. The treated material shall be a uniform blend of soil, lime, and water, free from loose or segregated areas. It shall have uniform density and moisture content and be void of all vegetation and other organic or man-made material. The subgrade shall be well bound for its full depth and width with a smooth surface suitable for placing subsequent courses. The Contractor shall regulate the sequence of the work to accurately apply and uniformly blend the lime at the designated rate and rework the courses as necessary to meet these requirements.

   The Contractor shall submit a mix design to the Engineer for approval, prior to constructing a test section. The Contractor shall mix hydrated or quicklime with water to produce lime slurry at the job site with equipment specifically manufactured for this purpose. Excessive aeration of lime slurry will not be permitted. The lime-treated subgrade shall not be mixed when it is raining, or when the subgrade material is frozen. The lime-treated subgrade shall not be mixed or compacted if the temperature of the lime or soil is below thirty five (35º) degrees F.

4. Preparation of subgrade. Prior to beginning any lime treatment, the surface of the roadbed subgrade shall be graded and finished to smooth and uniform surfaces conforming to the established lines, grades, and cross sections specified. Variation from the subgrade plane elevations specified shall not be more than plus or minus one tenth (±0.1') foot. The subgrade shall also be proof rolled. Soft or otherwise unsuitable subgrade disclosed by proof rolling shall be over-excavated, and replaced to a compacted stable state.

5. Test Section. Prior to full-scale production, the Contractor shall construct a test section to demonstrate, to the satisfaction of the Engineer, subgrade stabilization using the materials, equipment, and methods to be used in full-scale production. The test section shall be at least one hundred (100') feet long, two (2) spreading and mixing lanes wide, and the same depth as the course represented in the plans. The test section shall be constructed at a location approved by the Engineer. The test section shall be tested in accordance with the same test requirements for the lime and soil design mix, and as determined by the Contractor.

   If the test section is unsatisfactory, the Contractor shall adjust the materials, equipment, and methods or combinations thereof as necessary to conform to the specifications. Additional test sections shall be constructed as required to produce a satisfactory test section prior to full-scale production. Unsatisfactory test sections shall be removed and replaced at the Contractor's expense. Full production shall not begin until a satisfactory test section is completed and approved by the Engineer. Prior to start of work, the Contractor shall determine the lime application rate, and the maximum dry density and optimum moisture content of the material after it has been treated with lime. All tests shall be performed in the presence of the Engineer. These test results will be used to determine the requirements for lime application.

6. Proof Rolling. Both prior to and after the lime treatment, the Contractor shall perform proof rolling in accordance with Subsection 3.1 E of this section, except that final proof rolling will take place a minimum of seven (7) days after lime treatment, unless otherwise approved by the Engineer.

7. Application. After the prepared roadbed subgrade has been finished and approved as specified, the subgrade shall then be cut and pulverized to the depth and width required for subgrade stabilization. Precautions shall be taken to avoid forming furrows of loosened material below the depth specified for the lime-stabilized soil mixture. The material thus obtained shall be pulverized. Application, mixing, and compaction shall be in accordance with CDOT Specification Sections 307.08 and 307.09.

8. Finishing and Curing. When initial compaction of the top layer of the lime-stabilized soil mixture is nearing completion, the surface shall be shaped to the required lines, grades, and cross section, and compaction continued until uniform and adequate compaction is obtained. The treated material shall be maintained at a moisture content satisfactory for proper curing by sprinkling for a period of seven (7) days or applying a protective film of emulsified asphalt prime coat (diluted one to one with water) after the lime-treated subgrade has been finished. One application shall be made consisting of two tenths (0.20) gallon diluted mixture per square yard.

   The completed section shall be cured for a minimum of seven (7) days before further courses are added or any traffic is permitted, unless otherwise directed by the engineer.

9. Design and Testing. A site-specific lime-stabilization design is required prior to construction and based on the Soil Report with additional testing required. Testing shall verify that projected "R" values were achieved.

10. Mix Design Approval. To be approved, the mix shall have a minimum five (5) day compressive strength of one hundred sixty (160 psi) pounds per square inch. In addition, the plasticity index of the treated soil shall not exceed six (6). The minimum acceptable hydrated lime content shall be four (4%) percent by weight. Only mix designs approved by the Town shall be used. Minimum in-place thickness for this material shall be eight (8") inches.

B. Fly Ash Stabilization.

1. General. Fly ash stabilization shall conform to the recommendations contained in the Soil Report and shall consist of treating the earth subgrade or existing base, by pulverizing, adding Class C fly ash, and mixing and compacting the mixed material to the required density to the specified depth and compaction requirements.

2. Purpose. The purpose of fly ash stabilization is to secure a completed course of treated material which contains a uniform fly ash/soil mixture with no loose or segregated areas, has a uniform density and moisture content, is well bound for its full depth, and has a smooth surface suitable for placing subsequent courses.

3. Construction. The Contractor shall construct one or more compacted courses of treated material, to the depth specified in the Soils Report. The treated material shall be a uniform blend of soil and fly ash, free from loose or segregated areas. It shall have uniform density and moisture content and be void of all vegetation and other organic or man-made material. The Contractor shall regulate the sequence of the work; to process a sufficient quantity of material to provide full depth as shown on the plans or as called for in the Soil Report; to use the proper amounts of fly ash; to maintain the work and to rework the courses as necessary to meet these requirements.

   The Contractor shall maintain in a satisfactory and workmanlike manner all machinery, tools, and equipment necessary for proper execution of the work which shall be approved by the Engineer prior to the beginning of construction operations. Fly ash shall be furnished in enclosed trucks and each truck shall have the weight of fly ash recorded on certified scales.

4. Preparation of subgrade. Before other construction operations have begun, the surface of the roadbed subgrade shall be graded and shaped to enable the fly ash treatment of materials in place, conforming to the established lines, grades, thickness, and cross sections specified. Variation from the subgrade plane elevations specified shall not be more than plus or minus one tenth (± 0.1') foot.

The subgrade shall also be proof rolled. Soft or otherwise unsuitable subgrade disclosed by proof rolling shall be over-excavated, and replaced to a compacted stable state.

5. Test Section. Prior to full-scale production, the Contractor shall construct a test section to demonstrate, to the satisfaction of the Engineer, subgrade stabilization using the materials, equipment, and methods to be used in full-scale production. The test section shall be at least one hundred (100') feet long, two (2) spreading and mixing lanes wide, and the same depth as the course represented in the plans. The test section shall be constructed at a location approved by the Engineer. The test section shall be tested in accordance with the same test requirements for the fly ash and soil design mix, and as determined by the Contractor.

   If the test section is unsatisfactory, the Contractor shall adjust the materials, equipment, and methods or combinations thereof as necessary to conform to the specifications. Additional test sections shall be constructed as required to produce a satisfactory test section prior to full-scale production. Unsatisfactory test sections shall be removed and replaced at the Contractor's expense. Full production shall not begin until a satisfactory test section is completed and approved by the Engineer. Prior to start of work, the Contractor shall determine the fly ash application rate. All tests shall be performed in the presence of the Engineer. These test results will be used to determine the requirements for fly ash application.

6. Proof Rolling. Both prior to and after the fly ash treatment, the Contractor shall perform proof rolling in accordance with Subsection 3.1 E of this section, except that final proof rolling will take place a minimum of two (2) hours following addition of water to the fly ash, unless otherwise approved by the Engineer.

7. Application. The fly ash shall be spread by a method approved by the Engineer at the rates specified or as directed by the Engineer. Fly ash shall not be applied when wind conditions, in the opinion of the Engineer, are such that blowing fly ash becomes objectionable to traffic or adjacent property owners. During final mixing, the materials shall be sprinkled, as directed by the Engineer, until the proper moisture content has been secured. However, initial mixing after the addition of fly ash will be accomplished dry, or with a minimum of water, to prevent fly ash balls. Final moisture content of the mix, prior to compaction, shall not exceed the optimum moisture content of the mix by more than two (2%) percent. Should the natural moisture content of the soil be above the specified range, aeration of the soil may be required prior to addition of the fly ash.

8. Mixing. The soil and fly ash shall be thoroughly mixed by approved road mixers or other approved equipment. The mixing shall continue until, in the opinion of the Engineer, a homogeneous, friable mixture of soil and fly ash is obtained, free from clods or lumps. Water required to achieve the specified moisture content for the mixture should be added after initial mixing. There shall be a six (6") inch overlap between passes to assure a consistent mix.

9. Compaction. Compaction of the mixture shall begin immediately after mixing of the fly ash and shall be completed within two (2) hours following addition of water to the fly ash. The material shall be sprinkled as necessary to maintain the optimum moisture. Compaction of the mixture shall begin at the bottom and shall continue until the entire depth of mixture is uniformly compacted to the specified density.

   All non-uniform (too wet, too dry, or insufficiently treated) areas that appear shall be corrected immediately by sprinkling and rolling. The surface of the course shall be maintained in a smooth condition, free from undulations and ruts, until additional courses are placed thereon or the work is accepted by the Town.

   The stabilized section shall be compacted to the extent necessary to provide the density specified in **Table 02225-2, Fly Ash Density Specification**, given below:

**Table 02225-2**
**Fly Ash Density Specification**

| Description | Density |
|---|---|
| For fly ash treated subgrade, existing sub-base or existing base that will receive subsequent sub-base or base courses. | Not less than 95% maximum dry density (ASTM 698) |
| For fly ash treated base that will receive surface course. | Not less than 97% maximum dry density (ASTM 698) |

In addition to the requirements specified for density, the full depth of the material shown on the plans or specified in the Soil Report shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section is completed, tests as necessary will be made as directed by the Engineer. If the material fails to meet the density requirements, the Engineer may require it to be reworked as necessary to meet those requirements or require the Contractor to change construction methods to obtain required density. Throughout the entire operation the shape of the course shall be maintained by blading, and the surface, upon completion, shall be smooth and in conformity with the typical section shown on the plans and to the established lines and grades. Blading should be terminated within two (2) hours after blending of the fly ash with the soil. Should the material, due to any reason or cause, lose the required stability, density, or finish before the next course is placed, or the work is accepted, it shall be reprocessed, re-compacted, and refinished at the sole expense of the Contractor. Reprocessing shall follow the same pattern as the initial stabilization, including the addition of fly ash.

10. Finishing, Curing, and Preparation for Surfacing. After the final layer or course of the treated subgrade, sub-base, or base is nearing completion, the surface shall be shaped to the required lines, grades, and cross section, and compaction continued until uniform and adequate compaction is obtained. The resulting base surface shall be thoroughly rolled with a pneumatic tire roller and "clipped," "skinned" or "tight bladed" by a power grader to a depth of approximately one quarter (¼") inch, removing all loosened stabilized material from the section. Re-compaction of the loose material should not be attempted. The surface shall then be thoroughly compacted with the pneumatic roller, adding small increments of moisture as needed during rolling. If plus No. 4 aggregate is present on the surface of the mixture, one complete coverage of the section with the flat wheel roller shall be made immediately after the "clipping" operation. When directed by the Town Engineer, surface finishing methods may be varied from this procedure provided a dense, uniform surface, free of surface compaction planes, is produced. The moisture content of the surface material must be maintained within the specified range during all finishing, and shall proceed in such a manner as to produce, in not more than two (2) hours, a smooth, closely knit surface, free of cracks, ridges or loose material conforming to the crown, grade and line shown on the plans.

    After the fly ash treated course has been finished as specified herein, the surface shall be protected against rapid drying in a thorough and continuously moist condition by sprinkling for a period of not less than three (3) days, or until the surface or subsequent courses are placed. Minimum in-place thickness for this material shall be eight (8") inches.

11. Testing. Testing shall verify that projected "R" values from the Soil Report were achieved.

## 3.4 GEOTEXTILE REINFORCEMENT

A. Geotextile reinforcement shall be used in areas of unstable subgrade if recommended by the Owner's Geotechnical Engineer and approved by the Town. Geotextile reinforcement shall be installed as per the manufacturer's recommendations and as approved by the Town Engineer.

B. Areas on which geotextile reinforcement is to be placed shall have a uniform slope, be reasonably smooth, free from mounds and windrows, and free of any debris or projections which could damage the material.

C. The geotextile fabric shall be unrolled as smoothly as possible on the prepared subgrade in the direction of construction traffic. The geotextile shall be placed by machinery or by hand labor. The geotextile shall not be dragged across the subgrade. Wrinkles and folds in the geotextile (not associated with roadway curves) shall be removed by stretching and staking as required. The geotextile may be held in place prior to placement of cover by pins, staples or piles of fill or rock. On curves, the geotextile may be folded to conform to the curve. The fold or overlap shall be in the direction of construction and held in place as prescribed above. Adjacent geotextile rolls shall be overlapped in the direction of sub-base placement using the guidelines in the table below. Before covering, the condition of the geotextile will be inspected by the Engineer to determine that no holes, rips or other defects exist. If any defects are observed, the section of the geotextile containing the defect shall be repaired by placing a new layer of geotextile extending beyond the defect in all directions a minimum distance equal to the overlap shown in the table below. Alternatively, the defective section may be replaced.

Either sewn seams or overlaps (unsewn seams) shall be used in construction. The widths of the overlaps shall conform to the values given in **Table 02225-3, Minimum Required Overlap**, below. Sewn seams shall be in accordance with the manufacturer's recommendations.

**Table 02225-3**
**Minimum Required Overlap**

| Subgrade Strength (R-value) | Unsewn Seam Overlap Width (Inches) |
|---|---|
| 5 – 10 | 30 |
| 10 – 20 | 24 |
| > 20 | 18 |

The first lift of cover material shall be end-dumped or spread over the geotextile from the edges of the geotextile. The height of the dumped pile shall be limited to avoid local bearing capacity failures. The first lift of cover material shall be graded to a twelve (12") inch thickness or to top of grade whichever is less and compacted. Equipment shall not be on the treated area with less than the minimum thickness of compacted cover material over the geotextile. Small dozer equipment or front end loader shall be used to spread the cover material.

Construction vehicles shall be limited in size and weight such that rutting in the initial lift is no deeper than three (3") inches. If rut depths exceed three (3") inches, the Contractor shall use a smaller size and weight of construction vehicles. Ruts shall be filled in with cover material. Compaction of lifts shall be accomplished without damaging the geotextile. Construction equipment shall not make turns on the first lift of cover material.

## 3.5 SUBGRADE SURFACE TOLERANCE

The excavation and embankments for the street, intersections, and driveways shall be finished to a reasonable smooth and uniform surface. Variations from the subgrade shall not vary more than one quarter (1/4") inch above or one half (½") inch below the required subgrade elevation in soil and shall be sub-excavated to a minimum depth of twelve (12") inches in rock. Where bituminous or Portland cement concretes are to be placed directly on the subgrade, the subgrade plane shall not vary from design grade.

## 3.6 FIELD QUALITY CONTROL

Field Quality Control shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.J; except subsection 1.3.J. shall be modified to include the following:

A. Lime. If a lime stabilizing agent is proposed, the Contractor shall supply the source, type and purity of the lime. The Contractor shall submit a mix design to the Engineer for review and approval, prior to constructing the test section. The test section shall be tested in accordance with the same test requirements for the lime and soil design mix. Full production shall not begin until a satisfactory test section is completed and approved by the Engineer. These test results will be used to determine the requirements for lime application.

B. Fly Ash. If fly ash is proposed as a stabilizing agent, the Contractor shall supply the source, type and purity of the fly ash. The Contractor shall furnish the Engineer with certified weight slips for all fly ash transported to the job site. Certified Test Reports showing that the fly ash meets the specification requirements and supporting this statement with actual test results may be required to be submitted to the Engineer. The fly ash shall be subject to sampling and testing by the Town. Test results that do not meet the physical and chemical requirements may result in the suspension of the use of fly ash until the corrections necessary have been taken to insure that the material meets the specifications. Preapproval may require submission of a report from the supplier documenting the results of testing the fly ash from that source in accordance with the Toxicity Characteristic Leaching Procedure (TCLP) described in 40 CFR, Appendix II, which shall include the results of TCLP testing for heavy metals and other contaminants found in the fly ash.

C. Geotextile Reinforcement. If geotextile reinforcement is proposed to be used in areas of unstable subgrade, the Contractor shall furnish to the Engineer a certified test report from the producer, containing all data required to verify compliance of geotextile reinforcement materials with these specifications

**END OF SECTION**

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**SECTION 02227**

**SUB-BASE**

## PART 1 – GENERAL

### 1.1 DESCRIPTION

The work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials needed to perform preparation of the sub-base within the public right-of-way. The sub-base, when required for stabilization of the subgrade, shall consist of a foundation course composed of granular material constructed on the prepared subgrade in accordance with these specifications and in conformance with the lines and grades and typical cross sections as shown on the plans or established in the field.

### 1.2 QUALITY ASSURANCE

Quality Assurance shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.C.

### 1.3 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I.

### 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.D.

## PART 2 – MATERIALS

### 2.1 GRADATION

This material need not be crushed, but can be of the pit run variety graded to meet the following limits: (**CDOT Standard Specifications** Class 1)

**Table 02227-1**
**SUB-BASE SPECIFICATION**

| STANDARD SIZE OF SIEVE | % BY WEIGHT PASSING SIEVES |
|---|---|
| 2 ½ inch | 100 |
| 2 inch | 95 - 100 |
| No. 4 | 30 - 65 |
| No. 200 | 7 - 15 |
| Liquid limit | 35 maximum |
| Plasticity index | 6 maximum |
| "R" value | 50 minimum |
| Los Angeles Abrasion test (AASHTO M147) | Loss < 50% |

The material supplied shall be a well graded mixture, consisting of sound aggregate particles and sufficient filler or other proper quality binding material, which when placed and compacted will result in a firm, dense, unyielding foundation. Sub-base material shall be well mixed, free of organic matter and lumps or balls of clay.

## PART 3 – EXECUTION

### 3.1 PLACEMENT AND COMPACTION

No sub-base material shall be placed upon a soft, spongy, frozen subgrade, or other unstable subgrade which is unsuitable for the placement thereof. Each layer of sub-base material shall be deposited and spread, without particle segregation, in lifts not to exceed six (6") inches in compacted depth. Each lift shall be wetted or aerated, if necessary, and compacted to ninety five (95%) percent of maximum density at plus or minus two (± 2%) percent of optimum moisture as determined by AASHTO T99.

The surface of each layer shall be maintained during the compaction operations so that a uniform texture is produced and the aggregates are firmly keyed. Water shall be uniformly applied during compaction in the quantity necessary for proper consolidation. The sub-base shall be tested for subgrade support value (R-value) as specified in the Soil Report.

### 3.2 SUB-BASE SURFACE TOLERANCE

The prepared surface of the sub-base shall not vary from the established grade by more than one-quarter (¼") inch above or one-half (½") inch below the required sub-base elevation.

### 3.3 FIELD QUALITY CONTROL

Field Quality Control shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.J.

**END OF SECTION**

**SECTION 02229**

**AGGREGATE BASE COURSE**

## PART 1 – GENERAL

### 1.1 DESCRIPTION

The Work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials necessary to construct a firm and stable foundation base course for roadway construction within the public right-of-way. The base course shall be composed of crushed gravel or crushed stone and filler, constructed on the previously prepared subgrade or sub-base, in accordance with these specifications and in conformance with the lines, grades, typical cross sections, and thicknesses as shown on the plans or established in the field.

### 1.2 QUALITY ASSURANCE

Quality Assurance shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.C.

### 1.3 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I.

### 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010**, Subsection 1.3.D.

## PART 2 – MATERIALS

### 2.1 AGGREGATE BASE COURSE

Crushed gravel or crushed stone base course material shall consist of hard, durable particles or fragments of stone or gravel crushed to required size and a filler of sand or other finely divided mineral matter. The portion of the material retained on a No. four (#4) sieve shall be known as course aggregate, and that portion passing a No. four (#4) sieve shall be known as filler. When produced from gravel, not less than sixty (60%) percent by weight of the coarse aggregate particles shall be particles having at least one (1) fractured face, and if necessary to meet this requirement or to eliminate an excess of filler, the gravel shall be screened. The composite base course material shall be free from vegetable matter and lumps or balls of clay and shall meet the following grading requirements: (CDOT Standard Specifications Class 5 or 6 Aggregate Base Course)

**Table 02229-1**
**AGGREGATE BASE COURSE SPECIFICATION**

| STANDARD SIZE OF SIEVE | PERCENT BY WEIGHT PASSING SIEVES | |
|---|---|---|
| | CLASS 5 | CLASS 6 |
| 1 inch | 90 - 100 | |
| 3/4 inch | 60 - 90 | 100 |
| No. 4 | 30 - 70 | 30 - 65 |
| No. 10 | 20 - 50 | 25 - 55 |
| No. 200 | 3 - 15 | 3 - 12 |
| Liquid limit | 30 maximum | 30 maximum |
| Plasticity index | 6 maximum | 6 maximum |
| "R" value | 72 minimum | 72 minimum |
| Los Angeles Abrasion test (AASHTO M147) | Loss < 50% | Loss < 50% |

The material supplied shall be a well graded, moisture stable mixture, consisting of sound aggregate particles and sufficient filler or other approved quality binding material, which when placed and compacted will result in a firm, dense, unyielding foundation.

## 2.2 SOIL STERILANT

Soil sterilization agent shall be a pre-emergent herbicide, soluble, dispersible, or mixable in water and nontoxic to humans when applied per the manufacturer's recommendations. The agent shall be active for one year after application.

# PART 3 – EXECUTION

## 3.1 PLACEMENT AND COMPACTION

No base course material shall be placed upon a soft, spongy, frozen subgrade or sub-base, or other unstable subgrade which is unsuitable for the placement thereof. Each layer of base course material shall be deposited and spread, without particle segregation, in lifts not to exceed four (4") inches in compacted depth. Each lift shall be thoroughly and individually compacted to ninety five (95%) percent of Standard Proctor Density ASTM D-698. Wetting or aerating and rolling of the material shall be required as ordered by the Engineer, following review of all field test results.

The surface of each layer shall be maintained during the compaction operations so that a uniform texture is produced and the aggregates are firmly keyed. Water shall be uniformly applied during compaction in the quantity necessary for proper consolidation. The base course shall be tested for load-bearing capacity (R-value) as specified in the Soil Report or as directed by the Engineer. At a minimum, the aggregate base course shall be tested for compaction and moisture once every two hundred fifty (250') feet for each lane per lift.

## 3.2 BASE COURSE SURFACE TOLERANCE

The prepared surface of the base course shall not vary from the established grade by more than one-quarter (¼") inch above or one-half (½") inch below the required base course elevation. The surface of the base course will be tested with a ten (10') foot straightedge, or other approved device. The surface shall be tested prior to the application of any other pavement courses, soil sterilant, primer, or pavement. The variation of the surface from the testing edge of the straightedge between any two (2) contacts with the surface shall not exceed one-quarter (¼") inch. All irregularities exceeding the specified tolerance shall be corrected to the satisfaction of the Engineer at the Contractor's expense.

## 3.3 SOIL STERILIZATION

Soil sterilization shall be applied under all new pavements when directed by the Engineer, determined on a case-by-case basis. The operator of the applicator shall be certified by the U.S. Environmental Protection Agency and licensed in the State of Colorado as a pesticide applicator and shall be held responsible for any damage to plant growth outside of the roadway or to pavement where such damage is attributable to carelessness or improper application of the agent. Care shall be taken to prevent contamination of surface waters. The agent shall be applied to the aggregate base course no more than three (3) days prior to paving. The agent shall not be used where it may contaminate water used for irrigation or drinking purposes. Application rates shall be according to the manufacturer's instructions.

## 3.4 FIELD QUALITY CONTROL

Field Quality Control shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.J.

**END OF SECTION**

**SECTION 02575**

**BITUMINOUS PAVING – SUPERPAVE METHOD**

## PART 1 – GENERAL

### 1.1 DESCRIPTION

The Work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials necessary for constructing superior performing asphalt pavements (SuperPave) for streets, or other pavements, on a firm and stable foundation base course within the public right-of-way. The Work shall consist of constructing one (1) or more courses of plant mix hot bituminous pavement, overlay, or leveling course on the previously prepared base, in accordance with these specifications and in conformance with the lines, grades, typical cross sections, and thicknesses as shown on the plans or approved design reports.

### 1.2 QUALITY ASSURANCE

Quality Assurance shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.C. and as modified herein:

A. Pavement Design Report. The pavement design report required in these Standards shall be submitted and approved a minimum of five (5) working days prior to any paving. Refer to **SECTION 2 – SOIL INVESTIGATIONS AND PAVEMENT DESIGN** for detailed information.

B. Mix Designs. The Contractor/Owner shall furnish to the Town Engineer pavement mix designs meeting the requirements of these Standards a minimum of five (5) working days prior to intended use of the mix. The mix design shall be reviewed and accepted by the Town Engineer prior to use. If a mix design not accepted by the Town is used, the Town may require removal of all improvements placed with the unaccepted material.

C. Test Reports. Test reports submitted to the Town shall include all tests performed on the project. Reports shall bear the seal and signature of a Professional Engineer registered in the State of Colorado and competent in the required testing practice. All test reports shall show the location where the test was performed or at which the work or batch represented by the test was located. Test reports shall include all information specified in the AASHTO, ASTM, or Colorado test procedure used. Improperly completed reports will not be accepted. Acceptance will not be complete until all final reports indicating compliance with these specifications are reviewed and placed on file by the Town.

D. Warranty Period. The warranty period for the completed public street improvements cannot start until all required test reports, record drawings, inspection reports, and other documentation are submitted in the proper format and accepted by the Town.

E. Quality Control Testing and Reporting Procedures. All testing methods and procedures performed by the Geotechnical Engineer personnel shall be done in accordance with the applicable AASHTO, ASTM, or Colorado Procedure requirements and procedures, as specified. Test reports shall include the AASHTO, ASTM, and Colorado Procedures (CP) test designations of all tests taken. All testing and retesting services shall be done at the expense of the Contractor/Owner.

When changes in materials or proportions are encountered during construction, or when the work fails to pass tests or fails to meet the Standards, additional tests shall be taken as directed by the Town Engineer. Failure of the Contractor/Owner to furnish satisfactory test data shall be sufficient cause for rejection of the work in question.

F. Testing Program.

1. Control, Acceptance, and Check Testing. All hot bituminous pavements shall be tested in accordance with the following program of process control testing, acceptance testing, and check testing.

Contractor/Owner shall be responsible for testing (and all expenses thereof) on all elements listed in **Table 02575-1**.

2. Quality Control Plan (QCP). Contractor/Owner shall develop a Quality Control Plan (QCP) for the Town and Testing Agency which shall be submitted at the preconstruction conference. No work shall start on the project until the Town Engineer has approved the QCP in writing. For each element listed in Table **02575-1**, the QCP must provide adequate details to ensure the Contractor/Owner will perform process control. The QCP shall address, at a minimum, the following:

   a. Frequency of Tests or Measurements. The QCP shall indicate a random sampling frequency, which shall not be less than that shown in **Table 02575-1**. The process control tests shall be independent of acceptance tests.

   b. Test Result Chart. Each process control test result, the appropriate tonnage, and the tolerance limits shall be plotted. For in-place density tests, only results after final compaction shall be shown. The chart shall be posted daily, or as necessary, at a location convenient for viewing by the Town and the Testing Agency.

   c. Quality Level Chart (QL). The Quality Level (QL) for each element in **Table 02575-1** and each required sieve size shall be plotted. The QL will be calculated in accordance with the procedure in Colorado Process (CP) 71 for Determining Quality Level. The QL will be calculated on tests one (1) through five (5), then thereafter the last five (5) consecutive test results. The tonnage of material represented by the last test result shall correspond to the QL. The chart shall be posted at a location convenient for viewing by the Town and the Testing Agency.

   The QCP shall also be in accordance with the following:

   a. Elements Not Conforming to Process Control. The QL of each discrete group of five (5) test results, beginning with the first group of five (5) test results, shall be a standard for evaluating material not conforming to process control. When the group QL is below sixty five (65), the process shall be considered as not conforming to the QCP. In this case, the Contractor/Owner shall take immediate action to bring the process back into control. Except where the cause of the problem is readily apparent and corrected without delay, production shall be suspended until the source of the problem is determined and corrected. A written explanation of actions taken to correct control problems shall accompany the test data and shall be submitted to the Town and Testing Agency on the day the actions are taken.

   b. Point of Sampling. The material for process control testing shall be sampled by the Contractor/Owner using approved procedures. Acceptable procedures and order of precedence is Colorado Procedures (CP), AASHTO procedures, and then ASTM procedures. The location where material samples will be taken shall be indicated in the QCP.

   c. Testing Standards. The QCP shall indicate which testing standards will be followed. Acceptable standards and order of precedence is the same as indicated in the paragraph above.

   d. Testing Supervisor Qualifications. The person responsible for the process control sampling and testing shall be identified in the QCP. This person must possess one or both of the following qualifications:

      i. Registration as a Professional Engineer in the State of Colorado.
      ii. Level II A, B, and C certifications from the Laboratory for Certification of Asphalt Technicians (LABCAT).

   e. Technician Qualifications. Technicians taking samples and performing tests must possess the following qualifications:

      i. Technicians taking samples and conducting compaction tests must have Level II A certification from LABCAT.

ii. Technicians conducting process control tests must have Level II B certification from LABCAT.

iii. Technicians determining asphalt mixture volumetrics and strength characteristics must have Level II C certification from LABCAT

f. Testing Equipment. All of the testing equipment used to conduct process control testing, including nuclear testing devices for testing of in-place density, shall conform to the standards specified in the test procedures and shall be in good working order.

g. Reporting and Record Keeping. The Contractor/Owner shall report the results of the process control tests to the Town and Testing Agency in writing. The Contractor/Owner shall make provisions such that the Testing Agency can inspect process control work in progress, including sampling, testing, plants, and the Contractor/Owner's testing facilities at any time.

3. Check Testing Program (CTP). The purpose of a check testing program (CTP) is to compare the testing equipment and personnel that will be used according to the requirements in these Standards. Samples used in the CTP do not need to be from random samples or from the project material. Prior to or in conjunction with placing the first five hundred (500) tons of asphalt pavement, under the direction of the Testing Agency, a CTP will be conducted between acceptance testing and process control testing, consisting of five (5) samples of the following elements: Asphalt Content, Voids in the Mineral Aggregate, Air Voids, and In-place Density. The average of the absolute differences between the process control and the acceptance testing personnel will be compared to the acceptable limits shown in column three (3) of **Table 02575-2**. The CTP will be continued until the acceptance and process control test results are within the permissible ranges shown in **Table 02575-2**.

   During production, split samples of randomly selected acceptance control tests will be compared to the permissible ranges shown in **Table 02575-2**. The minimum frequency will be as shown in **Table 02575-1**.

   If production has been suspended and then resumed, the Testing Agency may order a CTP between process control and acceptance testing persons to assure the test results are within the permissible ranges shown in **Table 02575-2**. Check test results shall not be included in process control testing. The Town Engineer shall be called upon to resolve differences if a CTP shows unresolved differences beyond the ranges shown in **Table 02575-2**.

4. Voids in Mineral Aggregate (VMA). After the mix design has been approved and production commences, the first three (3) acceptance tests for Voids in Mineral Aggregate (VMA) will be analyzed to verify and establish a target value of VMA. The Contractor/Owner shall make adjustments if required in accordance with the following: The target value for VMA will be the average of the first three (3) volumetric field test results on project produced hot bituminous pavement or the target value specified in **Table 02575-5** and **Table 02575-6** of the specifications, whichever is higher.

   Whenever a new or revised mix design is used and production resumes, the next three (3) acceptance tests will be required.

**Table 02575-1**
**Schedule for Minimum Sampling and Testing**

| Element | Process Control | Acceptance | Check (CTP) |
|---|---|---|---|
| CP-42 Determining Asphalt Content of Hot Bituminous Mixtures | 1/500 Tons | 1/1000 Tons[1] | 1/10,000 Tons |
| Cpl-5102, Cpl-5103 & Cpl-5115 Voids in the Mineral Aggregate | 1/1000 Tons | 1/1000 Tons[1] | 1/10,000 Tons |
| Cpl-5102, Cpl-5103 & Cpl-5115 Air Voids | 1/1000 Tons | 1/1000 Tons[1] | 1/10,000 Tons |
| Cpl-5106 & Cpl-5115 Hveem Stability | 1/10,000 Tons | 1/10,000 Tons[3] | N/A |
| Cpl-5109 Resistance to Moisture Damage (Lottman) | 1/10,000 Tons | Per Section 02575.1.2.K | N/A |
| CP-31 Gradation | 1/1000 Tons | 1/10,000 Tons[3] | N/A |
| CP-81 Determining % Relative Compaction of Bituminous Pavement | 1/500 Tons | 1/500 Tons[1,2] | 1/5,000 Tons |

Notes:
1. The minimum number of acceptance tests will be at least five (5) asphalt content, five (5) voids in the mineral aggregate, five (5) air voids, and ten (10) in-place densities for all projects.
2. The minimum number of HBP in-place density tests are those made after compaction has been completed and will be in addition to those made in compaction test sections. The acceptance test result for each compaction test section will be an average of the in-place density test results obtained for the Town in that compaction test section.
3. For information only.
4. When unscheduled job mix formula changes are made, acceptance and required number of tests shall be based upon the Town's recommendation.

**Table 02575-2**
**Acceptable Limits of Two (2) Laboratory Test Results**

| Element | Column 1 (Two Labs Testing a split of the same material) | Column 2 Maximum Difference Split Sample | Column 3 Maximum Difference Average 5-Test |
|---|---|---|---|
| Asphalt Content | 0.25 | 0.49 | 0.22 |
| Voids in the Mineral Aggregate | 0.60 | 1.18 | 0.53 |
| Air Voids | 0.59 | 1.16 | 0.52 |
| In-Place Density | 0.77 | 1.51 | 0.67 |

Notes:
1. **Table 02575-6** shows the derivation of the acceptable maximum differences between the averages of five (5) tests performed by two (2) different operators on split samples.
2. Column 1 is the base data showing the historical standard deviation between two (2) operators performing a test on split samples of the same material. Column 2 is the maximum expected difference between two (2) operators performing a test on split samples of the same material.
3. Column 2 is calculated by multiplying Column 1 by 1.96.
4. Column 3 is the maximum acceptable difference between the averages of five (5) tests performed by two (2) different operators on split samples. Column 3 is calculated by dividing Column 2 by the square root of five (√5).
5. In the case of in-place density there may be comparisons between the averages of seven tests performed by two (2) different operators on split samples. The maximum acceptable difference between the averages of seven (7) tests performed by two (2) different operators on split samples is calculated by dividing column 2 by the square root of seven (√7). Thus if there is to be a comparison of seven (7) in-place density tests performed by two (2) different operators on split samples, then the maximum acceptable difference is 0.57.

G. SuperPave Testing.

1. Specification. All testing shall be done in accordance with AASHTO, ASTM, or Colorado Procedures (CP), as designated throughout this section.

2. In-Place Density. A minimum of one (1) test per one hundred (100) tons of material placed, or fraction thereof, or one (1) test per five hundred (500') lane feet, or at a minimum, one per day.

3. Requirements. In addition to the requirements of **Table 02575-3**, all reports shall include elevation or depth below finish grade at which test was taken. Results shall report densities (maximum dry and relative) to nearest one tenth (0.1 #/ft³) pound per cubic foot, moisture content (optimum and in-place) to nearest one tenth (0.1%) percent, and compaction (relative and required) to nearest one tenth (0.1%) percent, results of the daily standardization checks, and the most recent adjusted manufacturer's calibration curve. The manufacturer's calibration curve shall be adjusted as required by ASTM D2950 whenever a change in either the material to be tested or the testing equipment is made. If a nuclear device is used, the report shall contain the method used (i.e. back scatter, direct transmission, etc.).

4. In-place Pavement Thickness. If requested by the Town Engineer, the in-place pavement thickness shall be determined as follows: The pavement shall be core drilled at five hundred (500') foot intervals, or fraction thereof, in each twelve (12') foot lane (nominal), with a minimum of three (3) cores in any area. The Town Engineer may require additional cores to define deficient areas. Core samples shall be taken prior to final lift. Pavement section shall be within one quarter (¼") inch of design thickness.

**Table 02575-3**
**Material Testing**

| SuperPave | AASHTO | ASTM | Frequency |
|---|---|---|---|
| Sampling | T168 | D979 & D3655 | |
| Compaction (Resistance to Flow) | T245 | D1559 | |
| Marshall | | D1561 | 1/650 tons |
| Density | | D1188 & D2950 | 1/500 lane ft |
| Asphalt Content | T164 | D2172 & D3203 | 1/500 tons |
| Thickness | | D3549 | |
| Aggregate Gradation | T27 | C136 | 1/1,000 tons |
| Fractured Faces | | | |

H. Conformance with Plans and Specifications. Conformance to the Standards for all hot bituminous pavements shall be determined by tests and evaluations of asphalt content, voids in the mineral aggregate, air voids and in-place density in accordance with these specifications and relevant CDOT Specifications.

I. SuperPave PG Asphalt Binder Testing and Certification.

1. Independent Laboratory. The Contractor/Owner shall furnish certified test results from an independent laboratory for the required SuperPave PG asphalt binder to the Town Engineer prior to the approval of the mix design. The Contractor/Owner shall have submitted, at least two (2) weeks prior to paving, suitable samples of all materials proposed for use on the project. The Testing Laboratory shall, at the Contractor/Owner's expense, test all materials for compliance with these Specifications and establish a job mix formula for each mixture proposed for use on the project. The independent laboratory shall not be owned, in part or whole, by a supplier of the binder, the Contractor/Owner, or affiliates of either.

2. Test Results and Report. The test results shall show all test data, graphs, tables, and charts used to establish the job mix formula. The report shall bear the seal and signature of a Professional Engineer, licensed in Colorado, and competent in asphalt concrete mix design and construction. The testing laboratory shall report that the proposed materials and job mix meet or exceed this Specification.

3. Project Acceptance. Binder testing for project acceptance will be in accordance with the test procedures referenced in AASHTO MP1 and CDOT Specifications Section 702.01.

4. Suspension of Materials. If proper corrective measures cannot be readily determined, the Engineer will suspend the use of such material until laboratory tests indicate that the corrective measures taken by the Contractor/Owner will provide material that is in compliance with the Course Aggregate Angularity (CAA) Criteria in **Table 02575-9**.

5. Frequency of Testing. A complete quality control test report showing compliance with requirements listed in **Table 02575-9**, shall be submitted for every five hundred (500) tons of binder manufactured for the project. A copy shall be furnished to the Town Engineer at the time of delivery.

6. Sample Location. SuperPave PG asphalt binders shall be sampled at the same location as listed in the CDOT Field Materials Manual for Asphalt Cement and the sample per one thousand (1,000) tons of mix or fraction thereof or as specified in the project plans.

7. Compliance. If testing indicates that the binder is not in compliance with the requirements of **Table 02575-4**, below, the Contractor/Owner shall correct the deficiencies at the direction of the Town Engineer, including removal of the pavement if deemed necessary by the Town Engineer.

**Table 02575-4**
**SuperPave Performance Graded Binders**

| Property | Requirement for PG Binder | | | | | | AASHTO Test No. |
|---|---|---|---|---|---|---|---|
| | 58-28 | 58-34 | 64-22 | 64-28 | 70-28 | 76-28 | |
| **Original Binder Properties** | | | | | | | |
| Flash Point Temp., ºC, minimum | 230 | 230 | 230 | 230 | 230 | 230 | T48 |
| Viscosity at 135°C, Pa•s, maximum | 3 | 3 | 3 | 3 | 3 | 3 | T316 |
| Dynamic Shear, Temp. ºC, where G*/Sinδ @ 10 rad/s ≥1.00 kPa | 58 | 58 | 64 | 64 | 70 | 76 | T315 |
| Ductility, 4 ºC (5 cm/min.), cm min. | - | - | - | 50 | - | - | T51 |
| Toughness, joules (inch-lbs) | - | - | - | 12.4 (110) | - | - | *CP-L 2210 |
| Tenacity, joules (inch-lbs) | - | - | - | 8.5 (75) | - | - | *CP-L 2210 |
| Acid or Alkali Modification (pass-fail) | Pass | Pass | Pass | Pass | Pass | Pass | *CP-L 2214 |
| **RTFO Residue Properties** | | | | | | | *CP-L 2215 |
| Mass Loss, percent maximum | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | *CP-L 2215 |
| Dynamic Shear, Temp. ºC, where G*/Sinδ @ 10 rad/s ≥2.20 kPa | 58 | 58 | 64 | 64 | 70 | 76 | T315 |
| Elastic Recovery, 25ºC, percent min. | - | - | - | - | 50 | 50 | T301 |
| Ductility, 4 ºC (5 cm/min.), cm min. | - | - | - | 20 | - | - | T51 |
| **PAV Residue Properties, Aging Temperature 100°C** | | | | | | | R28 |
| Dynamic Shear, Temp. ºC, where G*•/Sinδ @ 10 rad/s≤5,000 kPa | 19 | 16 | 25 | 22 | 25 | 28 | T315 |
| Creep Stiffness, @60 s, Test Temp in °C | -18 | -24 | -12 | -18 | -18 | -18 | T315 |
| S, maximum, MPa | 300 | 300 | 300 | 300 | 300 | 300 | T313 |
| m-value, minimum | 0.300 | 0.300 | 0.300 | 0.300 | 0.300 | 0.300 | T313 |
| **Direct Tension, Temperature in ºC, @ 1mm/min., where failure strain ≥1.0% | -18 | -24 | -12 | -18 | -18 | -18 | T315 |

* Colorado Procedure
** Direct Tension measurements are required when needed to show conformance to AASHTO MP 320.

8. Certification.

a. If requested by the Town, the Contractor/Owner shall supply copies of the "Certificate of Compliance" and "Certified Test Reports" from the binder supplier. These submittals shall meet all requirements of CDOT Standard Specifications, Section 106.09 and 106.10 respectively.

b. Binder furnished on the basis of "Certificates of Compliance" and "Certified Test Reports" may be sampled and tested by the Town to determine compliance with the applicable specifications.

c. If requested by the Town, the Contractor/Owner shall provide copies of the load delivery tickets for the binder supplied to the asphalt plant. These load delivery tickets shall include the following information:

i. Date, time, and address of delivery.
ii. Type, grade and quantity of binder delivered.
iii. Lot or batch number.

J. Asphalt Mix Design.

1. Test Methods and Criteria. Design mix for hot bituminous pavement shall conform to the following, **Tables 02575-5**, **6**, and **7**:

**Table 02575-5**
**Design Mix Criteria**

| **Property** | **Test Method** | **Value for Grading** | | | |
|---|---|---|---|---|---|
| | | **S** | **SG** | **SX** | **Patching** |
| Air Voids, percent at:<br>N (initial)<br>N (design) **C***<br>N (maximum) | CPL 5115 | <br>>11.0<br>3.0 – 5.0<br>>2.0 | <br>>11.0<br>3.0 – 5.0<br>>2.0 | <br>>11.0<br>3.0 – 5.0<br>>2.0 | <br>>11.0<br>3.0 – 5.0<br>>2.0 |
| Lab Compaction (Revolutions):<br>N (initial)<br>N (design)<br>N (maximum) | CPL 5115 | See **Table 02575-7** | | | |
| HVEEM Stability, minimum<br>(for information) | CPL 5106 | For 75 gyrations, HVEEM = 28.<br>For 100 gyrations, HVEEM = 30. | | | |
| Aggregate Retained on the 4.75 mm (No. 4) sieve with at least two mechanically Induced Fractured Faces, % minimum **B*** | CP 45 | 60% **A*** | 90% | 60% **A*** | |
| Accelerated Moisture Susceptibility Tensile Strength Ratio (Lottman), minimum **D*** | CPL 5109 Method B | 80 | 80 | 80 | 80 |
| Minimum Dry Split Tensile Strength, kPa (psi) | CPL 5109 Method B | 205 (30) | 205 (30) | 205 (30) | 205 (30) |
| Grade of Asphalt Cement, Top Layer | | See **Section 02575 Part 2 - Materials** below | | | |
| Grade of Asphalt, Layers Below Top | | See **Section 02575 Part 2 - Materials** below | | | |
| Voids in the Mineral Aggregate (VMA) % minimum | CP 48 | See **Table 02575-6** | | | |
| Voids Filled with Asphalt (VFA), % | AI SP-2 | See **Table 02575-7** | | | |

**A*** 70% minimum for interstate highways and pavement with ESALs> $1x10^7$
**B*** A Stone Matrix Asphalt mix is 100%.
**C*** Grading M material will be 4% to 8%.
**D*** Grading M material is 70, stone Matrix Asphalt is 70.
Notes:
1. AI SP-2 = Asphalt Institute Superpave Series 2
2. The current version of CPL 5115 is available from the region materials Engineer.

3. Mixes with gradations having less than 40% passing the 4.75 mm (No. 4) sieve shall be approached with caution because of constructability problems.
4. Table 1 of CPL 5115, which contains the laboratory mixing and compaction temperatures to be used for mix design development and laboratory verification of project produced mixtures, is modified for SuperPave projects and replace with the following:

**Modified CPL 5115 Table 1**
**(per note 4 in Table 02575-5, above)**

| SuperPave Binder Grade | Lab Mixing Temp., °C (°F) | Lab Compaction Temp., °C (°F) |
|---|---|---|
| PG 58-28 | 138 (280) | 127 (260) |
| PG 58-22 | 149 (300) | 135 (275) |
| PG 64-22 | 149 (300) | 135 (275) |
| PG 70-28 | 163 (325) | 149 (300) |
| PG 64-28 | 163 (325) | 149 (300) |
| AC 20-R | 163 (325) | 149 (300) |
| PG 58-34 | 154 (310) | 138 (280) |
| PG 76-28 | 163 (325) | 149 (300) |

**Table 02575-6**
**Minimum Voids in the Mineral Aggregate (VMA)**

| Nominal Maximum Size[1], mm (inches) | Design Air Voids[2] | | |
|---|---|---|---|
| | 3.5% | 4.0% | 4.5% |
| 37.5 (1 1/2) | 11.5 | 12.0 | 12.5 |
| 25.0 (1) | 12.5 | 13.0 | 13.5 |
| 19.0 (3/4) | 13.5 | 14.0 | 14.5 |
| 12.5 (1/2) | 14.5 | 15.0 | 15.5 |
| 9.5 (3/8) | 15.5 | 16.0 | 16.5 |

Notes:
1. The Nominal Maximum Size is defined as one (1) sieve larger than the first sieve to retain more than ten (10%) percent.
2. Interpolate specified VMA values for design air voids between those listed.
3. Air Void Criteria: A design air void range of 3.5 to 4.5% with a target of 4.0% will be used on all mixes. The air void criteria will be applied to the approval of the design mix.

**Table 02575-7**
**Criteria for Stability and Voids Filled with Asphalt (VFA)**

| SuperPave Gyratory Revolutions ($N_i$) | SuperPave Gyratory Revolutions ($N_{des}$) | SuperPave Gyratory Revolutions ($N_{max}$) | Recommended Minimum Stability | VFA (%) |
|---|---|---|---|---|
| 8 | 109 | 174 | 42 | 65-75 |
| 8 | 96 | 152 | 42 | 65-75 |
| 7 | 86 | 134 | 39 | 65-78 |
| 7 | 76 | 117 | 33 | 65-80 |
| 7 | 68 | 104 | 26 | 70-80 |

2. Selection of SuperPave Gyratory Design Revolution. SuperPave Gyratory Design Revolutions shall be as follows: for Arterial roadways – 75 gyrations; for Collector and Local roadways – 75 gyrations.

K. Plant Mix Pavement Samples. If one or more samples fail to meet the requirements of **Table 02575-8**, the area that the failing sample represented will be sampled and tested according to CDOT Specifications Section 401.02 with the following exceptions:

1. Samples shall be taken in an acceptable manner that will facilitate patching.

2. A minimum of nine (9 kg) kilograms (twenty (20#) pounds) of testable material shall be obtained from each location to conduct a moisture susceptibility test.

3. The "F" factor used in calculating P values shall be 2.5.

**Table 02575-8**
**Plant Mix Pavement Requirements**

| Grading | Test Procedure | Minimum Test Result | Sampling Frequency |
|---|---|---|---|
| All Gradings | CP L-5109 Method A | 80 | One per 10,000 tons or fraction thereof (minimum) |

## 1.3 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I.

## 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.D and as modified herein:

A. Aggregate stockpiles at batch plants should be carefully constructed on clean, stable surfaces with ample provision made to prevent intermingling or other contamination of the materials. Aggregates shall be stored and handled in such a manner that minimizes degradation, segregation and contamination.

B. Heating and drying of the aggregate material shall be performed prior to mixing with asphalt per these specifications. Very wet aggregate reduces dryer capacity and requires corrective measures. Fine aggregate will hold more moisture than coarse aggregate and requires more heat for drying.

C. A dust collector system, operated adjacent to and in conjunction with the dryer shall collect and separate the dust from the aggregate. If the material removed from the dust collector can be recombined satisfactorily with the aggregates in the mix, it may be returned to the facility. If it is unsuitable for use in the asphalt mixture, it shall be removed from the collector and wasted.

D. Asphalt storage tanks at batch plants, including all transfer lines, pumps and weigh buckets, shall be heated to maintain the asphalt at the required temperature. Thermometers should be placed in the asphalt feed system to ensure control of the asphalt temperature. Return lines discharging into the storage tank should be submerged below the asphalt level in the tank at all times to prevent the asphalt from oxidizing during circulation.

E. A valve or spigot should be installed in the circulating system to permit sampling of the asphalt.

F. Hot bituminous plant mix shall not be stored longer than nine (9) hours, unless additional protective measures are used and approved.

G. Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds thinly coated with a minimum amount of paraffin oil, lime solution, or other approved release agent. Petroleum distillates such as kerosene or fuel oil will not be permitted. Each truck shall have a cover of canvas or other suitable material to protect the mixture from the weather and to maintain proper temperature for laying.

## PART 2 – MATERIALS

### 2.1 AGGREGATES

A. Aggregate for Hot Plant Mix Bituminous Pavement. Aggregates shall be crushed stone, crushed slag, crushed gravel, or natural gravel which conform to the requirements of AASHTO M147, as hereinafter supplemented. Aggregate for hot plant mix bituminous pavement shall be in accordance with CDOT Specifications Section 703.04, as shown in **Table 02575-9** below:

**Table 02575-9**
**(CDOT 703-4)**
**Master Range Table for Hot Bituminous Pavement**

| Sieve Size | Mass Percent Passing Square Mesh Sieves | | |
|---|---|---|---|
| | Grading SX | Grading S | Grading SG |
| 37.5 mm (1 1/2") | | | 100 |
| 25.0 mm (1") | | 100 | 90 - 100 |
| 19.0 mm (3/4") | 100 | 90 – 100 | |
| 12.5 mm (1/2") | 90 – 100 | * | * |
| 9.5 mm (3/8") | * | * | * |
| 4.75 mm (#4) | * | * | * |
| 2.36 mm (#8) | 28 – 58 | 23 – 49 | 19 - 45 |
| 1.18 mm (#16) | | | |
| 600 µm (#30) | * | * | * |
| 300 µm (#50) | | | |
| 150 µm (#100) | | | |
| 75 µm (#200) | 2 – 10 | 2 – 8 | 1 - 7 |

*These additional screens will initially be established for the Contractor's Quality Control Testing using values from the As Used Gradation shown on the Design Mix.

B. New Aggregate. Only aggregate from Town approved sources shall be used. The mineral aggregate shall consist of hard, durable particles, or fragments of stone or crushed gravel having incorporated in it limestone dust, Portland cement, or other acceptable binder material, in such proportions that the whole will be a homogenous material after mixing at the asphalt plant. The mineral aggregate shall be clean and free from disintegrated stone, vegetable matter, clay lumps, or other deleterious substances. Aggregate may be conditionally accepted in stockpile at the plant site.

C. Coarse Aggregate Angularity (CAA). Coarse aggregate angularity (CAA) is defined as the percent by weight of the aggregate particles larger than the #4 sieve having two (2) or more fractured faces.

D. Fine Aggregate Angularity (FAA). Fine aggregate angularity (FAA) is defined as a minimum of forty five (45%) percent air voids present on loosely compacted aggregate that passes the #8 sieve. Fine aggregate angularity is measured on the fine aggregate portion of the blended aggregate by AASHTO Standard Method of Test TP33 (ASTM Standard Method of Test C1252).

E. Clay Content. Clay content is a measure of the amount of clay material present in the portion of aggregate that passes the #4 sieve. Clay content is measured on the portion of the blended aggregate passing the #4 sieve by means of the sand equivalent test (AASHTO Standard Method of Test T176). Clay content criteria for increasing levels of total traffic in Equivalent Single Axle Loads (ESALs) are as shown in **Table 02575-10** below:

**Table 02575-10**
**Clay Content Criteria**

| Traffic (ESALs) | Sand Equivalent |
|---|---|
| $<3x10^5$ | 40 |
| $<3x10^7$ | 45 |
| $\geq 3x10^7$ | 50 |

F. Thin, Elongated Particles. Thin, elongated particles are the coarse aggregate particles that have a ratio of maximum to minimum dimensions greater than five (5). The percentage of thin, elongated particles is measured on the portion of the blended aggregate retained on the #4 sieve by ASTM Standard Method of Test D4791. Maximum criteria for thin, elongated particles for increasing levels of traffic in ESALs are as shown in **Table 02575-11** below:

**Table 02575-11**
**Criteria for Thin, Elongated Particles**

| Traffic (ESALs) | Maximum Weight Percent of Thin, Elongated Particles |
|---|---|
| $\geq 1x10^6$ | 10 |

G. Dust Proportion. Dust proportion is defined as the ratio of the percent by weight of aggregate passing the #200 sieve to the effective asphalt binder, content expressed as percent by weight of the total mix. Dust proportion for all bitumen contents shall be presented in the mix design for information only.

## 2.2 SUPERPAVE PERFORMANCE GRADED BINDERS (Asphalt Cements)

A. Asphalt Cements Permitted. The SuperPave System specifies asphalt cement properties to address pavement performance for the climate and traffic loading found in the specific area of the project. The high and low temperature properties required are then specified according to a percent reliability against rutting (high temperature properties) and thermal cracking (low temperature properties) found for a given pavement. The physical properties that the asphalt cement are required to meet stay the same. What changes is the temperature at which these asphalt cement properties must be met

Because of the many and varied climate conditions nationwide, specifying asphalt cements based on climate conditions results in a very large number of asphalt cements; however, only a limited number of Performance Graded (PG) binders are needed within the Town of Windsor. Therefore, only seven (7) binders will be permitted in these specifications, as shown in **Table 02575-12** below:

**Table 02575-12**
**Permitted Asphalt Cements**

| Polymer Modified | Unmodified |
|---|---|
| PG 76-28 | PG 64-22 |
| PG 70-28 | |
| PG 64-28 | PG 58-28 |
| PG 58-34 | PG 58-34 |

SuperPave Graded Binders shall conform to the requirements listed in Table 702-2 of the CDOT Standard Specifications.

B. Binder Grades. For all roadways within the Town limits of the Town of Windsor, and its GMA, the binder grades to be specified for the various types of construction and road classifications shall be as shown in **Table 02575-13** below:

**Table 02575-13**
**Binder Grade Requirement**

| New Construction or Reconstruction | | Overlay | |
|---|---|---|---|
| Local/Residential | PG 58-28 | Local/Residential | PG 58-28 |
| Minor Collector | PG 58-28 | Minor Collector | PG 58-28 |
| Major Collector | PG 64-28 | Major Collector | PG 64-28 |
| Industrial/Commercial | PG 64-28 | Industrial/Commercial | PG 64-22 |
| Arterial | PG 64-28 | Arterial | PG 64-22 |

C. Grade Bumping. The Town may require grade bumping on Industrial/Commercial, Major Collector and Arterial roadways. Grade bumping will not be required on Local/Residential or Minor Collector roadways. Grade bumping means selecting an asphalt cement grade that is one (1) or two (2) high temperature grades higher than the minimums required in **Table 02575-13**, above, to account for extreme traffic flow and traffic loading conditions. Grade bumping criteria shall be as shown in **Table 02575-14** below:

**Table 02575-14**
**Grade Bumping Criteria**

| Condition | Recommendation |
|---|---|
| Slow Moving Traffic Loads | One (1) Grade Higher than Free Flowing |
| Standing Traffic Loads | Two (2) Grades Higher than Free Flowing |
| Total 18k ESAL ≥10,000,000 | One (1) Grade Higher than Free Flowing |
| Total 18k ESAL ≥30,000,000 | Two (2) Grades Higher than Free Flowing |

1. Free flowing traffic is traffic at speeds greater than forty five (45 mph) miles per hour.
2. Slow moving traffic is traffic moving between twelve (12 mph) and forty five (45 mph) miles per hour.
3. Standing traffic is traffic moving less than twelve (12 mph) miles per hour.
4. No adjustment will be allowed for the low temperature grade because of traffic speed or volume.

D. Asphalt Cement Selection for Lower Lifts. For pavements with multiple layers, a lesser grade of asphalt cement may be specified for the lower layers based on the amount of the material needed and other economical design decisions. In many cases, the requirements for the lower layers might be obtained with an unmodified or more economical grade of asphalt cement. At least ten thousand (10,000) tons of HMA in the lower lifts is needed before a separate asphalt cement is specified for the lower lift.

The Town may allow a lower grade of asphalt cement to be utilized in the lower layers of a pavement section in accordance with **Table 02575-15**, as given below:

**Table 02575-15**
**Grade Reduction for Lower Lifts**

| Lift | High Temperature Grade Specified for the Project (Assumes Mix in the Top Lift) | | | |
|---|---|---|---|---|
| Top | 58 | 64 | 70 | 76 |
| Four (4") or more below the surface | 52 | 58 | 64 | 70 |
| Six (6") inches or more below the surface | 52 | 52 | 58 | 64 |

## 2.3 ANTI-STRIPPING ADDITIVE

An anti-stripping additive shall be required and the following shall apply:

A. Liquid Additive.

1. Amount of Additive. The amount of additive used shall be a minimum of one half (0.5%) percent by mass (weight) of the asphalt cement.

2. In-Line Blender. The additive shall be added at the refinery or at the hot plant. If liquid anti-stripping additive is added at the plant, an approved in-line blender must be used. The blender shall be in the line from the storage tank to the drier drum or pugmill. The blender shall apply sufficient mixing action to thoroughly mix the asphalt cement and anti-stripping additive.

B. Hydrated Lime. If additive is not added at refinery, a minimum of one (1%) percent hydrated lime by mass (weight) of the combined aggregate shall be added to the aggregate for all hot bituminous pavements. Hydrated lime shall meet the requirements of ASTM C207, Type N. The "F" factor used in calculating P values for lime gradation shall be three tenths (0.3).

## 2.4 FILLER

Filler shall meet the requirements of AASHTO M17.

## 2.5 SUPERPAVE JOB MIX

A. Composition of Mixtures. The Bituminous plant mix shall be composed of a mixture of aggregate, filler, or additives if required and approved, bituminous material, and reclaimed material if permitted and used.

B. Mix Design. The Contractor/Owner shall submit the following to the Town Engineer for each proposed mix design:

1. A proposed job-mix gradation for each mixture certified by the independent laboratory shall be wholly within the ranges given in **Table 02575-5**, **Design Mix Criteria** before the tolerances shown in **Table 02575-16**, **Tolerances for Hot Mix Asphalt** are applied. The mass of lime shall be included in the total mass of the material passing the No. 200 sieve. The restricted zone boundaries given in the Asphalt Institute's "Superpave Series No. 2 (SP-2) Manual", Appendix B, are to be used as guidelines in mix design development; however, the job-mix gradation is not required to pass above or below the restricted zone boundaries

2. The aggregate source, percentage of each element used in producing the final mix, the gradation of each element, and the proposed job-mix formula (JMF) gradation. The gradation used shall be based on the Contractor's JMF.

3. The name of the asphalt cement supplier.

C. Sampling for JMF Testing. The Contractor's proposed job-mix formula for each hot bituminous pavement grading will be tested utilizing materials actually produced and stockpiled.

D. JMF Target Values. The job-mix formula for each mixture shall establish a single percentage of aggregate passing each required sieve size, a single percentage of bituminous material to be added to the aggregate, and a single temperature for the mixture at the discharge point of the plant.

E. Aggregate Source Changes. Should a change in the sources of material be made, a new job-mix formula shall be established and approved in accordance with B. Mix Design., above, before the new material is incorporated into the job.

F. Recycled Asphalt Pavement. The hot bituminous pavement shall not contain more than twenty five (25%) percent reclaimed asphalt pavement, where allowed. The reclaimed asphalt pavement shall meet the requirements of CDOT Standards, Section 703.04. Mixtures with more than twenty (20%) percent reclaimed asphalt pavement shall not be used in the top two (2") inches (wearing course) of any pavement section.

G. Aggregate Quality. Test for cleanliness, abrasion loss, and percent of fractured faces will be made on representative samples of aggregate taken during production or from the stockpiles.

H. JMF Compliance. When laboratory tests indicate that a proposed job-mix formula complies with the specifications, the JMF may be submitted for mix design approval in accordance with these specifications.

I. Mix Design Approval. Mix designs will be approved on a Laboratory/Production approval system. Initial approval will be given based on laboratory design. Production approval will then be given based on testing conducted on plant mixed samples to verify the approved laboratory design.

New mix design shall be submitted for each calendar year and shall remain in effect for a period not extending beyond the end of that calendar year. Should a change in sources of materials be made, a new mix design will be required and shall remain in effect for the remainder of that calendar year.

1. Laboratory Mix Design Approval. The Contractor/Owner may receive preliminary mix design approval of a new HBP mix design, based on the following procedure:

   a. Performance and Approval. The mix designs will be performed by an independent laboratory and approved by the Town.

   b. Conditions. The following conditions shall apply to the preliminary approval:

      i. Written Request and Submittals. The Contractor/Owner shall make a written request for preliminary mix design approval, and submit three (3) copies of the independent lab mix design containing all the information required in Laboratory Mix Design checklist.

      ii. Test Results. The results of all required tests shall meet the mix design specification requirements.

      iii. Asphalt Content. The Town Engineer, only, shall approve the asphalt content based on the private lab mix design.

2. Production Mix Design Approval. The Contractor/Owner may receive and maintain production mix design approval of an HMA mix design, based on the following procedure:

   a. Verification. Following laboratory mix design approval, verification of mix properties will be performed by an independent laboratory on plant-produced mix and approved by the Town. This verification is to be performed on or before the first day of production within the GMA.

   b. Frequency. To maintain production, mix design approval verification of mix properties will be performed by an independent laboratory on plant-produced mix and approved by the Town every ten thousand (10,000) tons of mix produced.

   c. Conditions. The following conditions shall apply to production mix design approval:

      i. Written Request and Submittals. The Contractor/Owner shall make a written request for production mix design approval, and submit the results of the mix verification report performed by an independent lab.

      ii. Test Results. The results of all required tests shall meet the mix design specification within the tolerances listed and as shown in **Table 02575-16** below:

**Table 02575-16**
**Tolerances for Hot Mix Asphalt**

| Element | Tolerance |
|---|---|
| Asphalt cement content | ± 0.30% |
| Voids in Mineral Aggregate (VMA) | ± 1.2% |
| Air Voids (Va) | ± 1.2% |
| Lottman | Min. 80 |
| **Hot Mix Asphalt Gradation:** | |
| Passing the 3/8" and larger sieves | ± 6% |
| Passing the No. 4 and No. 8 sieves | ± 5% |
| Passing the No. 30 sieve | ± 4% |
| Passing the No. 200 sieve | ± 2% |

iii. Review Period. The Town shall have five (5) days to review production mix design verification test results and approve or reject the mix design.

iv. Stop Work. If the results of mix design verifications are not within the tolerances as determined by the Town, the Contractor/Owner shall immediately stop paving within the GMA and submit a mitigation plan to the Town for approval. If given approval, paving may resume and a new mix design verification test will be performed on the first day of production. If after implementation of the mitigation plan the Contractor/Owner is not capable of meeting the original mix design specifications, he shall complete and submit a new mix design to the Town for laboratory mix design approval.

## 2.6 PRIME COAT

The prime coat shall be medium curing asphalt conforming to ASTM D598 or D2027. The grade of asphalt and the rate of application shall be determined by considering the condition of the base course, temperature, and other conditions affecting application.

## 2.7 TACK COAT

The tack coat shall consist of a very light spray application of diluted asphalt emulsion material of CSS-1.

# PART 3 – EXECUTION

## 3.1 WEATHER LIMITATIONS

A. Placement Temperatures. Plant mix pavement shall be placed only on properly prepared unfrozen surfaces which are free of water, snow, and ice. The hot, plant mix asphalt pavement shall be placed only when both the air and surface temperatures equal or exceed the temperatures specified in **Table 02575-17** below and the Engineer determines that weather conditions permit the pavement to be properly placed.

**Table 02575-17**
**Placement Temperature Limitations in °F**

| Compacted Layer Thickness in inches | Minimum Surface and Air Temperature °F | |
|---|---|---|
| | Top Layer | Layers Below Top Layer |
| < 1½" | 60 | 50 |
| 1½" to < 3" | 50 | 40 |
| 3" or more | 45 | 35 |

Note: Air temperature is taken in the shade. Surface is defined as the existing base on which the new pavement is to be placed. If the temperature falls below the minimum air or surface temperatures, paving shall stop.

B. Temporary Pavement Layer. The Work shall be scheduled so that no planed or recycled surface is left without resurfacing for more than ten (10) calendar days from October 1st to March 1st. The Contractor shall immediately place a temporary hot bituminous pavement layer on any surface that has been planed or recycled and cannot be resurfaced in accordance with the above temperature requirements within ten (10) calendar days after being planed or recycled.

1. Thickness. The minimum thickness of the temporary hot bituminous pavement layer shall be two (2") inches. The Contractor/Owner shall perform the quality control required to assure adequate quality of the hot bituminous pavement used in the temporary layer.

2. Markings. All applicable pavement markings shall be applied to the temporary layer surface.

3. Maintenance. The Contractor/Owner shall maintain the temporary layer for the entire period that it is open to traffic. Distress that affects the ride, safety, or serviceability of the temporary layer shall be immediately corrected to the satisfaction of the Town Engineer.

4. Removal. The temporary hot bituminous pavement layer shall be removed when work resumes.

## 3.2 PLANNING AND PREPARATION

A. Paving operations require careful planning and preparation. The surface to be paved must be properly prepared. Enough vehicles and equipment, in good operation, and adequate, trained personnel must be available to provide a steady flow of materials and progress without delays. Plant production must be closely coordinated with the paving operation, and the compaction of freshly placed mixture must be prompt and adequate.

B. Before spreading (placing) operations, the engineer and inspectors should confer with the contractor's superintendents and foremen and carefully plan the entire operation. Some important details that should be discussed include:

1. Continuity and sequence of operations,

2. Number of pavers needed for the project,

3. Number and types of rollers needed,

4. Number of trucks required,

5. The chain of command for giving and receiving instructions,

6. Reasons for possible rejection of the mix,

7. Weather and temperature requirements, and

8. Traffic control.

## 3.3 MIXING

A. The dried aggregates and asphalt shall be combined in the mixer in the quantities required to meet the job-mix formula. The materials shall be mixed until the aggregate is completely and uniformly coated, and the asphalt is uniformly distributed throughout the aggregate.

B. The minimum temperature of the mixture when discharged from the mixer and when delivered for use shall be as shown in **Table 02575-18** below, or the equivalent CDOT Table, whichever is more current:

**Table 02575-18**
**Mixture Minimum Temperatures**

| Asphalt Grade | Minimum Mix Discharge Temperature, °C (°F)* | Minimum Delivered Mix Temperature, °C (°F)** |
|---|---|---|
| PG 58-28 | 135 (275) | 113 (235) |
| PG 58-22 | 138 (280) | 113 (235) |
| PG 64-22 | 143 (290) | 113 (235) |
| AC-20 Rubberized | 160 (320) | 138 (280) |
| PG 76-28 | 160 (320) | 138 (280) |
| PG 70-28 | 149 (300) | 138 (280) |
| PG 64-28 | 149 (300) | 138 (280) |
| PG 58-34 | 149 (300) | 138 (280) |

* The maximum mix discharge temperature shall not exceed the minimum discharge temperature by more than 17° C (30°F)
** Delivered mix temperature shall be measured behind the paver screed.

C. Hot-mix bituminous asphalt mixture shall be produced at the lowest temperature within the specified temperature range that produces a workable mix and provides for uniform coating of aggregates ninety five (95%) percent minimum in accordance with AASHTO T195), and that allows the required compaction to be achieved.

D. The asphalt cement shall be heated to the specified temperature without local overheating and shall be continuously supplied to the mixer at a uniform temperature within the specified range.

E. Storing or holding of asphalt mixture will be permitted provided the characteristics of the mixture are not altered. If storing or holding of the mixture causes segregation, excessive heat loss, or adversely affects the quality of the finished product, corrective action shall be taken. Unsuitable mixture shall be disposed of at the contractor's expense.

## 3.4 PRIME COAT

A. When, in the opinion of the Engineer, a prime coat should be applied to the prepared base course prior to asphalt laying, the surface shall be thoroughly dried and cleaned by sweeping or other approved methods. The cleaning shall be continued until the embedded aggregates are uncovered but not dislodged and all dust, mud and foreign matter removed.

B. The equipment used to apply the prime coat shall be of the proper type and condition of maintenance to distribute the materials evenly and smoothly in the quantity specified. The material shall be heated to the proper temperature when applied, and shall only be applied when the outside temperature is above fifty (50°F) degrees Fahrenheit.

C. The prime coat shall be permitted to cure until thorough and proper penetration has been obtained, but at no time shall the curing period be less than twenty four (24) hours. Pools of bituminous material occurring in depressions shall be removed from the surface before applying the bituminous asphalt surfacing.

D. At no time during the period of prime coat curing shall traffic be allowed upon the primed surface.

## 3.5 TACK COAT

A. A tack coat shall be applied between pavement courses.

B. The surface to receive the tack coat shall be dry and cleaned by an approved method until all dust, debris and foreign matter are removed.

C. The tack coat material shall be applied at a rate and temperature which will provide a very thin coating uniformly distributed over the entire area to be covered. The tack coat shall not be applied when the outside temperature is below fifty (50°F) degrees Fahrenheit and/or if there is a threat of rain.

## 3.6 SURFACE CONDITIONING

A. Irregularities in the existing pavement or base shall be brought to uniform grade and cross section.

B. Prior to placing the tack coat and beginning overlay work, the surface to be tack coated shall be swept to remove accumulations of loose gravel and debris.

C. Bituminous plant mix shall be placed only on properly constructed surfaces that are free from substances that would adversely affect the pavement quality.

D. Contact surfaces of curbing, gutters, manholes, and other structures shall be painted with a uniform coating of asphalt cement (tack coat) prior to placing bituminous mixture against them.

E. All manholes, valve boxes, and other utilities shall be lowered prior to paving and shall be located with offset markers for future adjustment. Manholes shall be covered with steel plates and overlaid with bituminous pavement.

## 3.7 PLACING BIMUMINOUS PLANT MIX MATERIAL WITH PAVERS

A. Self-propelled bituminous pavers shall be provided and equipped with an activated screed assembly, heated if necessary, capable of spreading and finishing the bituminous plant mix material in lane widths applicable to the typical section and thicknesses shown on the Plans. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of asphalt plant mix material in widths shown on the Plans.

B. The paver's receiving hopper shall have sufficient capacity for a uniform spreading operation and shall have an automatic distribution system that will place the mixture uniformly in front of the screed. The screed or strike-off assembly shall produce the specified finished surface without tearing, shoving, or gouging the mixture.

C. The paver shall be capable of operating at forward speeds consistent with uniform and continuous laying of the mixture. Stop and go operations of the paver shall be avoided.

D. The bituminous paver shall be equipped with a means of preventing the segregation of the coarse aggregate particles from the remainder of the bituminous plant mix when that mix is carried from the paver hopper back to the paver augers. The means and methods used shall be approved by the paver manufacturer and may consist of chain curtains, deflector plates, or other such devices and any combination of these.

E. Prior to the start of using the paver for placing plant mix, the contractor shall submit for approval a full description in writing of the means and methodologies that will be used to prevent bituminous paver segregation. Use of the paver shall not commence prior to receiving approval from the Engineer. The contactor shall supply a Certificate of Compliance that verifies that the approved means and methods used to prevent bituminous paver segregation have been implemented on all pavers used on the project.

F. Pavers shall be equipped with automatic screed controls with sensors capable of sensing grade from an outside reference line, and maintaining the screed at the specified longitudinal grade and transverse slope. The sensor shall be constructed to operate from either or both sides of the paver. The controls shall be capable of maintaining the screed at the specified transverse slope within plus or minus one tenth of a ($\pm$ 0.1%) percent.

G. Manual operation will be permitted only for constructing irregularly shaped and minor areas. If the automatic controls fail or malfunction, the equipment may be operated manually for the remainder of the normal working day, provided specified results are obtained.

H. If the contractor fails to obtain and maintain the specified surface tolerances, the paving operations shall be suspended until satisfactory corrections, repairs, or equipment replacements are made.

## 3.8 SPREADING AND FINISHING

A. Bituminous pavers shall be used to distribute the mixture to the established grade and required thickness over the entire width or partial width as practicable.

B. As the paver spreads its first load of asphalt mix, the mat should frequently be "stabbed" or checked for thickness. After twenty (20') or thirty (30') feet of operation the paver should be stopped and the new surface checked. The texture of the unrolled surface should be uniform. If it is not, screed adjustments may be necessary. The adjustment of the screed, tamping bars or vibrators, spreading screws, hopper feed, and other adjustments should be checked frequently to assure uniform spreading of the mix to proper line and grade.

C. Hand raking should not be done unless absolutely necessary. The most uniform surface texture can be obtained by keeping the hand work behind the screed to a minimum. Surplus hot-mix from rakers should not be cast across the mat surface as this will result in nonuniformity of the surface texture.

D. On areas where the use of mechanical spreading and finishing equipment is impracticable, the mixture shall be dumped, spread, raked, screeded, and luted by hand tools to the required compacted thickness and grades.

E. Production of the bituminous mixture shall be maintained so pavers can be used in echelon to place the wearing course in adjacent lanes.

F. The bituminous mixture shall be transported and placed on the roadway without segregation. All segregated areas behind the paver shall be removed immediately upon discovery. The segregated material shall be replaced with specification material before the initial rolling has taken place. If more than fifty (50 $ft^2$) square feet of segregated pavement is ordered removed and replaced in any continuous five hundred (500') linear feet of paver width laydown, operations shall be discontinued until the source of the segregation has been found and corrected.

G. After rolling, any segregated areas will be delineated by the Engineer and evaluated per CDOT Specifications, Section 401.16. If the area is determined to be segregated, the segregated areas in the top lift shall be removed and replaced, full lane width, at the Contractor/Owner's expense. The Engineer may approve a method equivalent to remove and replace that results in a non-segregated top lift. Segregated areas in lifts below the top lift, that are smaller than fifty (50 $ft^2$) square feet per one hundred (100') linear feet of lane width, will be corrected by the Contractor at the Contractor's expense in a manner acceptable to the Engineer. Segregated areas larger than fifty (50 $ft^2$) square feet per one hundred (100') linear feet of lane width in any lift shall be removed and replaced, full lane width, by the Contractor at the Contractor's expense.

## 3.9 LONGITUDINAL JOINTS

A. The longitudinal joint in both a new pavement and an overlay pavement layer shall offset the joint in the layer immediately below by six (6") inches. In every pavement layer, the joints shall not be constructed in the wheel paths.

B. The Contractor shall submit a longitudinal joint and pavement marking plan at least three (3) days prior to paving. The plan shall show the location and configuration of the proposed longitudinal joints and pavement markings, and shall detail the methods to be used to field establish a control line. Paving shall not commence until the plan has been approved in writing by the Engineer.

C. The Contractor shall use a continuous string line to delineate every longitudinal joint during paving operations. All exposed string line shall be picked up and disposed of at the end of each day's paving.

D. The joints in the top layer of pavement shall be located as follows unless otherwise approved in writing by the Engineer:

1. For two (2) lane roadways, offset six (6") to twelve (12") inches from the center of pavement and from the outside edge of travel lanes.

2. For roadways of more than two (2) lanes, offset six (6") to twelve (12") inches from lane lines and outside edge of travel lanes.

E. Longitudinal joints shall not cross the centerline, lane line, or edge line unless approved by the Engineer.

F. Where paving operations are on the present traveled roadway, the Contractor shall arrange paving operations so there will be no exposed longitudinal joints between adjacent travel lanes at the end of a day's run. With the approval of the Engineer, the Contractor may leave an exposed longitudinal joint conforming to the specifications in CDOT Specifications, Section 401.16.

## 3.10 TRANSVERSE JOINTS

A. Placing of the plant hot-mix bituminous pavement shall be continuous, and rollers shall not pass over the unprotected end of a freshly laid mixture.

B. Transverse joints shall be formed by saw cutting back on the previous run, form a vertical construction joint to expose the full depth of the course. A coat of asphalt cement shall be applied to contact surfaces of all joints just before additional mixture is placed against the previously compacted material.

## 3.11 COMPACTION

A. Compaction is the process of compressing bituminous asphalt hot-mix into a smaller, denser volume to achieve the optimum air void content and provide a smooth riding surface.

B. The plant hot-mix bituminous pavements shall be compacted by rolling. Both steel wheel and pneumatic tire rollers will be required. The number, weight, and type of rollers furnished shall be sufficient to obtain the required density while the mixture is in a workable condition.

C. Compaction shall begin immediately after the mixture is placed and be continuous until the required density is obtained. When the mixture contains unmodified asphalt cement (P 58-28, PG 58-22, or PG 64-22) or modified (PG 58-34), and the surface temperature falls below eighty five (85°) degrees C (one hundred eighty five (185°) degrees F), further compaction effort shall not be applied unless approved. If the mixture contains modified asphalt cement (AC-20R, PG 76-28, PG 70-28, or PG 64-28), and the surface temperature falls below one hundred ten (110°) degrees C (two hundred thirty (230°) degrees F), further compaction effort shall not be applied unless approved.

D. The compaction level and density requirements shall be as shown in **Table 02575-19**, below. Voids in the Mineral Aggregate (VMA) percent minimum and Voids Filled with Asphalt (VFA) shall meet the current CDOT design criteria.

**Table 02575-19**
**SuperPave Compaction Requirements**

| Compaction Level | Required Density (Percent of Theoretical Maximum Specific Gravity) |
|---|---|
| $\mathbf{N}_{init\ (a)}$ | $\mathbf{C}_{init} < 89$ |
| $\mathbf{N}_{design\ (b)}$ | $\mathbf{C}_{design} = 96$ |
| $\mathbf{N}_{max\ (a)}$ | $\mathbf{C}_{max} < 98$ |

(a) Current CDOT design criteria
(b) All street classifications shall require 75 gyrations.

E. All roller marks shall be removed with the finish rolling. Use of vibratory rollers with the vibrator on will not be permitted during surface course final rolling.

F. Along forms, curbs, headers, walls, and all other places not accessible to the rollers, the mixture shall be thoroughly compacted with mechanical tampers.

G. Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective, shall be immediately removed and replaced with fresh hot mixture, and compacted to conform to the surrounding area.

H. Compaction Pavement Test Section (CTS). The Contractor shall construct a compaction pavement test section (CTS) for each job mix for which two thousand (2,000) or more tons are required for the project. The CTS will be used to evaluate the number of rollers and the most effective combination of rollers and rolling patterns for achieving the specified densities. Factors to be considered include, but are not limited to, the following:

1. Number, size, and type of rollers.
2. Amplitude, frequency, size and speed of vibratory rollers.
3. Size, speed, and tire pressure of rubber tire rollers.
4. Temperature of mixture being compacted.
5. Roller patterns.

The CTS shall be constructed according to the following procedures:

1. The CTS shall be constructed to provide the nominal layer thickness specified. The first five hundred (500) tons of hot-mix asphalt on the project location shall constitute the CTS. The production and placement rates of the CTS shall closely approximate the anticipated production and placement rates for the remainder of the project.

2. Compaction of the CTS shall commence immediately after the hot-mix asphalt has been spread, and shall be continuous and uniform over the entire CTS. For the CTS, compaction shall continue until no discernible increase in density is obtained by additional compactive efforts. All compaction shall be completed before the surface temperature of the mixture drops below those limits given in 3.9.C above.

3. Approved types of rollers shall be used to achieve the specified density. The Contractor shall determine what methods and procedures are to be used for the compaction operation. The compaction methods and procedures shall be used uniformly over the entire last two hundred (200) tons. The Contractor shall record the following information and a copy of this data shall be furnished to the Engineer:

   a. Type, size, amplitude, frequency, and speed of roller.
   b. Tire pressure for rubber tire rollers, and whether the pass for vibratory rollers is vibratory or static.
   c. Surface temperature of mixture behind the laydown machine and subsequent temperatures and densities after each roller pass.
   d. Sequence and distance from laydown machine for each roller, and number of passes of each roller to obtain specified density.

4. If in-place densities of the CTS, as determined by nuclear density equipment, meet the CTS density requirements, the Contractor may begin production paving and continue to place hot-mix bituminous pavement.

5. After production paving work has begun, a new CTS shall be constructed when a change in the compaction process is implemented. A new CTS may be required for different layers of pavement. Each additional CTS shall be constructed as specified herein, and shall be sampled, tested and accepted or rejected as described herein.

## 3.12 PAVEMENT SAMPLES

The Engineer may take samples of the compacted pavement at random locations on the project for testing. Where samples have been taken, new material shall be placed and compacted by the Contractor to conform with the surrounding area.

## 3.13 FIELD QUALITY CONTROL

Field Quality Control shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.J; except subsection 1.3.J. shall be modified to include the following:

A. The finished roadway surface smoothness shall be tested in accordance with CDOT Specifications, Section 105.07. If not specified otherwise on the plans, the roadway surface shall be subject to inches per mile requirements for Category II, Highways with speed limits equal to or greater than forty five (45 mph) miles per hour; in accordance with CDOT Table 105-6.

B. Tests for conformity with the specified crown and grade shall be made by the Contractor immediately after initial compactions, and any variation shall be corrected by removing or adding materials as directed and continuing the rolling.

C. The finished surface course shall not vary from the established grade by more than one-quarter (¼") inch for the wearing course when tested with a sixteen (16') foot straight edge applied parallel with or at right angles to the centerline.

D. In addition to the surface tolerances stated, there shall be no allowance for standing water on the final pavement surface. After compaction, the asphalt pavement adjoining the concrete gutter pan shall be between one quarter (¼") inch and one half (½") inch higher than the lip of the concrete pan.

E. The total thickness of the pavement, as called for on the Plans, shall not differ by more than ten (10%) percent for any one sample. The average total thickness of all samples taken shall not differ by more than seven and one-half (7.5%) percent. If the total thickness is proven to be less than these tolerances, the Town will require asphalt milling and overlay to correct the problem. If the total thickness is proven to be greater than these tolerances, the Town will not be responsible for compensating the Contractor/Owner for the excess amount of asphalt.

**END OF SECTION**

**SECTION 02576**

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**SECTION 02585**

**PORTLAND CEMENT CONCRETE PAVEMENT**

## PART 1 – GENERAL

### 1.1 DESCRIPTION

The Work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials necessary for constructing Portland Cement concrete pavements for streets, or other pavements, on a firm and stable foundation base course within the public right-of-way. The Work shall consist of constructing a pavement composed of Portland cement concrete on the previously prepared base, in accordance with these specifications and in conformance with the lines, grades, typical cross sections, and thicknesses as shown on the plans or approved design reports.

### 1.2 QUALITY ASSURANCE

Quality Assurance shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.C, and as modified herein:

A. Pavement Design Report. The pavement design report required in these Standards shall be submitted and approved a minimum of five (5) working days prior to any paving. Refer to **SECTION 2 – SOIL INVESTIGATIONS AND PAVEMENT DESIGN** for detailed information.

B. Mix Designs. The Contractor/Owner shall furnish to the Town Engineer concrete pavement mix designs meeting the requirements of these Standards a minimum of five (5) working days prior to intended use of the mix. The mix design shall be reviewed and accepted by the Town Engineer prior to use. If a mix design not accepted by the Town is used, the Town may require removal of all improvements placed with the unaccepted material.

C. Test Reports. Test reports submitted to the Town shall include all tests performed on the project. Reports shall bear the seal and signature of a Professional Engineer registered in the State of Colorado and competent in the required testing practice. All test reports shall show the location where the test was performed or at which the work or batch represented by the test was located. Test reports shall include all information specified in the AASHTO, ASTM, CDOT, or Colorado Test Procedure used. Improperly completed reports will not be accepted. Acceptance will not be complete until all final reports indicating compliance with these specifications are reviewed and placed on file by the Town.

D. Warranty Period. The warranty period for the completed public street improvements cannot start until all required test reports, record drawings, inspection reports, and other documentation are submitted in the proper format and accepted by the Town.

E. Quality Control Testing and Reporting Procedures. All testing methods and procedures performed by the Geotechnical Engineer personnel shall be done in accordance with the applicable AASHTO, ASTM, ACI, or Colorado Procedure requirements and procedures, as specified. Test reports shall include the AASHTO, ASTM, ACI, and Colorado Procedures (CP) test designations of all tests taken. All testing and retesting services shall be done at the expense of the Contractor/Owner.

When changes in materials or proportions are encountered during construction, or when the work fails to pass tests or fails to meet the Standards, additional tests shall be taken as directed by the Town Engineer. Failure of the Contractor/Owner to furnish satisfactory test data shall be sufficient cause for rejection of the work in question.

F. Testing Program.

1. Specification. All testing shall be done in accordance with AASHTO, ASTM, ACI or Colorado Procedures (CP), as designated throughout this section and in accordance with **Table 02585-1**, below. Concrete that does not meet strength in twenty eight (28) days is subject to removal.

**Table 02585-1**
**Material Testing**

| **Portland Cement Concrete** | **AASHTO** | **ASTM** | **Frequency** |
|---|---|---|---|
| Sampling | T141 | C172 | |
| Mold & Cure | T23 | C31 | |
| Transportation of cylinders | T23 | C31 | |
| Slump | T119 | C143 | First 3 loads each day |
| Temperature | | C1064 | First 3 loads each day |
| Unit Weight | | | 1/50 cy |
| **Air Content:** | | | |
| Pressure | T152 | C231 | 1/50 cy |
| Volume | T196 | C173 | |
| Gravimetric | T121 | C138 | |
| **Concrete Cores:** | | C174 | 1 per 500' per lane |
| Obtaining Cores | T24 | C42 | |
| Compressive Strength | T22 | C39 | 4 cylinders per 100 cy |
| Air Content | | C457 | |
| Cement Content | T178 | C85 | |

2. Concrete Testing.

   a. Sampling and testing shall be required on all concrete work including curb and gutter, sidewalk, crosspans, pavement, ramps, slope paving, retaining walls, inlets, manholes, or any other structures.

   b. Maximum time allowed between sampling and casting cylinders shall not exceed ten (10) minutes. If the concrete cannot be taken to the laboratory and cylinders cast within fifteen (15) minutes, the cylinders shall be cast in the field. Cylinders shall be transported to the laboratory within twenty four (24) hours of casting but after the concrete has hardened, (see AASHTO T23). All cylinders shall be six (6") inches in diameter or four (4") inches in diameter by eight (8") inches tall.

   c. The slump and air content tests shall be performed in accordance with **Table 02585-1**, above. Slump and air content test measurements shall be taken with each cylinder series. Concrete design criteria and slump and air content shall be done in accordance with CDOT Table 601-1. Concrete for pavements shall conform to the requirements for Class P concrete.

   d. Concrete cylinders shall be load-tested and broken at the times listed in **Table 02585-2**, below:

**Table 02585-2**
**Concrete Cylinder Breaks**

| **Number of Cylinders** (Series of four) | **Break Interval (Days)** |
|---|---|
| 1 | 7 |
| 2 | 28 |
| 1 | 56 |

NOTE: Additional cylinders may be required, as directed by the Town Engineer.
56-day cylinder used if 28-day cylinder strength less than required design strength.

   e. Compressive Strength Cylinders. At least four (4) compressive strength cylinders shall be taken from the same concrete delivery truck to provide design compliance testing at the laboratory. Two (2) of the four (4) specimens will be tested at twenty eight (28) days for acceptance and

one (1) shall be tested at seven (7) days for information. The fourth ($4^{th}$) cylinder shall only be necessary if the twenty eight (28) day fails. This is required for each pour per day with at least one (1) strength test series for each fifty (50 cy) cubic yards of concrete placed. Additional cylinders may be required to determine the rate of strength gain on high-early concrete mixes.

f. Other Tests. Slump, air content, unit weight, beam tests, and mix temperature shall be tested for each pour per day with at least one (1) test for each fifty (50 cy) cubic yards of concrete placed.

g. Low Strength Test Results. If compressive strength of cylinders and beams does not meet the specified values, the Design and/or Testing Engineer shall recommend and the Town Engineer shall approve the necessary mitigation measures needed.

   i. The Town Engineer and Testing laboratory shall determine the areas of concrete with potentially low strength and clearly denote the areas to the Contractor/Owner.
   ii. The Contractor/Owner shall have an independent testing laboratory, acceptable to the Town Engineer, obtain and cure core samples per ASTM C42 or AASHTO T24. A minimum of three (3) samples shall be taken for each one hundred (100 cy) cubic yards or fraction thereof of concrete in question.
   iii. Concrete in the area represented by the core tests shall be considered to have adequate strength if the average of the three (3) cores is equal to at least ninety one (91%) percent of the design compressive strength and no single core is less than eighty five (85%) percent. To check testing accuracy, locations represented by erratic core strengths may be retested.
   iv. If the concrete is determined not to have adequate strength, the Town Engineer may require the low strength areas to be replaced.

h. Coring. Coring is not generally permitted unless approved by the Town Engineer and, if approved, the section cored shall be repaired to the Engineer's satisfaction.

G. Concrete Mix Design. Concrete mix design shall be performed in accordance with the provisions of CDOT Specifications 601.05. A separate mix design shall be provided if pumped concrete is to be used. Mix designs shall be submitted no less than five (5) working days prior to placement of any concrete.

## 1.3 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I.

## 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.D, and as modified herein:

A. Batching. Measuring and batching of materials shall be done at a batching plant in accordance with AASHTO M157 and shall be in accordance with the provisions of CDOT Specifications 601.06.

B. Mixing. Mixing of all concrete products shall be performed be in accordance with the provisions of CDOT Specifications 601.07.

C. Air Content Adjustment. When a batch of concrete delivered to the project site does not conform to the minimum specified air content, an air entraining admixture conforming to CDOT Specification 711.02, may be added, one (1) time only for the batch, at the Contractor's option prior to consideration for rejection. After the admixture is added the concrete shall be re-mixed for a minimum of twenty (20) revolutions of the mixer drum at mixing speed. The concrete shall then be re-tested and if found acceptable may be placed in accordance with the specifications. A maximum of three (3) batches per day may be adjusted by adding air entraining admixture at the delivery site.

# PART 2 – MATERIALS

## 2.1 PORTLAND CEMENT CONCRETE PAVEMENT

Portland Cement Concrete Pavement materials shall consist of a mixture of coarse and fine aggregates, Portland cement, water, and other materials or admixtures as required. CDOT Class "P" or "AX" mix may be used. Alternatives to "P" or "AX" shall be according to CDOT Specifications 412.03. Other high-early strength concretes may be used only where special conditions warrant, subject to written approval by the Town Engineer.

## 2.2 PORTLAND CEMENT

Portland cement shall comply with the CDOT requirements and shall meet the requirements of Class "P" concrete and as shown in **Table 02585-3, Concrete Table**, given below. The type of cement shall be Type II, unless sulfate conditions necessitate otherwise. ACI 201 indicates recommendations for sulfate resistance. Laboratory trial mix for Class "P" concrete must produce an average twenty eight (28) day flexural strength of at least six hundred fifty (650 psi) pounds per square inch. Class "P" concrete shall contain seventy (70%) percent to eight (80%) percent Portland cement and twenty (20%) percent to thirty (30%) percent Class F fly ash in the total weight of cement plus fly ash. Unless acceptance is based on flexural strength, the total weight of cement plus Class F fly ash shall not be less than six hundred sixty (660 #/cy) pounds per cubic yard. If acceptance is based on flexural strength, the total weight of cement plus Class F fly ash shall not be less than five hundred twenty (520 #/cy) pounds per cubic yard.

**Table 02585-3**
**Concrete Table**

| Concrete Class | Required Field Compressive Strength | Minimum Cement Content | Air Content Percent Range | Maximum Water Cement Ratio |
|---|---|---|---|---|
| Class "P" | 4200 psi at 28 days | 660 lbs./cu.yd. | 4 – 8 | 0.44 |

## 2.3 FINE AGGREGATES

Fine aggregates for Portland Cement concrete pavements shall meet CDOT Specifications 703.01, CDOT Table 703-1 and **Table 02585-4**, below:

**Table 02585-4**
**Fine Aggregates for Portland Cement Concrete**

| Sieve Size or Test Procedure | Percent Passing or Test Requirement |
|---|---|
| Friable Particles, % | 1.0%, Maximum |
| Coal and Lignite, % | 1.0%, Maximum |
| Deleterious Material (AASHTO T-11), % | 3.0%, Maximum |
| Sand Equivalent (AASHTO T176), % | 80%, Minimum |
| Fineness Modulus | 2.50 – 3.50 |
| Sodium Sulfate Soundness, % | 20.0%, Maximum |

## 2.4 COARSE AGGREGATES

Coarse aggregates for Portland Cement concrete pavements shall meet the requirements of CDOT Specifications 703.02 and **Table 02585-5**, below:

**Table 02585-5**
**Coarse Aggregates for Portland Cement Concrete**

| Sieve Size or Test Procedure | Percent Passing or Test Requirement |
|---|---|
| 2" | 100% |
| 1-1/2" | 95% - 100% |
| 3/4" | 35% - 70% |
| 3/8" | 10% - 30% |
| #4 | 0% - 5% |
| #200 | 1.0%, Max. (1.5% if crusher fines) |
| % Wear | 45.0%, Maximum |
| Clay Lumps and Friable Particles, % | 2.0%, Maximum |
| Coal and Lignite, % | 0.5%, Maximum |
| Sodium Sulfate Soundness, % | 12.0%, Maximum |

## 2.5 FLY ASH

Fly ash for Portland Cement concrete pavements shall comply with CDOT Specifications 701.02.

## 2.6 WATER

Water for Portland Cement concrete pavements shall meet the requirements of CDOT Specifications 712.01.

## 2.7 AIR ENTRAINING AND CHEMICAL ADMIXTURES

Air entraining and chemical admixtures for Portland Cement concrete pavements shall meet the requirements of CDOT Specifications 711.02 and 711.03. No additive manufactured with the purposeful addition of chloride shall be permitted. Water-reducing admixtures are used when concrete temperatures are as follows: Type A is used between fifty (50°) degrees and ninety (90°) degrees F; Type D is used when over ninety (90°) degrees F.

## 2.8 CURING MATERIALS

Curing materials for Portland Cement concrete pavements shall meet the requirements of CDOT Specifications 711.01.

# PART 3 – EXECUTION

## 3.1 WEATHER LIMITATIONS

A. Hot Weather Limitations. Placing of concrete during hot weather shall be limited by the temperature of the concrete at the time of placing. Mixed concrete which has a temperature of ninety (90°) degrees F or higher, shall not be placed. The Contractor shall provide fogging equipment and keep the concrete surface moist at all times by fogging with an approved atomizing nozzle until the curing material is in place.

The aggregate stockpiles shall be kept moist at all times

B. Cold Weather Limitations.

1. The Contractor is responsible for the strength and quality of the concrete placed during cold weather. Before starting paving operations, the Contractor shall be prepared to protect the concrete from freezing. Maturity meters, to monitor and record time and pavement temperature, shall be installed at the time of placement when the air temperature is expected to fall below forty (40°) degrees F during the next three (3) days or as requested by the Engineer when the air temperature is expected to fall below forty five (45°) degrees F during the next three (3) days. The Contractor shall maintain the

temperature of the pavement at or above forty (40°) degrees F until the pavement has attained a compressive strength of at least two thousand (2,000 psi) pounds per square inch. The compressive strength of the concrete shall be determined by the use of maturity meters. Maturity meters shall meet the requirements of CDOT Specifications 412.15.

2. Concrete shall not be placed on frozen ground. Before concrete placement, all ice, snow, and frost shall be completely removed from within formwork. Salt shall not be used to thaw ice, snow, or frost.

3. The mixed concrete temperature shall be between fifty (50°) degrees and ninety (90°) degrees F at the time of placement. Water, aggregates, or both shall be heated when necessary under such control and in sufficient quantities to avoid fluctuations in the temperature of the concrete of more than ten (10°) degrees F from batch to batch.

4. Heating equipment or methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used. The equipment shall be capable of heating the materials uniformly. Aggregates and water used for mixing shall not be heated to a temperature exceeding one hundred fifty (150°) degrees F. Materials containing frost or lumps of frozen material shall not be used.

5. Electrically heated curing blankets or insulation blankets may be used in cold weather to maintain specified curing temperature and to retain moisture in concrete. Blankets shall be lapped at least eight (8") inches and shall be free of holes. Blankets shall be secured at laps and edges to prevent moisture from escaping.

## 3.2 PLANNING AND PREPARATION

A. Paving operations require careful planning and preparation. The surface to be paved must be properly prepared. Enough vehicles and equipment, in good operation, and adequate, trained personnel must be available to provide a steady flow of materials and progress without delays. Batch plant production must be closely coordinated with the paving operation.

B. Before spreading (placing) operations, the engineer and inspectors should confer with the contractor's superintendents and foremen and carefully plan the entire operation. Some important details that should be discussed include:

1. Continuity and sequence of operations,
2. Number and description of equipment needed for the project,
3. Number of mixer trucks required,
4. The chain of command for giving and receiving instructions,
5. Reasons for possible rejection of the mix,
6. Weather and temperature requirements, and
7. Traffic control.

## 3.3 EQUIPMENT

Equipment and tools shall be capable of handling materials, performing the Work, producing a product of specified quality, and shall be approved. The equipment shall be at the job site sufficiently ahead of the start of paving operations to be examined and approved.

A. Hauling Equipment. Concrete may be hauled and placed with nonagitator equipment. Bodies of nonagitating equipment shall be smooth, mortar tight containers, and shall be capable of discharging the concrete at a controlled rate without segregation.

B. Consolidating and Finishing Equipment. Concrete shall be spread, struck-off and finished by mechanical equipment, either from fixed forms or by slip form method, unless otherwise permitted. Consolidation shall be accomplished by vibrators for the full width of the concrete paving slabs. The vibrators shall be the internal type meeting the requirements of CDOT Specifications 412.07(b).

C. Tining Equipment. When longitudinal tining is required, the concrete pavement shall be longitudinally tined with a metal device with a single row of tines. The tines shall be of such dimensions as to produce grooves parallel with the centerline of the road in accordance with the dimension specified later herein. The tining machine shall be mechanically operated and shall cover the full pavement width in a single pass at a uniform speed and depth. Longitudinal tining shall be accomplished by equipment with horizontal and vertical controls to ensure straight, uniform grooves. Hand tining will be allowed on irregular areas or areas inaccessible to the tining machine. Hand tining shall consist of creating uniform grooves placed parallel with the centerline of the road.

D. Concrete Saw. Where sawed joints are required, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimension and at a rate that will control cracking. The Contractor shall provide at least one (1) standby concrete saw in good working order at all times. An ample supply of saw blades shall be maintained at the site of the Work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of the equipment shall be on the job during concrete placement. Wastewater generated from concrete saw operations shall be contained and disposed of in an approved manner.

E. Test Bridge. The Contractor shall furnish a movable bridge that conforms to CDOT Specifications 601.15(g) for use by the Engineer.

## 3.4 PREPARATION OF SUBGRADE

A. After the roadbed base course has been graded, compacted and prepared per these specifications, the subgrade shall be trimmed to the correct elevation and slope. For slip form paving, the elevation and slope of the trimmer shall be automatically controlled from outside reference lines established for this purpose. The trimmed subgrade shall extend at least two (2') feet beyond each edge of the proposed concrete pavement when forms are used and at least one (1') foot outside the track width of finishing, curing, and tining equipment for slip form operations. Any work required beyond the planned roadbed necessary to support the contractors' paving equipment or hauling vehicles, shall be included in the work.

B. The subbase or base course shall be brought to the specified cross section. High areas shall be trimmed to the proper elevation. Low areas in untreated bases may be filled and compacted to a condition similar to that of the surrounding grade, or filled with concrete integral with the pavement. Low areas in treated bases shall be filled with concrete integral with the pavement. The finished grade shall be maintained in a smooth and compacted condition until the pavement is placed.

C. Untreated subgrade or base course shall be uniformly moist during concrete placement. If it becomes too dry, the untreated subgrade or base course shall be sprinkled without forming mud or pools of water.

## 3.5 FORMS

A. Design.

1. Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the concrete operations, including vibration.

2. The rate of depositing concrete in forms shall be controlled to prevent deflections of the form panels in excess of the deflections permitted by these specifications.

3. Forms for drainage inlets may be constructed of any suitable material that will produce a structure with the inside dimensions and at least the wall thicknesses shown on the plans. Undulation of finished interior wall surfaces shall not exceed one half (0.5") inch.

B. Material.

1. Forms shall be made of wood, metal or other material as approved by the Town Engineer.

2. Approved flexible forms shall be used for construction where the radius is one hundred (100') feet or less. Unexposed surfaces shall have wood forms of No. two (2) common (or better) lumber.

3. Metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms shall be free from rust, grease or other foreign matter

C. Construction.

1. Forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber. The use of ties consisting of twisted wire loops to hold forms in position will not be permitted.

2. The inside surfaces of forms shall be cleaned of all dirt, mortar, and foreign material. Forms which will later be removed shall be thoroughly coated with form oil prior to use. The form oil shall be a commercial quality form oil or other equivalent coating which will permit the ready release of the forms and will not discolor the concrete.

3. Forms which do not present a smooth surface or do not line up properly shall not be used.

4. Forms shall have a depth equal to or greater than the specified edge thickness of the concrete, without horizontal joint.

5. Top surface of the forms shall be set flush with the proposed concrete surface. The top face of the form shall not vary from a true plane by more than one eighth (1/8") inch in ten (10') feet, and the vertical leg shall not vary more than one quarter (1/4") inch from vertical.

6. Forms shall be provided with adequate devices for secure setting so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be staked securely to line and grade to the satisfaction of the Engineer.

7. Concrete shall not be deposited in the forms until all work connected with constructing the forms has been completed; all materials required to be embedded in the concrete have been placed, unless otherwise specified on the plans or approved; and the Engineer has inspected said forms and material. Such work shall include the removal of all dirt, chips, sawdust, water and other foreign material from the forms.

8. In lieu of construction by form method, the concrete may be placed with an approved, self propelled slip form paver capable of spreading, consolidating, screeding, and finishing the freshly placed concrete with one pass of the paver. The paver shall be capable of providing a dense and homogenous pavement with an even texture and no porous areas, and to the slope and elevation specified.

D. Removal of Forms.

1. The forms for any portion of the concrete pavement shall not be removed until the concrete is strong enough to withstand damage when the forms are removed.

2. Removal of forms shall not occur before twelve (12) hours after concrete pour. When the ambient temperature is below forty (40°) degrees F, the time shall be twice that duration.

3. If high-early-strength (Type III) cement or accelerating admixtures are used, the above periods may be reduced as approved.

## 3.6 PLACING CONCRETE

A. Placing.

1. Concrete pavement may be placed using slip form methods or fixed forms.

2. The concrete shall be uniformly deposited on moist subgrade in such a manner as to require as little rehandling as possible. Reasonable care shall be taken to prevent any segregation of the concrete materials and the displacement of the reinforcement.

3. Concrete shall not be dropped more than five (5') feet, unless confined by closed chutes or pipes. Concrete shall be placed in lifts not to exceed eighteen (18") inches.

4. Care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The coarse aggregate shall be worked back from the forms and worked around the reinforcement without displacing the bars. After initial set of the concrete, the forms shall not be jarred and strain shall not be placed on the ends of projecting reinforcement.

5. Concrete shall be placed by an approved placer spreader machine. Necessary hand spreading shall be done with shovels, not rakes. Workers shall not walk in freshly mixed concrete with footwear coated with earth or foreign substances. All footprints in the fresh concrete shall be vibrated and finished flush with the adjacent surface.

6. Where concrete is placed adjacent to a newly constructed lane of pavement with the concrete paving equipment operating on the newly constructed pavement, the concrete shall have attained a minimum compressive strength of two thousand (2,000 psi) pounds per square inch prior to commencing paving. Determination that the concrete has reached the 2000 psi shall not relieve the Contractor of the responsibility for protecting the pavement.

7. Any concrete or foreign materials that falls on or is worked into the surface of a completed slab shall be removed immediately.

B. Vibrating.

1. Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies by means of suitable mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate consolidation.

2. Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and imbedded fixtures and into corners and angles of the forms. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form.

3. Vibrators shall not be used as a means to cause concrete to flow or run into position in lieu of placing. The vibration at any point shall be of sufficient duration to accomplish consolidation, but shall not be prolonged to the point where segregation occurs.

4. Following placement, the concrete shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the plans or established.

C. Finishing.

1. The sequence of operations shall be strike-off and consolidation, floating, and final surface finish.

2. The Contractor shall not add water to the surface of the concrete to assist in finishing operations.

3. The surface shall be finished to a uniform texture, true to grade and cross section, and free from porous areas. When the finishing machine (either form or slip form) or hand finishing method, leaves a surface that is not acceptable, the operations shall stop and corrective action shall be taken.

4. A float finish shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar surface. Creation of concave surfaces shall be avoided.

5. After the concrete has been struck off and consolidated and joints formed (if necessary), the surface shall be thoroughly worked and floated with a suitable floating tool, or bull float having a handle long enough to permit operation from the edge of the pavement. Any excess water and latencies shall be removed from the surface of the pavement.

6. Wastewater generated from concrete finishing operations shall be contained and disposed of in an approved manner.

7. The straightedge shall be operated at ninety (90°) degrees to the traverse joints and shall be overlapped one half (½) of its length after each pass. Irregularities shall be corrected by adding or removing concrete material. All disturbed places shall again be straightedged. The use of hand tools shall be kept to a minimum. They may be used in areas not accessible to finishing equipment and for compacting concrete in the vicinity of formed joints.

8. For the final finish, a strip of plastic turf shall be dragged longitudinally over the full width of pavement after a strip of burlap or other approved fabric has been dragged longitudinally over the full width of pavement to produce a uniform surface of gritty texture.

   The plastic turf drag shall be made of material at least three (3') feet wide and be maintained in such a condition that the resultant surface finish is of uniform appearance and reasonably free from grooves over one sixteenth (1/16") inch in depth. Drags shall be maintained clean and free from encrusted mortar.

9. Where posted speeds are forty (40 mph) miles per hour or higher, the surface shall be given a longitudinal metal tine finish immediately following turf drag. Tining is not required where posted speeds are less than forty (40 mph) miles per hour. Tining shall produce grooves of one eighth (1/8") inch by one eighth (1/8") inch spaced three quarter (3/4") inch apart and parallel to the longitudinal joint. Longitudinal tining shall stop at the edge of travel lanes. Tining devices shall be maintained clean and free from encrusted mortar and debris to ensure uniform groove dimensions. The tining finish shall not be performed too early whereby the grooves may close up.

   The tining grooves shall be neat in appearance, parallel with the longitudinal joint, uniform in depth and in accordance with what is shown in the plans and these specifications.

D. Joints. The spacing of contraction joints depends on slab thickness, shrinkage potential of the concrete, subgrade friction, environment, and the absence or presence of steel reinforcement and therefore is a design determination. Transverse and longitudinal joints shall be constructed to the dimensions and at the spacing shown on the plans. Transverse joints shall extend the entire width of the pavement and through the curbs. Joints may be formed in the plastic concrete or sawed after the concrete has hardened. Tooled joints may be constructed by depressing an approved tool into the plastic concrete cut a minimum of one quarter (¼) the thickness of the slab.

1. Sawed Joints. Sawing of joints shall begin within twenty four (24) hours or as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling and before uncontrolled cracking occurs. If necessary, the sawing operations shall be carried on both day and night, regardless of weather conditions. At Contractor's option, tooled joints may be installed during initial placement to control cracking.

   Immediately after sawing, the sawed joints shall be flushed with water to remove any saw residue, and the saw residue shall be completely removed from the surface of the pavement by approved

methods. All equipment other than saws shall be kept off the pavement until the sawing and sealing are complete.

After the proper curing period, the sawed joint shall be thoroughly cleaned and immediately sealed in accordance with these specifications as detailed below.

2. Construction Joints. Construction joints shall be made only where located on the plans or shown in the placing schedule, unless otherwise approved. All construction joints shall be cleaned of surface laitance, curing compound, and other foreign materials before fresh concrete is placed against the surface of the joint. Surfaces on which concrete is to be placed shall be thoroughly moistened with water immediately before placing concrete.

   When new concrete is to be joined to existing concrete by means of bar reinforcing dowels placed in holes drilled in the existing concrete, the diameter of the holes shall be the minimum needed to place non-shrink grout or epoxy grout and the dowel. Immediately prior to placing the dowels, the holes shall be cleaned of dust and other foreign material and sufficient grout placed in the holes so that there are no voids in the drilled holes after the dowels are inserted.

   a. Longitudinal Construction Joints. Keyways and epoxy coated, deformed steel tie bars shall be placed as specified in the plans. Tie bars shall be placed perpendicular to the longitudinal joint by an approved method. When adjacent lanes of pavement are constructed separately, tie bars may be bent at right angles against the edge of the first lane constructed and straightened into final position before the concrete of the adjacent lane is placed. In lieu of bent tie bars, approved two (2) piece connectors may be used. If the coating of epoxy coated tie bars is damaged, the bars shall be repainted with epoxy paint prior to placement of concrete.

   b. Transverse Construction Joints. Transverse construction joints shall be installed where called for on the plans, when the concrete placement is interrupted for more than thirty (30) minutes and initial set is imminent, or whenever the placing of concrete is suspended for an excessive length of time as determined by the Engineer. No traverse joint shall be constructed within two (2') feet of another transverse joint.

      Transverse construction joints shall be placed at the end of each day's placement.

3. Expansion Joints. Preformed joint filler expansion joints shall be constructed at all existing or proposed structures and features projecting through, into, or against the concrete pavement and at other locations specified in the Contract. Features include but are not limited to items such as fire hydrants, poles, inlets, other fixed objects, i.e. ends of sidewalk slabs and curbs. Expansion joint material must be set vertical and with the top edge flush with the finished surface. The joint shall be edged with a suitable edging tool.

E. Curing. Immediately after the finishing operations have been completed, the entire surface, including tined grooves and exposed sides of the newly placed concrete pavement, shall be sprayed uniformly with an impervious membrane curing compound. The impervious membrane curing compound shall meet the requirements of AASHTO M148, Type 2 and shall be volatile organic content (VOC) compliant. The new concrete shall not be left exposed for more than thirty (30) minutes before being covered with curing compound. Failure to cover the surface of the concrete within the thirty (30) minutes shall be cause for immediate suspension of the paving operations. The freshly placed concrete shall be protected from premature drying and excessive cold or hot temperatures as well as rain, flowing water, and mechanical injury. In hot, dry, and windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporative-control material.

1. Curing compound shall be applied under pressure by mechanical sprayers at the rate of not less than one (1) gallon per one hundred fifty (150 $ft^2$) square feet of pavement surface. Curing compound may be applied in two (2) passes, one forward and one backward. The spraying equipment shall be fully atomized, equipped with a tank agitator, and a wind guard. During application, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle and the compound shall be stirred continuously by effective mechanical means. Hand

spraying of irregular widths or shapes and surfaces exposed by removal of forms may be permitted. Curing compounds shall not be applied to the inside faces of joints to be sealed.

2. Should the curing film become damaged from any cause, within seventy two (72) hours after application, the damaged portions shall be repaired immediately with additional compound.

3. The sides of concrete pavement slabs shall be immediately sprayed with curing compound when the forms are removed.

4. Curing compound shall not be used on construction joints.

5. The minimum curing period shall be one hundred twenty (120) hours.

6. The Contractor is responsible for the strength and quality of the concrete placed during cold weather. When the ambient temperature is below thirty five (35°) degrees F, the Contractor shall maintain the concrete temperature above fifty (50°) degrees F during the curing period. It is the Contractor's responsibility to determine for himself the necessity for undertaking protective measures.

## 3.7 REPAIR OF DEFECTIVE CONCRETE PAVEMENT

A. Defective concrete pavement shall be repaired or replaced at the contractor's expense. This corrective work shall be accomplished prior to joint sealing and final smoothness measurement. Defective concrete pavement replaced after smoothness measurement shall be retested for final smoothness. The Contractor's corrective work plan shall be approved prior to performing the work.

B. When necessary, the extent of defects will be determined by the inspection of cores drilled at the Contractor/Owner's expense.

C. Pavement slabs with any of the following conditions shall be removed and replaced:

1. Pavement slabs in driving lanes containing one (1) or more cracks through the full depth of the slab that separate the slab into two (2) or more parts.

2. Pavement slabs containing honeycomb areas.

3. Pavement slabs containing an extreme void as defined below.

4. Pavement slabs containing more than one (1) void greater in depth than half (½) the pavement thickness.

5. Pavement slabs containing a cumulative surface area of moderate and severe voids, as defined below, greater than one (1%) percent of the slab's total area.

6. Pavement slabs containing twenty (20) or more severe voids as defined below.

7. Pavement slabs containing concrete gouges that meet or exceed the following:

a. One (1) gouge that penetrates three quarters (3/4") inch or deeper and covers an area of ten (10 $in^2$) square inches.

b. Two (2) gouges that penetrate one half (1/2") inch or deeper and cover a combined area of fifteen (15 $in^2$) square inches.

c. Three (3) gouges that penetrate one quarter (1/4") inch or deeper and cover a combined area of twenty five (25 $in^2$) square inches.

d. Four (4) gouges that penetrate one eighth (1/8") inch or deeper and cover a combined area of thirty five (35 $in^2$) square inches.

8. Pavement slabs containing other imperfections in the concrete surface such as stress cracking, D-cracking, pop-outs, spalling, rain damage, graffiti, and other surface defects will remain discretionary and will usually require removal and replacement.

D. A void is a defect in a slab caused by air pockets, clay balls, clumps of sand, cement or reinforcing fibers caused by incomplete mixing or foreign materials such as cans, rags, bottles, etc. The defect will be considered a moderate void when the largest dimension, either height, width, or length is at least one half (½") inch but no more than two (2") inches. The defect will be considered a severe void when the largest dimension, either height, width, or length is greater than two (2") inches. The defect will be considered an extreme void when the largest dimension, either height, width, or length is greater than the thickness of the pavement.

E. When the Engineer determines that voids are at an unacceptable level, the paving shall stop, and the cause shall be identified and corrected by the Contractor before paving operations are allowed to resume.

F. Concrete slabs that are determined by the Engineer to be acceptable if repaired shall have voids filled using materials and methods approved by the Engineer.

G. When portions of concrete pavement are removed and replaced, the portion removed shall be the full width of the lane and length of the affected slab. All saw cuts for removal of slabs shall be full depth cuts. All sections removed shall have edges approximately parallel with adjacent panel joints.

H. All corner cracks to a panel shall be removed and replaced as required by the criteria contained herein.

I. Slabs with cracks penetrating the full depth of pavement shall be removed as required above. Cracks that penetrate partial depth may, with the written approval of the Engineer, be epoxy injected using materials and methods approved by the Engineer.

J. Joints and cracks that are spalled shall be repaired as follows:

1. A saw cut at least one (1") inch outside the spalled area and to a minimum depth of two (2") inches shall be made parallel to the joint or crack.

2. The concrete between the saw cut and the joint or crack shall be chipped out to solid concrete to a minimum depth of two (2") inches.

3. The cavity formed shall be thoroughly cleaned.

4. A prime coat of epoxy-resin binder shall be applied to the dry, cleaned surface on all sides of the cavity, except the face of the joint or crack. The prime coat shall be applied by scrubbing prime coat material into the surface with a stiff bristle brush.

5. Placement of Portland cement concrete or epoxy-resin concrete shall immediately follow the application of the prime coat.

If the spalled area, to be repaired, abuts a working joint or a working crack which penetrates the full depth of the pavement, an insert or other bond-breaking medium shall be used to maintain the working joint or crack during the repair work.

## 3.8 SEALING JOINTS

All longitudinal and transverse joints in the concrete pavement shall be filled before the pavement is opened to traffic. The methods and materials to be used for sealing joints shall be in accordance with the provisions of CDOT Specifications 412.18.

## 3.9 FIELD QUALITY CONTROL

Field Quality Control shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.J; except subsection 1.3.J. shall be modified to include the following:

A. Mix Design. The Contractor shall submit a Concrete Mix Design Report consisting of design mix proportions, laboratory trial mix and aggregate data for each class of concrete being placed on the project. Concrete shall not be placed on the project before the Concrete Mix Design Report has been reviewed and approved by the Town Engineer. The design mix proportions shall show the weights and sources of all ingredients including cement, fly ash, aggregates, water, additives and the water cement ratio (w/c). When determining the w/c, cement (c) shall be the sum of the weight of the cement, the weight of the fly ash and the weight of silica fume.

   The laboratory trial mix data shall include results of all the information requested in CDOT Standard Specifications 601.05.

B. Field Acceptance Tests. These provisions apply to all concrete placed in the field:

   1. Air Content. At any time during the placement of the concrete pavement, when a batch deviates from the minimum or maximum percent of total air content by more than one (1%) percent, the entire batch shall be rejected.

   2. Slump. At any time during the placement of the concrete pavement, when a batch deviates from the maximum slump specified by more than one and one half (1½") inch, the entire batch shall be rejected. Portions of loads incorporated into structures prior to determining test results which indicate rejection as the correct course of action shall be subject to acceptance or removal as determined by the Engineer.

   3. Strength. The concrete will be considered acceptable when the running average of three (3) consecutive strength tests is equal to or greater than the specified strength and no single test falls below the specified strength by more than five hundred (500 psi) pounds per square inch.

      a. A test is defined as the average strength of three (3) test cylinders cast in plastic molds from a single sample of concrete and cured under standard laboratory conditions prior to testing. If the compressive strength of any one (1) test cylinder differs from the average by more than ten (10%) percent, that compressive strength will be deleted and the average strength will be determined using the compressive strength of the remaining two (2) cylinders.

      b. When the compressive strength test is below the specified strength by more than five hundred (500 psi) pounds per square inch but not more than one thousand (1,000 psi) pounds per square inch, the concrete represented will be evaluated by the Town Engineer for removal, corrective action, or acceptance. When the compressive strength is below the specified strength by more than one thousand (1,000 psi) pounds per square inch, the concrete represented shall be rejected.

      c. The Contractor/Owner may take cores at its own expense and in accordance with Colorado Procedure 65 to provide an alternative determination of strength.

C. Surface Smoothness. The roadway surface smoothness shall be tested by one of the following two methods. The Engineer shall determine the required process on a site specific basis.

   1. Conformity to CDOT Roadway Smoothness Criteria. If specified by the Engineer, the Contractor shall test the smoothness of the concrete paved roadway in accordance with the provisions of CDOT Specifications 105.07, for both Transverse Pavement Surface Smoothness and Longitudinal Pavement Surface Smoothness criteria. Incentive and disincentive payments shall not apply. If not specified otherwise on the plans, the roadway surface shall be subject to inches per mile requirements for Category II, Highways with speed limits equal to or greater than forty five (45 mph) miles per hour; in accordance with CDOT Table 105-6.

2. Conformity to Straight Edge Tolerances. If specified by the Engineer, the Contractor shall test the smoothness of the concrete paved roadway in accordance with the following:

   a. The finished surface course shall not vary from the established grade by more than one half (½") inch for the wearing course when tested with a ten (10') foot straight edge applied parallel with or at right angles to the centerline.

   b. Areas showing high spots greater than one quarter (¼") inch as measured with a ten (10') foot straight edge, but less than one half (½") inch, shall be diamond ground to within the specification of less than one quarter (¼") inch.

   c. Where the constructed surface of concrete paved roadways varies from the design cross slope by more than one half (½") inch when tested with a ten (10') foot straight edge, the pavement shall be removed and replaced as specified herein.

D. Standing Water. In addition to the surface tolerances stated, there shall be no allowance for standing water on the final pavement surface.

E. Conformity to Plans. Tests for conformity with the specified crown and grade shall be made by the Contractor prior to opening to traffic, and any variation shall be corrected by removing or adding materials as directed. Prior to final acceptance, the Contractor/Owner must provide to the Town a field verification of critical elevations and cross sections to ensure that the construction complies with the approved plans. Verification shall consist of a letter and/or drawings, certified by a Professional Engineer or Land Surveyor, stating that the field verification has found the work substantially conforms to the approved plans.

F. Tolerances. After construction, the concrete pavement adjoining the concrete gutter pan shall be flush with or no higher than one quarter (¼") inch above the lip of the concrete pan. All manholes, water valves, range boxes, etc., shall be flush to one quarter (¼") inch below the final concrete pavement surface grade. Refer to **Section 02610**, for adjustments to final grade.

G. Determining Pavement Thickness. The total thickness of the pavement, as called for on the Plans, shall be determined by measurement of the length of cores tested, as required and directed by the Town Engineer. A minimum of two (2) cores per one thousand (1,000 sy) square yards will be taken at random. Should any deviation from specification be found, additional cores may be taken to define the horizontal limits of the deviation. When measurement of the core from a unit is not deficient by more than one quarter (¼") inch from the design thickness, the pavement thickness will be considered to be within acceptable tolerance. When such measurement is deficient more than one quarter (¼") inch and not more than one (1") inch from the design thickness, two (2) additional cores at intervals not less than three hundred (300') feet will be taken and used to determine the average thickness for that area. When the thickness of pavement is deficient by more than one (1") inch, the Town Engineer may require that the area be removed and replaced.

## 3.10 OPENING TO TRAFFIC

The Town Engineer will determine when the concrete paved roadway shall be opened to traffic; otherwise it shall not be opened to traffic until fourteen (14) days after the concrete was placed or the field-cured concrete has attained a compressive strength of at least three thousand three hundred (3,300 psi) pounds per square inch. Prior to opening the pavement to traffic, the roadway shall be cleaned, striped, signed, and otherwise prepared as specified within these Specifications.

**END OF SECTION**

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**SECTION 02595**

**UTILITY CUTS, BACKFILL AND PAVEMENT PATCHING**

## PART 1 – GENERAL

### 1.1 DESCRIPTION

The Work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials necessary for reconstruction and repair of utilities and improvements in existing streets, or other pavements, within the public right-of-way or public easements within the Town of Windsor or its Growth Management Area. The Work shall consist of cutting and carefully removing pavement wearing surfaces, excavation of sub-bases and materials to the necessary depth for reconstruction and/or repair, utility installation or repair, backfilling, compaction, and pavement replacement in accordance with these specifications and in conformance with the lines, grades, typical cross sections, and thickness as shown on the approved plans.

All infrastructure elements that undergo reconstruction and repair shall be restored to a condition equal to, or better than, the initial condition prior to repairs.

Utility cuts on State Highways is governed by State law and regulations, and these Standards where they may apply, and all utility work in State Highways shall be reviewed and approved by the Colorado Department of Transportation (CDOT) prior to any excavations.

### 1.2 QUALITY ASSURANCE

Quality Assurance shall be as specified in **Section 01010**, **Summary of Work**, Subsection 1.3.C., and as modified herein:

A. If the reconstruction and repair improvements occur in an existing Town roadway paved with asphalt pavement, Quality Assurance and construction processes shall be as specified in **Section 02575, Bituminous Paving – SuperPave Method**, and as modified herein.

B. If the reconstruction and repair improvements occur in an existing Town roadway paved with Portland Cement concrete pavement, Quality Assurance and construction processes shall be as specified in **Section 02585, Portland Cement Concrete Pavement**, and as modified herein.

C. Removal and replacement of unsatisfactory work shall be completed within fifteen (15) days of written notification from the Town Engineer of the deficiency unless the condition is deemed an emergency requiring immediate correction. In the event the replacement work is not completed within the specified time period, the Town Engineer may take action to complete the work and charge the Contractor/Owner for all related costs.

### 1.3 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I., and as modified herein:

A. Verification of Existing Utilities.

1. Responsibility. The Contractor/Owner is responsible for field locating and verifying elevations of all existing sewer mains, storm mains, water mains, service lines, and other utilities at the points of connection shown on the plans, and at utility crossings prior to any reconstruction or repair.

2. Pot Holing. All excavations for utility locates, unless otherwise approved by the Town of Windsor Engineering Division, shall be made by the pot holing method. All pot holing locates shall meet the following requirements:

a. Locate potholes shall not be placed within the wheel track of a travel lane.

b. All locate potholes in the pavement section shall be cored with a circular coring saw with a maximum diameter of twelve (12") inches. The plug shall be carefully removed without causing damage.

c. Materials beneath the wearing surface shall be removed by methods approved by the Town Engineer that will not damage the utility or facility.

d. Excavations for potholes shall be backfilled with flowable fill and capped with non-shrink grout in conformance with **Section 02223**, Subsection 2.2. Native material removed shall not be used to backfill the pothole.

e. The caps on the backfilled potholes shall be five and a half (5½") inches thick in local streets, seven and a half (7½") inches thick in other streets, and shall be finished between one quarter (¼") inch and one half (½") inch below adjacent pavements. Alternate methods must be approved by the Town Engineer.

f. Initial locate potholes may be temporarily repaired, meeting all applicable safety requirements, for no more than thirty (30) days unless additional time is authorized by the Town in writing. Initial locate potholes may be reused during construction.

B. Design Alignment.

1. The utility alignment shall not vary greater than eighteen (18") inches plus one half (½) of the diameter of the proposed conduit from the approved design horizontal alignment or thirty six (36") inches plus one half (½) of the diameter of the proposed conduit from the approved design vertical alignment without prior Town approval.

2. If the designed alignment conflicts with other facilities not shown on the approved plans, or a design modification is required, the permittee shall submit an alignment modification request and the change shall be approved by the Town prior to proceeding.

3. All underground cables and wires, excluding electrical, shall be placed within a conduit sleeve, with a locator tracer.

4. All underground installations shall have a minimum of thirty (30") inches of cover below the roadway surface.

C. Traffic Control.

1. When it is necessary to obstruct roadways or pedestrian ways, the permittee shall submit traffic control plans, in compliance with the Manual on Uniform Traffic Control Devices (MUTCD), showing all work and including the following information:

a. Each lane closure scenario, including work zones for locate pothole work.

b. Lane configurations and access locations specific to the actual work zone.

c. Any upstream intersections within five hundred (500') feet of the work zone, showing all impacted inbound lanes to the intersection.

d. Pedestrian route detours showing the nearest crossing intersection at each end of the work zone.

e. Proposed hours of operation of each traffic control setup.

2. All traffic control plans shall be prepared under the supervision of a certified Work Site Traffic Control Supervisor. Documentation of certification shall be submitted with the traffic control plans(s).

3. Unless otherwise noted on the permit, lane closures shall be permitted only between the times shown below:

    a. For Arterial and Collector roadways: between 8:30 a.m. and 3:30 p.m. on weekdays, and, upon written approval of the Town Engineer, between 8:00 a.m. to 7:00 p.m. on Saturdays, and 10:00 a.m. to 7:00 p.m. on Sundays.

    b. For Local roadways: between 8:00 a.m. and 4:30 p.m. on weekdays, 8:00 a.m. to 7:00 p.m. on Saturdays, and 8:00 a.m. to 6:00 p.m. on Sundays.

4. When conditions warrant, in order to minimize impact to the motoring public, the Town may require that the permittee perform work between the hours of 7:00 p.m. and 6:00 a.m. or on weekends. Timing of reconstruction and repair work may be restricted by the Town Engineer to certain time periods to accommodate traffic and other public uses.

5. When planning construction phasing and developing traffic control plans, the permittee shall make every effort to minimize the impact to the motoring public and maintain the capacity of the roadway system. The Town may require that a traffic control plan be modified to comply with this requirement. The permittee shall make adequate provisions to assure that traffic and adjacent property owners experience a minimum of inconvenience.

6. All signs and devices shall conform to the Manual on Uniform Traffic Control Devices (MUTCD). The devices and signs shall be clean, legible, and properly mounted. All signs and devices used for the night operation shall meet the retro reflective requirements of CDOT Specifications Section 713.10.

7. For major installations, as defined by the Town Engineer, the Town may require that a permittee place Variable Message Boards five (5) working days in advance of the work to notify the travelling public of the upcoming construction impacts. All costs for this work shall be borne by the permittee.

8. If the closure of a street is required for completion of the work, the permittee shall provide all notifications to emergency agencies, government entities, school and bus districts, newspapers, adjacent businesses and homeowner's associations in a format approved by the Town.

9. No permittee shall block access to any private property, fire hydrant, fire station, utility structure, or any other emergency response equipment unless the permittee provides the Town with written approval from the affected agency and/or property owner.

10. When necessary for public safety and when required by the Town, the permittee shall employ flag persons to control traffic around or through the work site.

11. The permittee shall be responsible for maintaining all work area signing and barricading required throughout the duration of work. During non-work hours, all signs that are not appropriate shall be removed, covered or turned around so that they do not face traffic.

12. Any deficiencies noted by the Town shall be corrected immediately by the permittee. If the permittee is not available or cannot be found, the Town may make the required corrections and charge the cost thereof to the permittee.

13. If a temporary patch is used and construction traffic control for the project is terminated, the appropriate contractor must obtain another Street Cut Permit, including the approval of a construction Traffic Control Plan, to provide for the final patch work. This is to insure proper approval of traffic control and schedule inspections. If this final patch work is completed within thirty (30) days of the temporary patch, no additional fees will be charged for the follow-up permit.

D. <u>Equipment</u>.

1. The use of trench digging equipment will be permitted only in places where its operation will not cause damage to existing structures or features, otherwise, hand methods shall be employed.

2. Backhoe equipment outriggers shall be fitted with rubber pads or other like protective material whenever outriggers are placed on any paved surface.

3. No tracked vehicles will be permitted on streets unless approved by the Town Engineer. When tracked vehicles are allowed, specific precautions shall be taken to protect the pavement surface and damaged facilities shall be restored to original condition at the Contractor's/Owner's expense.

4. Haul routes for equipment and materials may be restricted as a condition of the Permit.

5. All equipment and trucks tracking mud and debris into a public right-of-way shall be cleaned of mud and debris at the end of each day or as otherwise directed by the Town.

### 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010**, **Summary of Work**, Subsection 1.3.D., and as modified herein:

A. If the reconstruction and repair improvements occur in an existing Town roadway paved with asphalt pavement, Product Delivery, Storage and Handling and construction processes shall be as specified in **Section 02575, Bituminous Paving – SuperPave Method**, and as modified herein.

B. If the reconstruction and repair improvements occur in an existing Town roadway paved with Portland Cement concrete pavement, Product Delivery, Storage and Handling and construction processes shall be as specified in **Section 02585, Portland Cement Concrete Pavement**, and as modified herein.

## PART 2 – MATERIALS

### 2.1 FLOWABLE BACKFILL

Flowable backfill meeting the requirements of **Section 02223**, **Structural Backfill**, Subsection 2.2, shall be used to backfill all open cuts in portions of the Public right-of-way beneath existing paving, curb, gutter, or sidewalk improvements. Alternate backfill methods for large excavations (greater than one hundred (100 cy) cubic yards) will be considered on an individual basis with the Town Engineer.

### 2.2 BASE COURSE

If the existing base course material is untreated, it shall normally be replaced with CDOT Class 5 or 6 aggregate base course material and compacted in lifts not to exceed six (6") inches in thickness. The resulting total compacted base thickness shall be the thickness of the removed base plus two (2") inches.

### 2.3 NATIVE BACKFILL

A. In cases where flowable backfill is not required and the Contractor wants to use the excavated onsite material, the material must be evaluated by a Geotechnical Engineer. The engineer must confirm in writing that the material meets structural fill requirements. A proctor curve for each different type of the material must accompany the letter from the engineer. Backfill of suitable material shall be placed in maximum eight (8") inch lifts and mechanically compacted. Density and moisture control shall be per CDOT Specifications Section 2.03.

B. The Contractor shall provide compaction testing for all backfill work per the requirements of Subsection 1.2, Quality Assurance, stated above. Compaction test requirements shall be at least one per one hundred fifty (150') lane foot, minimum of two (2) tests per lift. Each lift not tested in accordance with these requirements may be rejected by the Town Engineer.

### 2.4 STRUCTURAL BACKFILL

Structural backfill meeting the requirements of **Section 02223**, **Structural Backfill**, Subsection 2.1, may be used to backfill bridges, box culverts, or where otherwise specified, and permitted only upon approval of the Town Engineer.

## 2.5 BRIDGING PLATES

When required by the Town Engineer, substantial steel bridging, properly anchored and capable of carrying the legal limit loading, in addition to adequate trench bracing, may be used to bridge across trenches at street crossings where trench backfill and temporary patches have not been completed during regular working hours. Steel bridging plates shall meet the following minimum requirements:

A. Steel bridging plates shall typically be four (4') foot by eight (8') foot in width and length, one (1") inch thick minimum, and shall be secured to the pavement with anchored pins so that it does not slip. The bridging plate shall extend over supporting pavement by a minimum of one (1') foot on all sides. Asphalt material shall be placed at the edges of the plate to provide a ramp at a minimum 1:12 slope.

B. The Contractor's design engineer shall certify in writing the suitability of the plates for the specific use proposed. Typically, bridging plates shall be ASTM A709 Grade 50W steel and meet AASHTO M270 requirements.

C. The use of bridging plates shall not be allowed from October through April. Use of bridging plates shall only be allowed with the prior approval of the Town Engineer.

## 2.6 ASPHALT PATCHING

If the reconstruction and repair improvements occur in an existing Town roadway paved with asphalt pavement, materials for Street Pavement Patching shall be as specified in **Section 02575, Bituminous Paving – SuperPave Method**, Subsection 2.1 thru 2.8, and as modified herein:

A. Minimum requirements for temporary patching material shall be well-compacted surfacing material conforming to "Road Mixed Asphalt Surfacing Material" of the CDOT Specifications.

B. Patching material shall match flush with the existing pavement surface and shall have a thickness one (1") inch greater than the existing pavement and shall not be less than four (4") inches thick.

C. The mineral aggregate shall conform to the grading specified for three eights (3/8") inch maximum aggregate plus or minus five (± 5%) percent.

D. Bituminous binder to be mixed with the mineral aggregate shall be liquid asphalt, Grade MC-3000, and shall be an amount between five and a half (5½%) and six (6%) percent by weight of the dry mineral aggregate. Asphalt binder grading shall be PG 64-22 or PG 58-28.

## 2.7 PORTLAND CEMENT CONCRETE PATCHING

If the reconstruction and repair improvements occur in an existing Town roadway paved with Portland Cement concrete pavement, materials for Street Pavement Patching shall be as specified in **Section 02585, Portland Cement Concrete Pavement**, and as modified herein. Materials for the repair or reconstruction of concrete sidewalks, curbs, gutters, aprons, ramps, pedestrian crossing, etc. shall also meet these requirements.

A. Concrete Pavement. Patching material shall match flush with the existing concrete pavement surface and shall have a thickness one (1") inch greater than the existing pavement and shall not be less than eight (8") inches thick.

B. Concrete Sidewalks. Patching material shall match flush with the existing concrete sidewalk surface and shall have a thickness one (1") inch greater than the existing sidewalk and shall not be less than four (4") inches thick for sidewalks without vehicle access and are located behind vertical curb and gutter, and shall not be less than six (6") inches thick for sidewalks with drive over curb and gutter.

C. Concrete Flat Work. Patching material for all other flat work concrete surfaces shall match flush with the existing concrete surface and shall have a thickness one (1") inch greater than the existing flat work and shall not be less than six (6") inches thick.

D. Concrete Strength. All concrete repair material and placement shall be CDOT Class P, with four thousand two hundred (4,200 psi) pounds per square inch compressive strength at twenty eight (28) days. Mix design shall be performed in accordance with the provisions of CDOT Specifications 601.05.

E. Quick Curing Concrete. The use of quick curing concrete (3,000 psi strength within 48 hours) shall be used on all Arterial and Collector streets when repair areas are less than five hundred (500 $ft^2$) square feet or when temperatures are below forty (40°) degrees F. Mix design shall be performed in accordance with applicable CDOT Specifications.

## 2.8 AGGREGATE

When reconstruction and repair improvements occur in streets or alleys that have only a gravel surface, the Contractor shall replace such surfacing on a satisfactory compacted backfill with gravel aggregate conforming to CDOT Class 5 or Class 6 aggregate base course.

A. The thickness of gravel replacement shall be one (1") inch greater than the thickness of the original gravel surface, but shall not be less than four (4") inches. The surface shall conform to the original street grade.

B. Where the completed surface settles, additional gravel material shall be placed and compacted by the Contractor immediately after being notified by the Town Engineer, to restore the roadbed surface to finished grade.

C. Where existing graveled streets or alleys may have been previously treated with a special surface treatment to control dust and/or bind the aggregates together, the Contractor is responsible for installing the gravel surface in the same manner. Such surface treatments shall be of the same chemical composition as what existed prior to the excavation work.

## 2.9 BORING AND CASING

Utility crossings under sidewalks, curbs, roadways, etc., may be made by boring and casing and then installing the utility; however, boring and casing will not be allowed where existing PVC conduits are available. Materials shall meet the following requirements:

A. Casing Pipe. The casing pipe shall be fabricated steel having a minimum yield strength of thirty five thousand (35,000 psi) pounds per square inch. The minimum wall thickness shall be as shown in **Table 02595-1**, below, or as otherwise noted on the approved drawings:

**Table 02595-1**
**Casing Wall Thicknesses**

| Casing Pipe Diameter | Minimum Wall Thickness |
|---|---|
| 36" and smaller | 3/8 inch |
| 42" and smaller | 5/8 inch |

Casing pipe placed by boring may be bare steel pipe unless otherwise noted on the plans. Cathodic protection shall be as recommended by the manufacturer, but at a minimum shall consist of a five (5 lb) pound anode bag placed at and connected to each end of the steel casing pipe. A locator tracer wire or tape shall be installed above the casing pipe.

B. Carrier Pipe. The carrier pipe shall be approved PVC pipe, ductile iron pipe, reinforced concrete pipe, vitrified clay pipe or other materials approved by the Town Engineer or specific utility. Carrier pipes

shall be installed with a minimum of four (4) polymer skids, CCI Pipeline System type or approved equal, banded to the pipe with stainless steel clamps per manufacturer's specifications. Restrained casing spacers, if required, shall be installed as directed. A rubberized casing seal, specifically manufactured for the casing and carrier pipe diameters proposed, shall be installed on both ends of the bore and clamped with two (2) stainless steel adjustable clamps each end.

## PART 3 – EXECUTION

### 3.1 WEATHER LIMITATIONS

A. Bituminous Materials. Bituminous material shall not be applied when the weather conditions would inhibit the desired function. No bituminous material shall be applied to any surface that is wet, frozen, or in any other condition that the Town Engineer or his authorized representative shall consider unsuitable.

1. Placement Temperatures. Hot, bituminous asphalt materials shall be placed only when both air and surface temperatures equal or exceed the temperatures specified in **Table 02575-17, Placement Temperature Limitations**.

2. Temporary Patching. The Work shall be scheduled so that no unpatched surface is left without surfacing for more than ten (10) calendar days from October 1st to March 1st. Temporary patches shall be installed in compliance with **Section 02575**, Subsection 3.1.B, "Weather Limitations, Temporary Pavement Layer".

B. Portland Cement Concrete Materials. All concrete patching installations shall be done in compliance with **Section 02585**, Subsection 3.1.A & B, "Weather Limitations".

### 3.2 PLANNING AND PREPARATION

A. Permits Required. All Contractors, public utility agencies, and private property owners performing reconstruction and repair improvements, installing public or private improvements, or storing materials or equipment, within any public right-of-way or easement, must obtain the required permit prior to the commencement of the Work.

1. Applications for Excavation Permits are available at the public counter of the office of the Town Engineer. The application form must be completed and submitted to the Town Engineer along with the required items stated on the permit application.

2. The application will be reviewed by the Town Engineer. If additional information is required, the Applicant will be contacted at the provided phone number and/or address. The Town will check to make certain that the Applicant has provided the required bond and, when applicable, the license and insurance certificates. Once the permit application and all required submittals have been reviewed and found to be complete, the Permit may be issued by the Town.

3. The Applicant shall pay all required fees, provide specified insurance and surety (if required), and supply appropriate plans, drawings, traffic control schedules, and other supporting documents if necessary.

4. The Applicant shall be responsible for coordinating any utility work including relocation of utilities, obtaining separate permits or permission including easements.

5. Application for required permits shall be submitted at least five (5) working days prior to commencement of construction.

B. Locates. The Permittee shall at all times take proper precautions for the protection of existing utilities, the presence of which are known or can be determined by field locations of the utility companies. The Permittee shall contact the UNCC (One Call) at 1-800-922-1987 for utility locates, a minimum of two (2) working days prior to proposed start of work. Other unregistered utility entities (such as irrigation ditch

companies) shall be contacted individually to arrange locating their utilities. Utility service laterals shall be located prior to beginning excavation or grading.

1. Utility markings shall be limited to the boundaries of the construction area. Flagging and other protrusions shall be removed within forty five (45) days of the completion of work. The Town may require the removal of paint markings.

2. Permittee shall advise the Town at least forty eight (48) hours in advance of the date work will be started and shall notify the Town at least twenty four (24) hours in advance if this date is changed or cancelled.

C. Worksite Maintenance. Each Permittee shall maintain its work site so that:

1. Trash and construction materials are contained and not blown off the work site.

2. Trash is removed from a work site often enough so that it does not become a health, fire, or safety hazard.

3. Trash dumpsters and storage or construction trailers shall not be placed in the street.

4. As the work progresses, all public rights-of-way and other property shall be cleaned of all rubbish, excess dirt, rock, and other debris, at the sole expense of the Permittee.

5. Utilize best efforts to eliminate the tracking of mud or debris upon any street or sidewalk. Streets and sidewalks shall be cleaned of mud and debris at the end of each day.

6. Utilize erosion control measures to prevent erosion and degradation of water quality.

7. Provide employee and construction vehicle parking so that there is no parking in the neighborhood adjacent to the work site. There shall be no unauthorized parking on sidewalks.

8. Provide necessary sanitary facilities for workers, the location of which shall be approved by the Town Engineer and set forth in the permit.

9. Violation of any of these provisions shall be sufficient reason for a stop work order or revocation of permit or both.

D. Existing Improvements. The permittee shall at all times take proper precautions and be responsible for the protection of existing street and alley surfaces, driveway culverts, street intersection culverts or aprons, irrigation systems, mail boxes, driveway approaches, curb, gutter and sidewalks and all other identifiable installations that may be encountered during construction.

1. Existing improvements to adjacent property such as landscaping, fencing, utility services, driveway surfaces, etc., that are not to be removed, shall be protected from injury or damage resulting from the Contractor's operations.

2. The Permittee shall at all times take proper precautions for the protection and preservation of all surface monuments and accessories, property pins/corners, survey control monuments, property marks or survey hubs and points encountered during construction. Any damaged or disturbed survey monument, hub or point shall be replaced by a Colorado Registered Land Surveyor at the Permittee's sole expense and shall include updating the records of and informing the appropriate government agency.

E. Miscellaneous.

1. The Town may restrict any work that causes pavement disturbance from November 1st to April 1st.

2. For major installations, as defined by the Town Engineer, the Permittee shall locate all parallel dry facilities within forty two (42") inches plus one half (½) of the diameter of the proposed conduit and all parallel wet facilities within seventy eight (78") inches plus one half (½) of the diameter of the proposed conduit. The location of parallel facilities shall be field verified by locate potholes, unless the locate potholing causes pavement disturbance in an adjacent travel lane that otherwise would be undisturbed. The location of existing facilities, including lateral crossings, which may affect the proposed facility alignment shall also be field verified by locate potholes. Wet facilities include water, sewer, and gas; all other facilities shall be considered dry facilities.

3. Completion of the utility cut including pavement replacement and cleanup shall normally be accomplished within two (2) days after the activity involving the cut is completed.

4. For major installations, the Permittee shall provide "as-built" information to the Town Engineer on a daily basis or upon completion of every five hundred (500') feet of work, whichever is less frequent. It shall be the Permittee's responsibility to immediately notify the Town of any variance from the approved alignment.

## 3.3 UTILITY EXCAVATION

A. Types of Utility Excavation. The construction of any repair activity within the any street or alley right-of-way shall be accomplished by open cut excavation, jacking, boring, tunneling or a combination of these methods, as approved by the Excavation Permit. The Town Engineer must approve any variation from the approved permit. Crossings under sidewalks or curbs may be made by tunneling only when approved by the Town Engineer.

B. Asphalt Pavement Removal.

1. All asphalt pavement cuts shall be in straight lines. Irregular shaped cuts with more than four (4) sides, or cuts within existing patches shall not be allowed. All cuts shall be rectangular in shape, and edges shall be parallel or perpendicular to the flow of traffic and at least one (1') foot beyond the trench side wall.

2. All pavement cuts parallel to the direction of travel shall be placed on the lane line or at the center of the aligned travel lane. For bicycle lanes, the cut shall be at the line or the edge of the gutter. Longitudinal joints are not allowed in the wheel track.

3. In order to provide straight edges, all asphalt pavement cuts shall be cut by saw cutting, rotomilling, or another approved method which assures a straight edge for the required depth of the cut. The edge for removal shall be in a straight line set by a string line, chalk line, or other means to ensure a straight removal line.

4. Pavement designated for removal shall be cut vertically with square edges and shall be done in such a way that damage to the adjoining mat is minimized. Any over-break, separation, gouging, or other damage to the existing asphalt mat outside of the designated removal limits shall be repaired at the cost of the Permittee.

C. Concrete Pavement Removal.

1. Concrete pavement shall be removed and replaced from existing panel joints only. Concrete pavement shall be removed to full depth.

2. Concrete removed adjacent to asphalt pavements shall be saw cut along the abutting edge prior to removal in order to remove without damage to the pavement. The saw cut edge shall be protected and used as a form for the new concrete pavement.

3. Concrete that is to remain shall be cut in a straight, true line with a vertical face. Concrete shall be cut with a saw in accordance with CDOT Specifications Section 202.02. Concrete that will be required to be dowelled shall be sawed to the full depth of the concrete.

4. If the removed portion falls within three (3') feet of a construction joint, cold joint, expansion joint, or edge, the concrete shall be removed to the joint or edge.

5. The Permittee shall be responsible for the cost of removal and replacement of all over-breaks. In the case of damaged concrete, the limits of removal should be identified in the field by the Town Engineer.

D. Excavation.

1. All trench excavation shall be made by open cut to the depth required to construct the facility. Adequate bracing of trench walls shall be provided. All excavation, trenching, shoring, and stockpiling of excavated materials shall be in strict compliance with the applicable Occupational Safety and Health Administration (OSHA) rules and regulations. The Permittee/Contractor shall furnish, place, and maintain all supports and shoring required for the sides of the excavation, so as to prevent damage to the work or adjoining property. If the Permittee/Contractor is not expected to fully complete the work within any excavated area in a reasonable length of time as determined by the Town Engineer, the Town may require the Permittee/Contractor to backfill the excavation and re-excavate when the work can be completed expeditiously.

2. The Permittee/Contractor shall proceed with caution in the excavation of the trench, so that the exact location of underground structures, both known and unknown, may be determined. The Permittee/Contractor shall locate all existing underground utilities, by non-destructive means, before trench excavation. Excavation and visual verification of the utility location shall be performed by the Permittee/Contractor when required by the Town Engineer or the utility owner.

3. The length of an open trench shall be limited to the amount of pipe or conduit that can be placed and backfilled in a single day. Once trenches are excavated, the Permittee/Contractor shall proceed diligently towards completion of the work and completion of the backfill. However, in no case shall the length of the open trench exceed three hundred (300') feet unless otherwise approved by the Town Engineer. No open trench shall be left unprotected overnight.

4. A maximum of two (2) excavations shall be open at any time for access structure installation and conduit splicing, unless otherwise approved by the Town.

5. Only material that will be hauled or backfilled within one (1) day shall be stockpiled in the public right-of-way. The Town shall approve all proposed construction staging areas.

6. All open excavations shall be properly barricaded to protect vehicles and pedestrians.

7. Current field moisture and density test results (taken within forty eight (48) hours of the scheduled construction date) for top one (1') foot of subgrade shall be provided to the Town prior to proceeding with the next phase of construction. If any lift of the top one (1') foot of subgrade does not meet moisture or density requirements, then the material shall be scarified, wetted and re-compacted accordingly. If subgrade requires stabilization, the method shall be approved by the Town prior to proceeding.

8. Failure by the Permittee/Contractor to comply with these requirements may result in an order to stop the excavation in progress until compliance has been achieved.

E. Concrete Structures Removal.

1. Structural Concrete.

a. When removing structures or portions of structures, care shall be taken to protect surrounding improvements.

b. Where portions of structures are to be removed, remaining portions shall be prepared to fit the new work. Reinforcing steel projecting from the remaining structure shall be cleaned and aligned to join with the new construction. Dowels required by plans shall be secure within drilled holes, set in an approved grout.

c. The substructures of existing structures (such as bridges, culverts, drainage inlets, etc.) shall be removed according to CDOT Specifications Section 202.08. Steel, pre-cast concrete, and wood bridges as specified, shall be carefully dismantled without unnecessary damage.

d. All pipe, flared-end sections, box culverts, and other appurtenances designated for removal and reuse within the project shall be carefully removed, cleaned, and care taken to prevent damage to them.

e. When removing manholes, catch basins, and inlets, any active drainage or sanitary sewers shall be properly bypassed in order to maintain service during the repair operation.

2. Non-Structural Concrete.

a. Concrete shall be removed to edges that are neatly sawed to full depth of the existing concrete thickness. Sidewalks and driveways shall be saw cut in straight lines either parallel to the curb or perpendicular to the alignment of the sidewalk or curb.

b. No concrete section to be replaced shall be less than five (5') feet in either width or length for a driveway or crosspan, and five (5') feet in length, for sidewalk, curb, and gutter.

c. If a proposed saw cut falls within five (5') feet of a construction joint, expansion joint, or edge, the concrete shall be removed to the joint or edge.

d. During adjacent construction, any damaged concrete pavement shall be removed and replaced as a full panel section with dowels set into adjacent panels in compliance with CDOT M&S Standards.

e. During adjacent construction, any damaged flatwork and/or curb and gutter shall be replaced in full sections from existing construction joints. Partial section replacement shall not be permitted.

f. Whenever construction, alteration, or repair to an existing street affects any part of the apron, radius, ramp area, or pedestrian crossing area, the entire apron, radius, ramp area, or pedestrian crossing area shall be removed and replaced with a pedestrian ramp. Work shall be done in accordance with these standards and as required by the Americans With Disabilities Act guidelines, Section 14, Public Rights of Way, as amended.

F. Boring and Casing.

1. To minimize the impact to traffic and the right-of-way infrastructure, the Town encourages boring rather than open trenching.

2. Boring pits shall be kept to the minimum size required and shall be properly shored, braced and bulked. Dewatering of the pit shall be maintained along with a firm, graveled working surface for the boring machine. Adequate access to and from the pit which meets OSHA requirements shall always be available.

3. Casing shall be kept on line and grade as required by the approved plans. Joints in casing shall be field welded and watertight. Welds shall be of a size and quality to develop the full strength of the pipe materials. After welding, the joints of coated and wrapped pipe shall be primed and tarred.

4. Upon completion of the casing installation, the utility (carrier) pipe shall be installed in the casing pipe at the design grade and elevations. The utility pipe shall be installed by pushing the pipe into

the casing on “skids” and subsequently supporting the pipe by placing a sandbed under the pipe and around the ‘skids”.

5. Joint restraints shall be installed at each pipe joint on carrier pipe installations when the utility pipe carries pressurized fluids or where recommended by the specific utility.

6. Upon completion of the carrier pipe installation, the void area between the casing and carrier pipes shall be filled with sand or flowable fill. In lieu of filling the void area, rubberized boots may be installed at each end that effectually couples the pipes and eliminates intrusion of water or other foreign material.

7. Where steel casing pipe is used, cathodic protection shall be installed at each end of the bore. The design and installation shall be per manufacturer’s recommendations.

8. Upon completion of the boring operation, the Permittee/Contractor shall certify that all storm and sanitary sewer service lines to adjacent properties have not been damaged by the boring operation in a signed affidavit in a form acceptable to the Town.

9. If the Permittee/Contractor’s boring results in disturbance to other utilities or facilities in the public right-of-way, the Permittee/Contractor shall immediately contact the owner of the damaged utility or facility so that the owner may make any necessary arrangements for repair. The Permittee/Contractor shall provide the Town written notice that the owner of the damaged utility or facility has been informed and provide proof to the Town that the affected utility installation has been repaired or replaced to a form acceptable to the affected utility organization.

10. In cases where the bore hole is larger than the casing pipe, high pressure grout shall be placed around the outside of the casing pipe to completely fill all voids between the casing and the bore.

11. Waste material from boring operations shall be contained within the work site and shall not be allowed to discharge onto private property, the curb and gutter, or the roadway.

## 3.4 UTILITY INSTALLATION

The use of existing conduit sleeves for method of installation shall be the first priority when installing utilities under existing sidewalks, curbs and pavement. Tunneling is discouraged in major intersections and will not be allowed if existing PVC conduits are available, and is only permissible upon approval of the Town Engineer. If existing conduits are not available and boring is not the chosen method, then open cut excavation may be used. Once the existing pavement has been properly saw cut and removed and the excavation has been performed, as directed above, the necessary utility installation, reconstruction, or repair may proceed as shown on the approved plans and/or as directed by the appropriate utility company.

## 3.5 BACKFILLING OF EXCAVATIONS

A. Flowable backfill meeting the requirements specified herein shall be used to backfill all open cuts in portions of the Public right-of-way beneath existing paving, curb, gutter, sidewalk, crosspan, ramps, driveways, or other flat work improvements. Alternate backfill methods for large excavations (greater than one hundred (100cy) cubic yards) will be considered on an individual basis with the Town Engineer.

B. Flowable backfill shall be required in all voids and openings created by jetting, pumping, and pneumatic removal of the soil and where compaction equipment is unsuitable.

C. Excavation and backfill shall be accomplished on the same day in order to minimize impact to the public right-of-way. In instances where the Town determines that this cannot be accomplished, the Permittee/Contractor shall submit a plan for Town approval showing how traffic will be handled around the work zone.

D. If the existing base course is untreated, it shall normally be replaced with CDOT Class 5 or Class 6 aggregate base course material and compacted in layers that do not exceed six (6") inches in depth. The

resulting total compacted base thickness shall be at least the thickness of the removed base plus two (2") inches.

E. Aggregate base course shall be required for any areas that have been opened up during inclement weather (rain, snow, hail, etc.) and shall be replaced at the expense of the Permittee/Contractor. The Contractor shall protect all excavated areas from water infiltration of any type and will be responsible for any dewatering or subgrade stabilization.

F. The excessive use of water during backfilling operations will not be permitted.

G. Compaction equipment or methods that produce horizontal or vertical earth pressures, which may cause excessive displacement or overturning, or may damage structures, shall not be used.

H. Compaction of flowable backfill will not be required. Compaction of alternative backfill material will be as directed elsewhere herein.

I. The maximum layer or lift thickness for flowable backfill shall be five (5') feet. Additional layers shall not be placed until the flowable fill has lost sufficient moisture to be walked on without indenting more than two (2") inches. Damage resulting from placing flowable fill in layers that are too thick or from not allowing sufficient time between placements of layers shall be repaired at the Permittee's expense.

J. Unless otherwise indicated in the drawings or as directed by the Town Engineer, all sheeting, shoring, and bracing used in excavations shall be removed by the Permittee/Contractor prior to backfilling.

## 3.6 TEMPORARY PATCHING

A. When it becomes necessary to remove any existing pavement or surfacing within a roadway for reconstruction and repair as specified herein, the travelled way shall be properly barricaded and traffic control measures implemented in accordance with the Traffic Control Plan approved through the permit process. However, unless specifically approved in the Permit or by the Town Engineer, after each days work, all trenches across traffic lanes shall be repaired to enable vehicular travel, as detailed herewith.

B. Whenever permanent patches are not constructed immediately following properly compacted trench backfilling operations, temporary pavement patches must be utilized to provide the required number of paved travel lanes.

C. Upon receiving approval of the Town Engineer, temporary pavement patches shall consist of any one of the following or a combination thereof:

1. The temporary surface may consist of a minimum of four (4") inches of either a hot mix or cold mix asphaltic paving material. Temporary surfaces shall be compacted, rolled smooth, and sealed to prevent degradation of the repair and existing structures during the temporary period. Cold mix asphaltic material may only be used as a temporary patch and the cold mix material shall be approved by the Town Engineer.

2. Steel bridging plates may be used to bridge across trenches provided they are properly anchored and capable of carrying the legal limit loading and meet all of the specific requirements contained in this **Section 02595**, subsection 2.5. Steel plates shall be placed such that traffic will not cause them to move and may only be left in place for the duration specified by the Town Engineer.

3. For Local roadways and alleys, a temporary patch of gravel material flush with the surface may be acceptable for a period not to exceed one (1) day.

D. The surface of the temporary patch shall provide a smooth driving surface.

E. If approved by the Town, good quality asphalt milling material may be used as a temporary patch on low volume streets.

F. The Permittee/Contractor shall monitor temporary patches on a daily basis and temporary patches exhibiting ruts, humps, deflections, movements, or depressions shall be repaired or replaced immediately. The temporary surface installation and daily maintenance shall be the responsibility of the Permittee/Contractor until the permanent surface is completed and accepted.

G. The Permittee/Contractor is responsible for maintaining temporary patches. In case of an emergency the Town of Windsor may elect to repair the temporary patch and charge the Permittee/Contractor for all costs associated with the repairs.

H. Permanent patching shall occur within two (2) weeks unless approved in advance by the Town Engineer. The temporary patch shall be completely removed prior to placement of the permanent patch. Refer to subsection 3.7 below for permanent patching.

I. Temporary Pavement Layer. All work shall be scheduled so that no planed or recycled surface is left without resurfacing for more than ten (10) calendar days between October 1st and March 1st.

1. Within ten (10) calendar days after being planed or recycled, the Contractor/Owner shall immediately place a temporary hot bituminous pavement layer on any surface that has been planed or recycled and cannot be resurfaced in accordance with the specified temperature requirements contained elsewhere in these Specifications.

2. The minimum thickness of the temporary hot bituminous pavement layer shall be two (2") inches.

3. The Contractor/Owner shall perform the quality control required to assure adequate quality of the hot bituminous pavement used in the temporary layer. All applicable pavement markings shall be applied to the temporary layer surface.

4. The Contractor/Owner shall maintain the temporary layer for the entire period that it is open to traffic. Distress that affects the ride, safety, or serviceability of the temporary layer shall be immediately corrected to the satisfaction of the Town Engineer. The temporary hot bituminous pavement layer shall be removed when work resumes.

## 3.7 PERMANENT PATCHING

A. General.

1. Prior to placing the permanent patch, the existing pavement shall be removed to clean, straight lines parallel or perpendicular to the flow of traffic. Patches shall not be constructed with angled sides or irregular shaped edges. If pavement adjoining the original pavement saw cut is damaged during construction, additional pavement shall be removed with cuts parallel with the original cuts. The additional pavement damaged due to construction shall be repaired at the Permittee/Contractor's expense.

2. When the excavation and patch falls within three (3') feet of a section of failed pavement, the failed area shall be removed up to sound pavement and patched. Scarring, gouging, or other damaged pavement adjacent to a patch shall be removed and the pavement repaired.

3. Patches within existing patches are to be avoided. Where this does occur, boundaries of the new patch shall match or exceed the existing patch.

4. Strips of pavement greater than six (6') feet in width from the edge of the new patch to the edge of an existing patch or the lip of the gutter may remain.

5. Trenches shall be patched for the entire lane width for a distance of one (1') foot minimum on all sides of the trench. Transverse patch lengths shall extend across the full width of the travel lane. Minimum width of transverse patches shall be as listed in **Table 02595-2**, **Minimum Patch Requirements**. The width of patches shall be consistent to simplify future maintenance.

6. Edges of patches shall not fall in existing wheel paths or tracks. The edges of patches parallel to the direction of traffic shall be limited to the boundaries of lanes or to the centerline of travel lanes.

7. Patches should have a smooth longitudinal grade consistent with the existing roadway. Patches should also have a cross slope or cross section consistent with the existing roadway.

8. In most cases, and particularly in the cases of extensive excavation and repairs, it is desirable to survey the existing pavement condition with the Town Engineer prior to the work. After completion of the work, the pavement condition again shall be surveyed to verify that the pavement condition has been maintained or improved.

   a. Minor Repairs. In the case of minor repairs, pavement surveys can be made by visual observation.
   b. Major Repairs. In the case of major projects that involve excessive haul of materials or unusually heavy construction equipment or activity, nondestructive testing of the pavement condition before and after construction may be required.

B. Bituminous Asphaltic Pavements.

1. Prior to placing the permanent bituminous asphalt patch, the existing pavement shall be removed to clean, straight lines parallel or perpendicular to the flow of traffic as detailed in subsection 3.3.B, above, and a tack coat shall be applied to all edges of the existing pavement.

2. The Contractor/Owner shall provide the necessary equipment for heating and applying the bituminous material. The equipment shall be capable of applying the materials in a uniform manner for the specified rates of application.

3. The surface upon which the bituminous tack and/or prime coat is to be placed shall conform to the established lines. Grades shall be smooth and uniform and shall be compacted to the required density. If the required density deteriorates between the time the gravel course was originally compacted and the time the prime coat is placed, for any reason whatsoever, the surface shall be recompacted to the required density at the Contractor/Owner's expense.

4. The edge of existing asphalt pavements shall be painted with a tack coat prior to placing the new pavement. The tack coat shall be applied sufficiently in advance so that a tacky surface exists at the time the asphalt surface mix is placed. The time interval between application of the tack coat and placement of the asphalt mix will be regulated by the Town Engineer.

5. A prime coat application to the sub-base, where required by the Town Engineer, shall be made less than twelve (12) hours prior to placing the asphalt base course and shall be pressure sprayed at the rate of two tenths (0.2) to five tenths (0.5) gallon per square yard. Application methods and equipment shall be approved in advance by the Town Engineer. The primed surface shall be maintained by removing all loose sand prior to placing any pavement or surfacing material thereon. Immediately before placing pavement, additional prime coat shall be applied as directed to areas where the prime coat has been damaged. Loose or extraneous material shall be removed.

6. The thickness of asphalt patches in asphalt streets shall be the thickness of the existing asphalt plus one (1") inch with minimum widths as specified in **Table 02595-2**, **Minimum Patch Requirements** as given below, or as specified by the Town Engineer:

**Table 02595-2**
**Minimum Patch Requirements**

| Min. Asphalt Thickness (for full depth pavement) | Required Grading | Minimum Widths (Transverse Patches) |
|---|---|---|
| Residential – six (6") inches | 2" grading S on 4" grading SG | Residential – five (5') feet |
| Collector – eight (8") inches | 2" grading S on 6" grading SG | Collector – eight (8') feet |
| Arterial – ten (10") inches | 3" grading S on 7" grading SG | Arterial – ten (10') feet |

7. Wherever the existing asphalt pavement is greater than these minimum depths, the hot bituminous patches shall be placed in maximum three (3") inch compacted lifts to a depth of the existing pavement plus one (1") inch.

8. Patch back areas greater than one hundred twenty (120 $ft^2$) square feet shall require the submittal and approval of a mix design to the Town prior to placement.

9. In all cases, the pavement wearing course must match the grading of the surrounding pavement. The hot bituminous pavement must be placed with a self-propelled paver if patching widths are greater than eight (8') feet. For patch widths greater than four (4') feet and up to eight (8') feet, the mixture must be placed with either a self-propelled paver or a box spreader. These machines may be used to patch areas wider than eight (8') feet with the use of a screed extension that will extend beyond the width of the proposed patch. Patches paved with a self-propelled paver shall conform with the requirements specified in CDOT Specifications Section 401.10. Rollers shall move at a uniform speed with the drive roll or wheels nearest the paver. Steel-wheeled rollers shall operate at a maximum speed of three (3 mph) miles per hour. The use of plate type compactors will not be permitted except in areas not accessible to the roller. Areas wider than the machine screed may be patched with a box spreader only if the length of the patch is less than fifty (50') feet. Areas as wide as the street or longer than fifty (50') feet, shall be patched with an asphalt lay down machine.

10. Where irregularities, unavoidable obstacles, or patch widths of less than four (4') feet make the use of mechanical spreading and finishing equipment impractical, the mixture shall be spread, raked, and luted by hand tools. For such areas, the mixture shall be dumped, spread, and screeded to give the required compacted thickness. New hot bituminous pavement shall be added in compacted layers, until the patch thickness meets these requirements. Compaction equipment shall be capable of compacting corners and edges of all patches.

11. The asphalt patch area for street excavations that fall within the wheel path of the vehicular travel lane shall be increased in size to the center of the lane or adjacent lane.

12. Where three (3) or more pavement cuts are proposed within a seventy five (75') foot long roadway section, the pavement between the patches shall be milled and inlaid with new pavement over the entire work area. In cases where the existing pavement is in poor condition and may require overlay within the next few years, this requirement may be modified or waived by the Town Engineer. A series of patches may also be repaired with an overlay:

    a. In streets where more than one (1) cut is made within a seventy five (75') foot long roadway segment, an overlay of the entire street width, including the patched area may be required. The determination of need for a complete overlay shall be made by the Town Engineer.

    b. All overlay work shall be coordinated with adjacent landowners such that future projects do not cut the new asphalt overlay work.

    c. All proposed overlay work shall be scheduled such that all roadway pavement placed prior to the time paving operations end for the year shall be completed to the full thickness required by the plans.

    d. There shall be no feathered edges on any type of street. When edge of existing pavement adjoins gutter, overlays should be placed by first removing the edge of existing pavement to the desired depth by grinding and then replacing the pavement with an asphalt lay down machine. Grinding shall be to a depth such that the top of overlay is no more than one quarter (¼") inch from the top of the gutter lip.

    e. Particular care must be taken in constructing joints to provide smooth transitions, and to avoid problems with drainage or access at the edges of gutter pans.

f. All asphalt surfaces to receive an overlay shall be given a tack coat prior to placing the new pavement, and as specified above.

g. Overlaying layers of hot bituminous pavement shall not be placed until the lower layer has cooled sufficiently to provide a stable material that will support the equipment without rutting, shoving, or moving in any manner. The temperature of the first asphalt layer shall be less than one hundred fifty (150°) degrees F before applying the second asphalt layer. All paving on each street shall be completed in one (1) continuous operation, weather permitting, unless otherwise approved in writing by the Town Engineer.

13. Infrared patching may be allowed only where approved by the Town Engineer:

    a. The infrared heating unit must be equipped with adjustable height controls and heating chambers capable of heating the existing bituminous pavement to a workable temperature without oxidizing or burning the oils. There shall be no flame in direct contact with the existing pavement surface. The infrared heating unit must be capable of heating an area that extends a minimum of twelve (12") inches beyond the edge of the patch area.

    b. Heat shall be continuously applied to the patch area until the existing pavement material can be manually raked and shaped to a depth of two (2") inches below the existing surface and replaced with new material. A minimum depth of one and one half (1½") inches of new pavement shall be provided at the joint line.

    c. Prior to placement of new material, the patch area will be raked, compacted, and tacked. Mechanized compaction equipment shall be used to compact bottom lifts of the patch, then self-propelled, vibratory roller shall be used to provide complete compaction of the patch area. The tack agent shall be applied at the rate of two tenths (0.20 gal/yd²) gallons per square yard. Excess material shall be disposed or used in the bottom layer of the patch.

14. Manhole frames, covers and valve boxes shall be adjusted using the criteria given in **Section 02610**, **Manhole and Valve Box Adjustment**, with concrete surrounding the object at least one (1') foot from the object in all directions.

15. Removal and replacement of unsatisfactory or failed pavement patches shall be completed within thirty (30) days of written notification of deficiency. Failure to comply may result in the Town of Windsor taking action upon the Contractor's performance bond.

16. After placing the new asphalt, all seams (joints) between the new and existing pavements shall be sealed with a hot melt asphalt or rubberized asphalt sealant. Particular care must be taken in constructing joints to provide smooth transitions, and to avoid problems with drainage or access at the edges of gutter pans.

17. The Contractor shall at all times protect the asphalt (both existing and new) from solvents and oils. Any piece of equipment leaking any fluid shall be removed from the work site immediately and shall not return to the work site until all leaks are repaired. If any piece of equipment leaks any fluid a second time, it shall be removed from the work site immediately and shall not be allowed on the work site again for the remainder of the project. The Contractor shall not use diesel or other solvents to remove or prevent the sticking of asphalt to the wheels of rubber-tired rollers or other equipment used on the asphalt. Remove and replace any asphalt damaged by solvents or oils.

C. <u>Portland Cement Concrete Pavements</u>.

1. Prior to placing the permanent Portland Cement concrete patch, the existing pavement shall be removed to clean, straight lines parallel or perpendicular to the flow of traffic as detailed in subsection 3.3.C of this Section.

2. When pavement has been identified to require reconstruction, the pavement shall be removed and replaced in sections from joint to joint. Replaced sections will require doweling connections.

3. The surface upon which the Portland Clement concrete patch is to be placed shall conform to the established lines. Subgrade elevation shall be brought up to plus or minus one tenth (± 0.1') foot with approved materials prior to placing concrete. Grades shall be smooth and uniform and shall be compacted to the required density. If the required density deteriorates between the time the gravel course was originally compacted and the time the concrete patch is to be placed, for any reason whatsoever, the surface shall be recompacted to the required density at the Contractor/Owner's expense.

4. Weather protection shall be provided as detailed in **Section 02585**, subsection 3.1.A & B, "Weather Limitations".

5. Concrete pavement patching material shall match flush with the existing concrete pavement surface and shall have a thickness one (1") inch greater than the existing pavement and shall not be less than eight (8") inches thick. The work shall be accomplished so that no abrupt change in grade between the old and new work results.

6. When making concrete repair patches, the removal perimeter shall be saw cut and dowels inserted into the existing surrounding concrete pavement in conformance with requirements by the Town. Refer to CDOT M-Standards for details.

7. Patch back areas greater than one hundred twenty (120 $ft^2$) square feet shall require the submittal and approval of a concrete mix design to the Town prior to placement.

8. No water shall be placed on the new concrete surface to assist finishing.

9. Concrete placed for patching shall be coated and sealed with a uniform application of membrane curing compound applied in accordance with manufacturer's recommendations. Refer to **Section 02585, Portland Cement Concrete Pavement**, for additional curing information. Completely coat all exposed concrete surfaces.

10. Quick curing concrete repairs may be opened to traffic within two (2) days or when the concrete has achieved a minimum strength equaling eighty (80%) percent of the twenty eight (28) day design strength. Concrete cylinders shall be taken and broken for verification. The mix design shall be in accordance with CDOT specifications.

11. Where existing cracks or damage are adjacent to the area being repaired, the repair area shall include the cracked or damaged concrete. Pavement repairs shall include all areas of damage, including leak test holes, potholes, equipment, and/or material scarring of the existing surface.

12. Expansion joint material shall be installed between new structure slabs and existing structure slabs. Joints shall be thoroughly cleaned of all foreign material, then filled with a hot-poured elastic type joint filler. Silicone sealants or other materials may be approved by the Town Engineer. Joint material shall be filled to within one half (½") inch of the surface. Excess material shall be scraped off to provide a smooth riding surface.

13. Manhole frames, covers, and valve boxes shall be adjusted and patched as follows: The concrete edges will be a full depth saw cut and shall be a minimum of one (1') foot from the manhole frame or valve box. Backfill around manholes, water valves and inlets shall be installed in eight (8") inch lifts and compaction tests taken on each side of the structure at each eight (8") inch lift interval. The adjacent concrete slab shall be drilled eight (8") inches deep and a sixteen (16") inch number four (#4) rebar grouted in place at twelve (12") inch on center. Concrete pavement shall be replaced to the existing depth or a minimum of eight (8") inches, whichever is greater, with a minimum mix design of six (6) sacks of cement and a minimum twenty eight (28) day compressive strength of four thousand two hundred (4,200 psi) pounds per square inch. The concrete shall be protected from weather and rapid loss of moisture and protected from vehicular traffic for a period not less than seven (7) days (three (3) days with High/Early concrete). Compressive strength of concrete shall

reach three thousand (3,000 psi) pounds per square inch prior to any traffic loading. Concrete patches shall be a minimum of nine (9 $ft^2$) square feet.

## 3.8 QUALITY OF REPAIRS

A. General. Every street and street repair situation is unique. Design criteria and construction specifications cannot address every situation. In order to maintain some form of consistency, these standards have been developed. In most cases, they provide the minimum acceptable standards for construction or repair. Consequently, when strictly applied, they will provide the minimum acceptable product. Therefore, this criteria has been developed to maintain the same integrity of the street pavement and subsurface condition as existed prior to its being cut for utility installations or repairs.

To achieve the goal of "Quality" or "Excellence" in street repairs, these criteria shall be viewed as guidelines when used in conjunction with good planning and judgment. This will restore the street to an acceptable condition with minimal patching failures. In many cases, it will be necessary to exceed the minimum standards to achieve a quality repair.

Issues that shall be considered in a quality approach to street repairs are as follows (these criteria must all be balanced against the long-term maintenance needs of the utility):

B. Appearance. Does the final appearance of the street pavement suggest the repairs were planned, or that they happened by accident?

1. Public Perception. Consciously or not, the driving public "rates" the appearance of the street system, including street repairs, every day. Street repairs which are satisfactory from a functional point of view may produce a negative reaction from the public if they give the appearance of being poorly planned or executed.

2. Appearance Guidelines. The public's perception of the street repairs is based primarily on shape, size, and orientation – the geometry of a patch. The following are some guidelines for the geometry of a quality patch:

a. Existing pavements should be removed to clean, straight lines parallel and perpendicular to the flow of traffic. Do not construct patches with angled sides and irregular shapes. Avoid patches within existing patches. If this cannot be avoided, make the boundaries of the patches coincide.

b. Do not leave strips of pavement less than one half lane in width from the edge of the new patch to the edge of an existing patch or the lip of the gutter.

c. Asphalt and concrete pavement should be removed by saw cutting or grinding. Avoid breaking away the edges of the existing pavement or damaging the remaining pavement with heavy construction equipment.

d. In concrete pavements, sidewalks, and other public use areas where the surface is in good repair, remove sections to existing joints. In damaged concrete, the limits of removal should be determined in the field by a representative of the Town Engineer.

e. In the case of a series of patches or patches for service lines off a main trench, repair of the pavement over the patches by overlay method shall be required when the spacing between the patches is less than seventy five (75') feet.

C. Guidelines for Rideability. Completed street repairs shall have a rideablitiy at least as good as, or better than, the pavement prior to the repairs being made. Street repairs may be visible but should not be "felt" when driving over them.

1. Do not construct asphalt overlays in such a manner that create a bump to the motoring public. If the leading edge of an overlay is substantially noticeable to a car it is likely to be significant to the snow plow trucks. The Town Engineer shall determine whether or not the rideablitiy of the overlay is

acceptable. If the transition is not smooth the Contractor shall remove and replace the pavement to provide a smooth leading edge to the satisfaction of the Town Engineer.

2. Surface tolerances for street repairs should meet the standard for new construction. That is, the finished surface of the street repair, when tested with a ten (10') foot straightedge parallel to the centerline or perpendicular across joints, will show variation measured from the testing face of the straightedge to the surface of the street repair which do not exceed three sixteenths (3/16") inch.

D. Pavement Management Guidelines. Street repairs should leave a pavement in a condition at least as good as, if not better than, the condition prior to the repairs.

1. In most cases, and particularly in the cases of extensive excavation and repairs, it is desirable to survey the existing pavement condition with a representative of the Town Engineer prior to the work. After completion of the work, survey the pavement condition again to verify that the pavement condition has been maintained or improved.

2. In the case of minor repairs, these pavement surveys can be made by visual observation. However, in the case of major projects that involve excessive haul of materials or unusually heavy construction equipment or activity, non-destructive testing of the pavement condition before and after construction is required.

3. Consideration of pavement management issues may also identify opportunities for joint efforts between the utilities and the Town such as splitting the cost on a street in need of an overlay that will need to be patched. Coordination for these types of cooperative repairs should occur as far in advance of actual construction as possible.

E. Future Maintenance Guidelines. Excavations and street repairs, even well constructed street repairs, shorten a pavement's life. Several types of street distress, settlement, alligator cracking, and potholes, often show up around patches. Quality street repairs should attempt to include adjacent minor damage and reduce the chances of associated growth out to these types of distress.

1. Avoid weakening or destroying the existing pavement around an excavation with heavy construction equipment, stockpiling, or delivery of materials, etc. When damage does occur, remove the damaged pavement, extending the limits of the street repair, before replacing the pavement. No stockpiling of backfill or road building materials is permitted on the pavement.

2. When the proposed excavation falls within three (3') feet of a section of failed pavement, the failed area shall be removed to sound pavement and patched. Scarring, gouging, or other damaged pavement adjacent to a patch shall be removed and the pavement repaired.

3. With older pavement where the likelihood of cracking and potholes next to the patch is greater, it shall be necessary to extend the "shoulders" of the patch beyond the one (1') foot minimum. When adjacent deterioration is less than three (3') feet away, reinforce this area with a geotextile fabric.

4. Avoid frequent changes in width of patches. For future maintenance this simplifies removal of adjacent pavement failures.

## 3.9 FIELD QUALITY CONTROL

A. Testing Frequency. Testing shall be performed by an independent testing company acceptable to the Town and results shall be provide to the Town Engineer within two (2) working days of completion of testing and prior to the next phase of construction. Testing shall be performed according to the schedule given in **Table 02595-3, Minimum Testing Frequency**, given below:

**Table 02595-3**
**Minimum Testing Frequency**

| ITEM | TYPE OF TEST | MINIMUM FREQUENCY |
|---|---|---|
| **All Excavation Backfill** | | |
| Backfill | Moisture/Density (Compaction Test) | 1 per 150 lineal feet, per vertical foot of fill, min, 2 tests per lift. |
| **Inlets/Structures** | | |
| Soil Testing | Moisture/Density (Compaction) | 1 test per vert. foot, min. 2 per lift |
| Concrete Testing | Air and Slump | 1st 3 loads, every 5th load thereafter |
| | Cylinders | 1 set of 4 per 100 cy, or fraction of. |
| **Sidewalk, Curb & Gutter** | | |
| Soil Testing | Moisture/Density (Compaction) | 1 per 150 lf, per 2 vert. feet of fill Min. 2 tests per lift |
| Concrete Testing | Proof-roll | All subgrade |
| | Air and Slump | 1 per day min. – machine placed<br>2 per day min. – hand placed<br>Plus 1 per 500 sy. |
| | Cylinders | 1 set of 4 per 100 cy, or fraction of. |
| **Roadways** | | |
| Subgrade Testing | Moisture/Density (Compaction) | 1 per 300 lane ft, min 2 tests per lift |
| | Proof-roll | All subgrade |
| Base Course Testing | Moisture/Density (Compaction) | 1 per 300 lane ft, min 2 tests per lift |
| | Gradation/Atterberg limits | 1 per 500 tons |
| | Proof-roll | All base course |
| Concrete Testing | Air and Slump | 1st 3 loads, if pass, 1 per 100 cy |
| | Slump | Every load |
| | Cylinders | 1 set of 4 per 100 cy, or fraction of. |
| Asphalt Testing | Density | 1 per 300 lane ft, min 2 tests per lift |
| | Extraction/Gradation, Marshall | 1 per 500 tons |

B. Asphalt Patching.

1. Compaction of hot bituminous asphalt pavement patches shall be between ninety two (92%) percent and ninety six (96%) percent of AASHTO T209. Average compaction of less than ninety two (92%) percent of AASHTO T209 shall be cause for rejection.

2. Upon completion of the permanent asphalt patch, the surface shall be thoroughly compacted, smooth, and free from ruts, humps, depressions, or irregularities. When a straightedge ten (10') feet in length is laid across the permanent patch parallel to the centerline of the street and in a direction transverse to the centerline, the surface shall not vary more than three sixteenths (3/16") inch from the lower edge of the straight edge. Patches exhibiting deviations more than three sixteenths (3/16") inch shall be replaced prior to acceptance of the patch. If the existing street exceeds the above tolerances, then the patch shall be equal or better than the condition of the surrounding pavement.

C. Concrete Patching. Variations of concrete surface shall not exceed one eighth (1/8") inch in ten (10') feet.

## 3.10 OPENING TO TRAFFIC

The Town Engineer shall determine when the patched roadway shall be opened to traffic, unless specifically indicated previously herein. Prior to opening the pavement to traffic, the roadway shall be cleaned, striped, signed, and otherwise prepared as specified within these Specifications.

**END OF SECTION**

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# SECTION 02610

# MANHOLE AND VALVE BOX ADJUSTMENT

## PART 1 – GENERAL

### 1.1 DESCRIPTION

The Work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials necessary including transporting, placing, finishing, curing, and performing all operations in connection with the adjustment of all manholes, valve boxes, survey monument boxes, and other fixtures encountered within a roadway to be paved within the public right-of-way in the Urban Growth Area of the Town of Windsor.

The Work shall consist of adjusting these various appurtenances to conform to the finished surface of the pavement to be built as per the street plans and details, followed by concrete encasement, in accordance with these specifications and in conformance with the lines, grades, typical cross sections, and thicknesses as shown on the applicable plans and drawings

### 1.2 QUALITY ASSURANCE

Quality Assurance shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.C, and as modified herein:

A. If the required adjustment of appurtenances occurs within a roadway to be paved with asphalt pavement, Quality Assurance and construction processes shall be as specified in **Section 02575, Bituminous Paving – SuperPave Method**, and as modified herein.

B. If the required adjustment of appurtenances occurs within a roadway to be paved with Portland Cement concrete pavement, Quality Assurance and construction processes shall be as specified in **Section 02585, Portland Cement concrete pavement**, and as modified herein.

C. Removal and replacement of unsatisfactory work shall be completed within fifteen (15) days of written notification from the Town Engineer of the deficiency unless the condition is deemed an emergency requiring immediate correction. In the event the replacement work is not completed within the specified time period, or is deemed an emergency, the Town Engineer may take action to complete the work and charge the Contractor/Owner for all related costs.

### 1.3 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I.

### 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010, Summary of Work** Subsection 1.3.D., and as modified herein:

A. If the required adjustment of appurtenances occurs within a roadway to be paved with asphalt pavement, Product Delivery, Storage and Handling and construction processes shall be as specified in **Section 02575, Bituminous Paving – SuperPave Method**, and as modified herein.

B. If the required adjustment of appurtenances occurs within a roadway to be paved with Portland Cement concrete pavement, Product Delivery, Storage and Handling and construction processes shall be as specified in **Section 02585, Portland Cement Concrete Pavement**, and as modified herein.

## PART 2 – MATERIALS

### 2.1 GENERAL

All materials necessary for adjusting manholes or valve boxes as required by these specifications must be on hand at the job site prior to placement of any asphalt or concrete pavement. See Standard Details.

### 2.2 FLOWABLE BACKFILL

Flowable backfill meeting the requirements of **Section 02223**, **Structural Backfill**, Subsection 2.2, shall be used to backfill all open cuts in portions of the Public right-of-way beneath existing paving, curb, gutter, or sidewalk improvements. Alternate backfill methods for large excavations (greater than one hundred (100 cy) cubic yards) will be considered on an individual basis with the Town Engineer.

### 2.3 NATIVE BACKFILL

A. In cases where flowable backfill is not required and the Contractor wants to use the excavated onsite material, the material must be evaluated by a Geotechnical Engineer. The engineer must confirm in writing that the material meets structural fill requirements. A proctor curve for each different type of the material must accompany the letter from the engineer. Backfill of suitable material shall be placed in maximum eight (8") inch lifts and mechanically compacted. Density and moisture control shall be per CDOT Specifications Section 2.03.

B. The Contractor shall provide compaction testing for all backfill work per the requirements of Subsection 1.2, Quality Assurance, stated above. Compaction test requirements shall be at least one per one hundred fifty (150') lane foot, minimum of two (2) tests per lift. Each lift not tested in accordance with these requirements may be rejected by the Town Engineer

### 2.4 GRADE RINGS AND ADJUSTERS

Concrete or other approved grade rings shall be used for adjusting manhole frames and covers. Water valve boxes, survey monument boxes, and other similar devices shall be provided with deep socket cast iron stems, five and one quarter (5¼") inch in diameter, screw adjustable to proper grade and alignment.

### 2.5 CONCRETE

Concrete used around manholes, valve boxes, survey monument boxes, and other similar devices shall be composed of Portland cement, coarse and fine aggregate, water, and entrained air. The concrete shall contain a minimum of six (6) sacks of cement per cubic yard or an equivalent cement/fly ash combination not to exceed twenty (20%) percent cement replacement (when approved), a maximum of six (6 gal) gallons of water per sack of cement, an air content between five (5%) percent and eight (8%) percent by volume, and a maximum coarse aggregate size of one and a half (1½") inches.

Any admixture (except air entraining agent) must be approved by the Town Engineer. Other high-early strength concretes may be used only where special conditions warrant, subject to written approval by the Town Engineer. Concrete shall also meet the additional requirements of **Section 03310**.

### 2.6 REINFORCING STEEL

Reinforcing Steel shall be as specified in CDOT Standard Specifications, Section 709.

### 2.7 GROUT

A good grade non-shrink grout shall be used for resetting manhole frames and grade rings and shall be as approved by the Town Engineer.

## PART 3 – EXECUTION

### 3.1 OBSERVATION AND REVIEW

Manhole frames and covers, valve boxes, and all other similar devices shall be raised to final grade. After adjustment, the Contractor shall notify the Town who shall make an inspection to check for cleanliness, proper alignment, and elevation.

All valve boxes shall be inspected by applying a valve key to each operating nut to insure an acceptable alignment.

### 3.2 SAFETY

To provide proper protection to the public, manhole frames and covers, and valve boxes shall be accessible no later than twenty-four (24) hours after they have been buried by the work in progress and brought to final grade within one (1) week.

### 3.3 ASPHALT PAVEMENT LOCATIONS

Following installation of the final lift of asphalt pavement, final grading adjustments shall be made for all manhole frames and covers, and valve boxes. Final grading adjustments shall be made within a one (1) week period following placement of the final wearing surface. The following procedures are required:

A. Remove bituminous pavement to clean straight lines and excavate as detailed in **Section 02595, Utility Cuts, Backfill and Pavement Patching**, subsection 3.3.B, at least eight (8") inches deep. The saw cut pavement edges shall be a minimum of one (1') foot out from the manhole frame or valve box (e.g.: for a two (2') foot diameter manhole lid, this would result in a four (4') foot diameter cut).

B. Complete final grading adjustments of the manhole frame or water valve box. Shim and grout into place, checking for proper alignment and slope of the grade ring.

C. Following inspection and acceptance by the Project Representative for proper alignment and slope of grade ring, proceed with placing concrete. The concrete shall be placed to the existing depth of asphalt pavement plus one (1") inch, or a minimum of eight (8") inches, whichever is greater, with a concrete mix as specified above in subsection Part 2 - Materials, 2.5 Concrete. Concrete shall be placed in accordance with **Section 02595, Utility Cuts, Backfill and Pavement Patching**.

D. Protect concrete from weather and rapid loss of moisture and protect from vehicular traffic for a period of not less than seven (7) days (three (3) days with High/Early concrete). Compressive strength of concrete shall reach three thousand (3,000 psi) pounds per square inch prior to any traffic loading.

### 3.4 ADJUSTMENT FOR CONCRETE PAVEMENT

After placement of the concrete pavement and jointing has begun, a transverse joint shall be placed at each manhole frame and at each water valve box or other similar device. In the event that a manhole frame, water valve box, or other similar device should be covered up during construction, the Contractor will be responsible for raising the manhole frame or water valve box up through the concrete. This work will take place no later than twenty-four (24) hours after completion of the work. The concrete edges will be full-depth saw cut and be a minimum of twelve (12") inches from the manhole frame or water valve box.

Final grading adjustments shall be made within a one (1) week period following placement of the concrete pavement wearing surface. The following procedures are required:

A. Remove concrete pavement to clean straight lines and excavate as detailed in **Section 02595, Utility Cuts, Backfill and Pavement Patching**, subsection 3.3.C, at least eight (8") inches deep. The saw cut pavement edges shall be a minimum of one (1') foot out from the manhole frame or valve box (e.g.: for a two (2') foot diameter manhole lid, this would result in a four (4') foot diameter cut).

B. Complete final grading adjustments of the manhole frame or water valve box. Shim and grout into place, checking for proper alignment and slope of the grade ring.

C. Following inspection and acceptance by the Project Representative for proper alignment and slope of grade ring, proceed with placing concrete.

D. Prior to placing concrete, the existing adjacent concrete slab shall be drilled eight (8") inches deep and a sixteen (16") inch number four (#4) rebar grouted in place at twelve (12") inch on center. The concrete shall be placed to the existing depth of concrete pavement plus one (1") inch, or a minimum of eight (8") inches, whichever is greater, with a concrete mix as specified above in subsection Part 2 - Materials, 2.5 Concrete. Concrete shall be placed in accordance with **Section 02595, Utility Cuts, Backfill and Pavement Patching**.

E. Protect concrete from weather and rapid loss of moisture and protect from vehicular traffic for a period of not less than seven (7) days (three (3) days with High/Early concrete). Compressive strength of concrete shall reach three thousand (3,000 psi) pounds per square inch prior to any traffic loading

## 3.5 FIELD QUALITY CONTROL

Testing, as directed and required by the Town Engineer, shall be in compliance with **Section 02595, Utility Cuts, Backfill and Pavement Patching**, Subsection 3.8.

**END OF SECTION**

## SECTION 02616

## TRAFFIC CONTROL SIGNING STANDARDS

### PART 1 – GENERAL

The specification and installation of all traffic control devices shall be in compliance with the current Manual on Uniform Traffic Control Devices (MUTCD) and the Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction.

Permanent signing, striping, pavement markings, and traffic signals, shall be in place before new roadways are completely opened to the public.

### 1.1 DESCRIPTION

A. The Contractor/Owner shall submit a striping and signage plan that shall be reviewed and approved by the Town Engineer. The Contractor/Owner shall install all traffic control devices in conformance to the approved drawings.

B. All traffic control devices on private property, i.e., pavement markings, regulatory signs, fire lane signs, and handicapped parking signs shall be installed and maintained by the property owner. A signage and striping plan specifying the various types and combinations of traffic control devices shall be submitted to the Town for review and approval.

C. The design of all permanently fixed traffic signals shall be performed by a qualified traffic engineer approved by the Town Engineer. The design should follow the CDOT Standards for a standard mast arm type traffic signal installation. In general, the design engineer can use the current version of the CDOT Standards, Section 614, "Traffic Control Devices" for guidance in preparing traffic signal plans which shall be submitted to, reviewed, and approved by the Town Engineer.

### PART 2 – MATERIALS

### 2.1 TRAFFIC SIGNS

A. Sign material shall consist of aluminum plates of 0.080 gauge as standard, except for signs larger than thirty six by thirty six (36" x 36") inches, which shall be 0.100 or 0.125 gauge aluminum. All plates shall have pre-punched holes.

B. All traffic control signs shall be fabricated with retroreflective materials and shall be 3M High Intensity Prismatic, ASTM D4956-04 Type III, IV, X, reflective sheeting with a ten (10) year guarantee, or approved equal. All traffic control signs for school installations shall be fabricated with retroreflective materials and shall be 3M Diamond Grade, ASTM D4956-04 Type IX reflective sheeting with a ten (10) year guarantee, or approved equal. Legends and symbols shall be made with Electro Cut (EC) Film, however, the Town reserves the right to request material changes to all signs. No silk screen signs shall be permitted. All new traffic control signs shall meet the new FHWA retroreflectivity standards per the MUTCD.

C. Sign sheeting standard - use reflective white background with green EC Film on top layer with reverse weed which shows reflective white blocked uppercase letters, numbers, and arrows. Refer to Standard Details or the MUTCD for font and height. At signalized intersections these signs shall comply with CDOT Standard Specifications and the MUTCD.

D. All retroreflective sheeting shall be sealed at the seams and edges as recommended by the manufacturer. Retroreflective sheeting shall be placed perpendicular to the sign face with arrow pointing up on the sheeting.

E. Aluminum sign blanks shall receive a chemical treatment conforming to ASTM B 449, Class 2, prior to placement of retroreflective sheeting.

## 2.2 STREET NAME SIGNS

A. Street name sign material shall consist of aluminum plates of 0.08 gauge as standard. All plates shall have pre-punched holes.

B. All street name signs shall be fabricated with retroreflective materials and shall be 3M High Intensity Prismatic, ASTM D4956-04 Type III, IV, X, reflective sheeting with a ten (10) year guarantee, or approved equal.

C. Sign sheeting standard - use reflective white background with green EC Film on top layer with reverse weed which shows reflective white blocked letters, numbers, and arrows. Refer to Standard Details or the MUTCD for font. At signalized intersections these signs shall comply with CDOT Standard Specifications and the MUTCD.

D. All retroreflective sheeting shall be sealed at the seams and edges as recommended by the manufacturer. Retroreflective sheeting shall be placed perpendicular to the sign face with arrow pointing up on the sheeting.

E. Aluminum sign blanks shall receive a chemical treatment conforming to ASTM B 449, Class 2, prior to placement of retroreflective sheeting.

F. Street name sign blanks shall be nine (9″) inches in height, green, with white lettering. All street names shall be composed of lower-case letters with an initial upper-case letter. On roadways with posted speed limits of forty (40 mph) miles per hour or less, lower-case letters shall be a minimum of four and one-half (4½″) inches high and the initial upper-case letter shall be a minimum of six (6″) inches high. On roadways with posted speed limits more than forty (40 mph) miles per hour, lower-case letters shall be a minimum of six (6″) inches high and the initial upper-case letter shall be a minimum of eight (8″) inches high.

G. If the street name sign exceeds thirty six (36″) inches in length, use back to back street name sign blanks with two (2), two (2″) inch shims between the blanks.

## 2.3 SIGN POSTS

A. All signs shall be installed on Telespar type perforated posts with anchor stubs, at proper heights as per current MUTCD Standards.

B. All signs shall be mounted with Town approved vandal type rivets or bolts and with metal washers. All hardware shall be compatible with sign material and shall not cause discoloration due to weather. The rivet or bolt system is used to fasten signs to Telespar posts.

1. 3/8" drive rivet or bolt.
2. 3/8" corner bolt with 5/16" nut.
3. Street name blade use 5/16" bolt, 1/2" thread length, 1/2" head.
4. 1½" metal fender washer with 3/8" hole for signs 24" x 30" or bigger.

C. Telespar type posts shall meet or exceed the following:

1. <u>Anchor Post</u> – 2¼" x 2¼" x 3', 12 gauge, ASTM Specification No. A446, (Telespar 22F12) with perforated 7/16" holes drilled on 1" centers.

2. <u>Post Section</u> – 2" x 2" x 10' or 12′, 12 gauge, ASTM Specification No. A446, Grade A, (Telespar 20F12) with perforated 7/16" holes drilled on 1" centers.

3. <u>Post Bolts</u> – Two (2) 2½" long, 3/8" hex head bolts may be used to attach sign posts to sign anchor (stubs). Preferably, use bolts with a carriage bolt head, with two (2) forty five (45°) degree bends that create a right angle for mounting in two (2) sides of the post and anchor.

4. All posts and anchors shall be galvanized to ASTM Specification A-653 coating designation G-90.

D. Streetlights and approved utility poles, when located appropriately, and when approved by the Town Engineer, may be used for signs such as warning, parking, and speed limit signs. Streetlight locations should be checked for potential sign installation during the design process and shown on the sign plan drawings.

E. For Wood/Metal/Fiberglass/post mounting: Band-It Type #201 ¾" stainless steel band, Band-It Type #201 ¾" Ear-Lokt Buckle, Band-It Type #DO22 ¾" Bracket, 5/16" x ¾" Bolt w/ six-sided head, and 5/16" washer, or approved equal.

## PART 3 – EXECUTION

### 3.1 GENERAL

A. Signs shall have a seven (7') foot clearance (minimum) from the bottom of sign to the finish grade elevation, or as approved by the MUTCD Standards and the Traffic Impact Study (TIS).

B. For all multiple mounted signs on a single post, the lowest sign shall be no lower than six (6') feet on urban roadways, with a one (1") inch gap between signs. The lowest sign shall be seven (7') feet if near pedestrian or parking traffic

### 3.2 TRAFFIC CONTROL SIGN INSTALLATION

A. Traffic control signs are categorized as regulatory, warning, and guide signs. Placement of these signs shall generally be as per the MUTCD and the TIS.

B. Traffic control signs shall be mounted on existing streetlight and power poles, with new posts being used only if necessary. Streetlight locations should be checked for potential sign installation during the design process and shown on the signing and striping drawings. The use of stainless steel banding of signs is acceptable for fiberglass and steel poles.

C. Traffic control signs shall be vertically mounted perpendicular (at right angles) to the direction of, and facing, the traffic that they are intended to serve. Signs placed less than thirty (30′) feet from the pavement edge, should be angled three (3°) degrees off perpendicular toward the oncoming traffic. Signs that are placed thirty (30′) feet or more from the pavement edge should be turned toward the road an appropriate amount for maximum legibility. On curved alignments, the angle of placement should be determined by the direction of approaching traffic rather than by the roadway edge at the point where the sign is located. On grades, sign faces may be tilted forward or back from the vertical position to improve the viewing angle.

### 3.3 STREET NAME SIGN INSTALLATION

A. Street name signs shall be placed on diagonally opposite corners at each intersection at the point of curvature of the corner radius. Accordingly, they will be on the far right-hand side of the intersection for traffic on the major street. Tee intersections also require two (2) sign locations. Signs naming both streets shall be erected at each location, including local and collector streets. Street name signs shall be offset per the MUTCD. Street name signs that exceed twenty four (24″) inches in length shall have an additional offset as approved by the Town Engineer.

B. Street name assemblies can be combined and placed on top of Stop signs. Sign placement for the Stop sign or other regulatory sign shall govern in those cases. In other instances, the street name assembly shall be placed as determined in the TIS or as directed by the Town Engineer.

C. Street name signs shall be mounted with an approved bracket on top of the post so that no part of the sign is obscured by the post. The signs are mounted to the bracket with a minimum of two (2) standard bolts with washers placed against the face of the sign.

## 3.4 SIGN POST INSTALLATION

The post shall be constructed in two (2) sections.

A. Anchor Post. The 2¼" x 2¼" x 3', 12 gauge, galvanized steel square stub section with holes, shall be driven into the ground thirty to thirty three (30" - 33") inches with three to six (3" - 6") inches remaining above the finished grade elevation. For installation in medians or concrete surfaces, install a four (4″) inch PVC sleeve, thirty six (36″) inches deep; fill with approved material (class VII base, cold mix asphalt, crushed stone, etc.) and drive anchor stub post into the sleeve, thirty to thirty three (30" - 33") inches with three to six (3" - 6") inches remaining above the finished grade elevation.

B. Post Section. The 2" x 2" x 10' or 12′, 12 gauge, galvanized steel square post section with holes, is then inserted into the stub and bolted. Posts shall be installed six to eight (6" - 8") inches into the anchor (stub), which has three to six (3" - 6") inches sticking out above the adjacent ground level.

C. Post Bolts. Use two (2) 2½" long, 3/8" hex head bolts or, preferably, two (2) bolts with a carriage bolt head, with two (2) forty five (45°) degree bends that create a right angle for mounting in two (2) sides of the post to attach sign posts to sign anchor (stubs). Install bolts a distance of two (2) pre-drilled post holes apart, at ninety (90º) degrees apart.

D. Sign Mounting. Mount signs to the post with a minimum of two (2) bolts (5/16" with metal washers).

E. Breakaway Post System. Posts must be of appropriate length to comply with MUTCD specifications for the location, must conform to CDOT Specification Section 614, meet all requirements and guidelines of the TIS, and must meet Federal breakaway standards as they apply.

**END OF SECTION**

## SECTION 02618

## PAVEMENT MARKING AND LANE STRIPING STANDARDS

### PART 1 – GENERAL

### 1.1 DESCRIPTION

The Work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials necessary including transporting, painting, placing, finishing, and performing all operations in connection with the construction of pavement markings on Town roadways, within the public right-of-way.

The Work shall consist of constructing these non-structural pavement marking appurtenances within the Urban Growth Area of the Town of Windsor in accordance with these specifications and in conformance with the lines, grades, directions, and dimensions as shown on the applicable plans and drawings.

All, striping and pavement markings, either temporary or permanent, shall be in place before new roadways are completely opened to the public

### 1.2 GENERAL

A. Pavement markings supplement and enhance the messages of other traffic control devices such as signs and signals and in some cases they are the only effective way of providing positive guidance or communicating certain regulations or other messages. Pavement markings communicate their messages through a uniform system of colors, patterns, widths, symbols, and words.

B. Generally, there are four types of pavement markings. These include 1) Longitudinal lines; 2) Transverse lines; 3) Arrows, Words, and Symbols; and 4) Special markings.

   1. Longitudinal lines delineate vehicular paths of travel along the roadway by marking the center of the road, lanes of travel, edges of pavement, etc. Color of longitudinal lines informs the driver whether they are on a one-way road or there may be opposing traffic to the left of the line. The pattern and/or width of a longitudinal line informs whether it is permissible, discouraged, or prohibited to cross the line.

   2. Transverse lines go across one or more lanes or across the whole roadway. They show drivers where to stop or yield and show pedestrians where to cross roadways.

   3. Arrows on the pavement convey directional or lane usage requirements. Words and Symbols marked on the pavement supplement signs in conveying important regulatory, warning, or guidance information.

   4. Special markings are used for special conditions or to communicate special messages that can't be communicated by other types of markings. Examples might include cross-hatching, dotted lines, two-way left turn lane markings, speed hump markings, parking space markings, etc.

C. There are four (4) standard colors of pavement markings. Each color is used for a specific type of message. Standard colors are 1) white; 2) yellow; 3) red; and 4) blue.

   1. White is the color for all markings except those that are specifically required to be yellow and except for special red and blue raised markers. Lane lines are always white. Edgelines along the right side of any roadway or ramp are always white. Transverse lines are always white, except for cross-hatching markings in medians or safety zones separating opposing traffic flows or in left shoulders, which are yellow. Arrows, words, and symbol markings are always white. Speed hump markings and parking space markings are always white.

   2. Yellow is the color for all centerlines because centerlines separate lanes traveling in opposing directions. Edgelines along the left edge of a one-way ramp are always yellow. Cross-hatching

markings in medians or safety zones separating opposing traffic flows or in left shoulders are always yellow.

3. The only markings that are red are special raised pavement markers (reflectors on or in the pavement) that are placed to be visible to "wrong-way" drivers. These special markers warn drivers not to enter one-way roadways or one-way ramps in the wrong direction.

4. Blue is the color of special markings that supplement white markings in a parking space specifically designated as reserved for the disabled. Blue raised pavement markers (reflectors mounted on or in the pavement) indicate the location of a fire hydrant adjacent to the road.

D. There are three (3) basic patterns of lines and each pattern communicates a unique message.

1. Solid lines usually indicate that crossing the line is discouraged. Edgelines are solid lines and a lane line is a solid white line in portions of a road where lane changing across the line is discouraged. A double solid white line indicates that lane changing (among lanes going in the same direction) is prohibited.

   In the case of lines used to designate no-passing zones, a solid yellow line immediately to the left of the driver's lane indicates that crossing the centerline to overtake and pass another vehicle is prohibited. A double solid yellow line indicates that passing is prohibited in both directions on an undivided road or highway.

2. Broken (dashed) white lines indicate that it is permissible to cross the line to change lanes to move into an adjacent lane moving in the same direction.

   A broken (dashed) yellow line is a roadway centerline indicating that crossing over into the oncoming traffic lane for the purposes of overtaking and passing another vehicle is permitted if it is safe to do so.

3. Dotted lines are special markings used to extend other lines. It may be an extension of a lane line or centerline through an intersection, or it may be a curved dotted line through an intersection to help guide turning vehicles as they move through their turn. A dotted line may extend an edgeline, especially where the road widens out for an added lane for deceleration or turning.

E. The width of a longitudinal line communicates a specific message. Most longitudinal lines are normal width lines of four to six (4″ - 6″) inches width. Wide lines are at least twice the width of a normal width line, so they are at least eight to twelve (8″ - 12″) inches wide. Wide lines are used for special emphasis.

## 1.3 REQUIREMENTS

All pavement marking and striping installations shall be in compliance with the current Manual on Uniform Traffic Control Devices (MUTCD) and Colorado Department of Transportation (CDOT) Standard Specifications and shall be of a permanent type marking, to include but not limited to: lane striping, Crosswalks, Arrows Only, Turn bay line, Centerline, bike Paths, Stop Bars, Yield lines, Pedestrian Crossings, etc.

All pavement markings shall be placed in accordance with the following requirements. When the term "full compliance" is used, it means pavement markings shall meet the requirements of these specifications.

A. Pavement Marking Plan. When pavement marking location details are not provided in the approved drawings, the Contractor/Applicator shall submit a layout of existing and proposed conditions to the Town for approval or modification. This layout is to be used as the final pavement-marking plan.

B. Roadways Closed to Traffic During Construction. Full compliance pavement markings shall be in place on all roadways prior to opening traffic.

C. Roadways Constructed Under Traffic. Full compliance final pavement markings shall be placed within two (2) weeks after final surfacing is completed. Full compliance pavement markings shall also be placed on any roadways open to traffic when the project pavement work is discontinued for more than two (2) weeks.

D. Temporary Pavement Markings. Temporary pavement markings and control points for the installation of those pavement markings for roadways that are being constructed under traffic are as follows:

1. When one roadway of a normally physically divided highway is closed, and a crossover is constructed, full compliance pavement marking shall be placed along the tapers and through the median crossovers to the two-way traffic section. Pavement marking through the two-way traffic section shall be as shown on the plans.

2. When a two-lane highway is closed, and a bypass detour is provided, full compliance pavement markings shall be placed the full length of the detour prior to operation of the detour.

3. In either case, the type of marking materials applied to a final surface, when removed, shall not leave a scar that conflict with permanent markings.

E. Pavement Marking Criteria. The following criteria apply to all construction and maintenance on roadways open to traffic other than Temporary Pavement Markings as described above:

1. Control points, four (4") inch by one (1') foot marks not exceeding forty (40') foot intervals, are guide markers for the installation of temporary and/or full compliance markings.

2. All temporary broken line pavement markings shall be installed daily and shall be at least eighteen (18") inches long with a maximum gap of thirty six (36') feet. An eighteen (18") inch stripe with a maximum gap of eighteen (18') feet may be used on curves for roadways with severe curvature. A severe curve is defined as a curve whose safe speed is ten (10 mph) miles per hour or more below the approach posted speed limit.

3. Temporary pavement markings for “no passing zones” shall be full compliance.

4. For short term situation (three (3) calendar days or less) where temporary broken center lines are installed, “no passing” restrictions may be identified by appropriate signs including R4-1 and R4-2 until final markings are installed.

5. For roadways with a volume of seven hundred fifty (750 ADT) average daily traffic, or less, “no passing” restrictions can be identified for up to two (2) weeks with appropriate signs.

6. Temporary pavement stencils (school, handicap symbols, etc.) are not required unless detailed on the plans.

7. Temporary pavement markings shall be installed per manufacturer’s recommendations in such a way that the markings adequately delineate the desired alignment.

F. All Inclusive. Control points, temporary pavement markings and Contractor pavement marking plans shall be included in the work and provided as indicated.

G. Striping Removal. When applicable, existing and temporary pavement striping and marking shall be removed prior to new installations according to CDOT Specifications Section 202.05.

H. Preparation. Surfaces shall be thoroughly cleaned and prepared prior to establishing control points and application of striping and marking.

## 1.4 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I.

## 1.5 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.D.; except Subsection 1.3.D. shall be modified to include the following:

A. Preformed thermoplastic pavement markings shall be packaged in a protective plastic film with cardboard stiffeners where necessary to prevent damage in transit. The carton in which the material is packed shall be clearly labeled for ease of identification.

B. Materials shall be stored to assure the preservation of their quality and fitness for the work. Paint materials shall be protected from freezing and excessive temperatures.

C. Clean up spills and overspray immediately with appropriate materials. Clean hands and tools immediately after use.

D. When removing old paint, scraping or sanding of old paint may release lead dust. LEAD IS TOXIC. EXPOSURE TO LEAD DUST CAN CAUSE SERIOUS ILLNESS, SUCH AS BRAIN DAMAGE. Wear a NIOSH-approved respirator to control lead exposure. Clean up carefully with a HEPA vacuum and wet mop. Before starting, find out how to protect from exposure by contacting the National Lead Information Hotline at 1-800-424-LEAD or log on to www.epa.gov/lead.

# PART 2 – MATERIALS

## 2.1 TEMPORARY MARKING MATERIALS

A. Temporary Pavement Markings with Paint (Waterborne).

1. Description. Low VOC, lead free, ready mixed, one component, 100% acrylic waterborne traffic paints.

2. All paints shall be suitable for application to Asphaltic or Portland Cement concrete pavements when applied with or without glass beads.

3. Recommended Dry Film Thickness per Coat – 9.8 mils.

4. Wet Film to Achieve Dry Film Thickness – 16 mils.

5. Dry times may vary depending upon temperature, humidity and degree of air movement; however, paint should be tack free in less than five (5) minutes at seventy (70°) degrees F and fifty (50%) percent relative humidity.

6. Waterborne pavement marking paint, for temporary pavement markings, shall conform to the requirement listed in the following table. All proportions are by weight. Pigment composition and vehicle composition shall not vary by more than one (1.0%) percent of each amount specified.

**Table 02618-1**
**TEMPORARY (WATERBORNE) PAVEMENT MARKING PAINT**

| CHARACTERISTICS | YELLOW | WHITE |
|---|---|---|
| Viscosity at 77 degrees F, KU | 80-90 | 80-90 |
| Dry to no pick up time, ASTM D-711 without beads, minutes | 3 max. | 3 max. |
| No-Track time, Actual @ 77 degrees F/50% RH, seconds | 90 max | 90 max |
| Directional Reflectance % | 87 min. | 50 |
| Contrast Ratio @ 15 mils wet | 0.98 min | 0.95 min. |
| Scrub test, Cycles | 1000 min | 1000 min |
| Volatile Organic Compound, grams/liter | Below 150 | |
| Total Pigment, % by Weight | 62 min. | 62 min. |
| Total Solids, % by Weight | 76 min. | 76 min. |
| Total Solids, % by Volume | 58 min. | 58 min. |
| PH | 9.6 min. | 9.6 min. |
| **REPORTABLE COMPONENTS:** | | |

| YELLOW | Vapor Pressure (mm Hg) | @ Temp (°F) | Weight (Percent) |
|---|---|---|---|
| METHYL ALCOHOL | 97.68 | 68 | 5 |
| QUARTZ SILICA | N/A | N/A | 0.32 |
| OSHA PEL = 200 PPM (skin) (260 MG/M3), STEL 250 PPM<br>ACGIH TLV = 200 PPM (skin) (260 MG/M3) STEL 250 PPM<br>NIOSH = TWA 200 PPM, 800 PPM (CEILING) | | | |
| 2,2,4TRIMETHYL-1,3-PENTANEDIOL MONOISOBUTYRATE | | | 1 |
| NOISH REL = TWA 0.05 MG/M3, 3,000,000 FIBERS/M3<br>OSHA PEL = TWA RESPIRABLE: 0.1 MG/M3 TOTAL DUST: 30 MG/M3<br>ACGIH TLV = TWA RESPIRABLE: 0.1 MG/M3 | | | |

| WHITE | Vapor Pressure (mm Hg) | @ Temp (°F) | Weight (Percent) |
|---|---|---|---|
| METHYL ALCOHOL | 98.68 | 68 | 5 |
| QUARTZ SILICA | N/A | N/A | 1.24 |
| OSHA PEL= 200 PPM (SKIN), STEL 250 PPM<br>ACGIH = 200 PPM (SKIN), STEL 250 PPM<br>NOISH = TWA 200 PPM, 800 PPM (CEILING) | | | |
| 2,2,4 TRIMETHYL - 1,3 - PENTANEDIOL MONOISOBUTYRATE | | | 1 |
| NIOSH REL = TWA 0.05 MG/M3, 3,000,000 FIBERS M/3<br>OSHA PEL = TWA RESPIRABLE: 0.1 MG/M3, TOTAL DUST: 30 MG/M3<br>ACGIH = TWA RESPIRABLE: 0.1 MG/M3 | | | |

B. Temporary Pavement Markings with Paint (Alkyd).

1. Alkyd pavement marking paint, for temporary pavement markings, shall conform to the requirements listed below. All proportions are by weight. Pigment composition and vehicle composition shall not vary by more than one (1.0%) percent of amount specified. Finished Paint Pigment (White and Yellow) shall be forty nine to fifty two (49%-52%) percent.

**Table 02618-2**
**TEMPORARY (ALKYD) PAVEMENT MARKING PAINT**

| **Pigment Composition:** | **White** | **Yellow** |
|---|---|---|
| Titanium Dioxide, ASTM D 476, Type III | 27.0% | 8.0% |
| Chrome Yellow, Medium ASTM D 211 Type III | | 18.0% |
| Calcium Carbonate, ASTM D 1199 Type GC-II | 18.0% | 17.0% |
| Magnesium Silicate, ASTM D 605 | 54.3% | 56.3% |
| Pigment Suspending Agent (see below) | | |
| **Vehicle Composition:** | **White** | **Yellow** |
| Alkyd Resin Solution, AASTO M 248 Type F | 70% | |
| VM&P Naphtha, Fed. Spec. TT-N-95, Type I | | 30% |
| Driers, ASTM D 600 cl.B, & Anti-Skinning Agent, Methanol | | |

2. Pigment Suspending. Organo-montmorillonite shall be added to achieve the desired storage and stability requirements.

3. Properties of Finished Paint. The paint at the time of container filling shall be free of skins, pigment agglomerates and foreign matter and shall meet the following requirements:

   Fitness of grind, Hegman, minimum: 2
   Consistency, Krebs-Stormer, K.U. @ 77° F (25° C): 70-80
   Drying time, a wet film of paint 15 mils thick tested according to ASTM Method D 711, minutes maximum: 30

4. Reflectance. The white paint shall have a daylight forty five (45°) degree, zero (0°) degree luminous directional reflectance of not less than eighty (80%) percent when compared to magnesium oxide (ASTM E 97).

5. Color. The yellow paint color shall have visually match color chip No 33538 of Federal Standard 595a.

C. Pavement Marking Tape (Removable).

1. Description. Pavement marking tape designated as removable shall conform to ASTM D 4592, Type I, and shall be four plus or minus one tenth (4" ± 0.1") inches wide. The marking tape shall consist of weather and traffic resistant yellow or white colored reflective material. The material shall consist of conformable (metal foil) backing with a pressure sensitive adhesive design for adhesion to asphalt or concrete surfaces.

2. Requirements:

   a. Color. The color of the visible or outer surface shall closely match the White or Yellow traffic marking paint specified for highway delineation. Glass beads shall be strongly adhered to the tape.

   b. Reflectance. The White and Yellow tapes shall have the following initial minimum reflectance values at two tenths of (0.2º) a degree and one half (0.5º) degree observation angles and eighty

six (86º) degrees entrance angles as measured in accordance with the testing procedures of Federal Test Method Standard 370. The photometric quantity measured is specific luminance (SL), and is expressed as millicandelas per square foot per foot-candle.

**Table 02618-3**
**REMOVABLE PAVEMENT MARKING TAPE**

| Color | White | | Yellow | |
|---|---|---|---|---|
| Observation Angle | 0.2° | 0.5° | 0.2° | 0.5° |
| Specific Luminance | 1360 | 760 | 820 | 510 |

c. Adhesive. The striping tape shall be supplied in rolls ready for application and have a protected pressure sensitive adhesive which shall not have a protective liner nor require a solvent activator.

d. Adhesion. The material shall adhere to asphalt and concrete surfaces when applied at surface temperatures of thirty five (35º) degrees F and above. Once applied, the tape shall adhere to the pavement at sub-freezing temperatures.

e. Conformability. The material shall be thin, flexible, conformable, and show no cracking, flaking, or bead loss. Following application, the tape shall remain conformed to the texture of the pavement surface. The thickness shall not be less than seventeen (17) mils.

f. Removability. The tape shall be removable by following manufacturers' recommendations so long as the material is substantially intact. Removal shall not require sandblast, solvents, or grinding methods.

g. Durability. The striping material applied in accordance with manufacturers' recommended procedures shall be weather resistant and show no appreciable fading, lifting, or shrinkage during the useful life of the line.

h. Packaging and Delivery. The striping material as supplied shall be of good appearance and free of cracks. The edges shall be true, straight, and unbroken. The material shall be supplied in rolls with no more than one (1) splice per fifty (50 yds.) yards of length.

3. Packaging. The striping material shall be packaged in accordance with accepted commercial standards to prevent damage during shipment and storage. The tape as supplied shall be suitable for use for a period of at least one (1) year following delivery when stored at temperatures of one hundred (100º) degrees F or below.

## 2.2 PERMANENT MARKING MATERIALS

A. Epoxy Pavement Marking Material:

1. Formulation. Epoxy pavement marking material shall be a two (2) component, one hundred (100%) percent solids, material formulated to provide simple volumetric mixing ratio of two (2) volumes of component A and one volume of component B unless otherwise recommended by the material manufacturer.

2. Composition. The component A of both white and yellow pigments shall be within the following limits:

**Table 02618-4**
**PERMANENT EPOXY PAVEMENT MARKING MATERIALS**

| White | | Yellow | |
|---|---|---|---|
| Min% by weight Titanium Dioxide, (ASTM D 476 Type II) | 18% | Min% by weight Chrome Yellow,(ASTM D 211,Type III | 23% |
| Epoxy Resin | 75 - 82% | | 70-77% |

3. Epoxy Number. The epoxy number of the epoxy resin shall be 0.38 ± 0.05 as determined by ASTM D 1652 for White and Yellow Component A on pigment free basis.

4. Amine Number. The Amine Number on the curing agent (component B) shall be four hundred ten plus or minus fifty (410 ± 50) per ASTM D 2071.

5. Toxicity. Upon heating to application temperature, the material shall not produce fumes, which are toxic or injurious to persons or property.

6. Color and Weather Resistance. The mixed epoxy compound, both white and yellow, when applied to three (3") inch by six (6")inch aluminum panels at fifteen plus or minus one half (15 ± ½) mils of thickness with no glass beads and exposed in the Q.U.V. Environmental Testing Chamber as described in ASTM G 154, shall conform to the following minimum requirements. (The test shall be conducted for seventy five (75) hours at one hundred twenty two (122º) degrees F, four (4) hours humidity, and four (4) hours U.V., in alternating cycles. The prepared panels shall be cured at seventy seven (77º) degrees F for seventy two (72) hours prior to exposure.) The color of the White Epoxy System shall not be darker than Federal Standard No. 595B-17778. The color of the Yellow Epoxy System shall conform to Federal Standard No. 595B-13538. The gloss values of both samples shall not be less than seventy (70º) degrees after the test.

7. Drying Time. The epoxy pavement marking material shall have a setting time to a no-tracking condition of not more than twenty five (25) minutes at a temperature of seventy three (73º) degrees F and above.

8. Curing. The epoxy material shall be capable of fully curing under the constant surface temperature condition of twenty five (25º) degrees F and above.

9. Adhesion to Concrete. The catalyzed epoxy pavement marking material, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified (4,000 psi minimum) concrete surface that there shall be a one hundred (100%) percent concrete failure in the performance of this test.

10. Hardness. The epoxy pavement marking materials, when tested according to ASTM D 2240, shall have a Shore D Hardness between seventy five (75) and one hundred (100). Samples shall be allowed to cure at room temperature (75º F ± 2º F) for a minimum of twelve (12) hours and a maximum of forty eight (48) hours prior to performing the indicated test.

11. Abrasion Resistance. The abrasion resistance shall be evaluated on Taber Abrader with a one thousand (1000) gram load and CS-17 wheels. The duration of the test shall be one thousand (1000) cycles. The wear index shall be calculated based on ASTM test Method C-501 and the wear index for the catalyzed material shall not be more than seventy (70). The tests shall be run on cured samples of material which have been applied at film thickness of fifteen plus or minus one half (15 ± ½) mils to code S-16 stainless steel plates. The samples shall be allowed to cure at seventy five, plus or minus two (75º ± 2º) degrees F for a minimum of forty eight (48) hours prior to performing the indicated tests.

12. Tensile Strength. When tested according to ASTM D 638, the epoxy pavement marking materials shall have a tensile strength of not less than six thousand (6,000 psi) pounds per square inch. The Type IV Specimens shall be cast in a suitable mold and pulled at the rate of one quarter (¼″/min)

inch per minute by a suitable dynamic testing machine. The samples shall be allowed to cure at room temperature (75º F ± 2º F) for a minimum of twelve (12) hours and a maximum of forty eight (48) hours prior to performing the indicated tests.

13. Compressive Strength. When tested according to ASTM D 695, the catalyzed epoxy pavement marking materials shall have a compressive strength of not less than twelve thousand (12,000 psi) pounds per square inch. The cast sample shall be conditioned at room temperature (75 º F ± 2 º F), for a minimum of twelve (12) hours and a maximum of forty eight (48) hours prior to performing the tests. The rate of compression of these samples shall be no more than one quarter (¼"/min) inch per minute.

B. Preformed Plastic Pavement Marking.

1. This retroreflective preformed plastic strip shall be suitable for application on Asphaltic or Portland Cement concrete pavement. The strip shall be applied at the locations called for on the plans.

2. If recommended by the manufacturer, an epoxy resin primer shall be applied to all pavement surfaces prior to the application of the preformed plastic pavement marking.

3. Preformed plastic pavement marking material shall conform to ASTM D 4505, Type I, Class B, C, D, or E, and shall have a minimum thickness of sixty (60) mils.

C. Thermoplastic Pavement Marking.

Thermoplastic marking material shall be a minimum of one hundred twenty five (125) mils thickness and shall conform to AASHTO M 249 except for the following:

1. In paragraph 3.1.2.of the AASHTO specifications, delete the first two (2) sentences and replace with the following:

   The material manufacturer shall have the option of formulating the material according to its own specifications. However, the binder shall be composed of alkyd resins wherein a minimum of seventy (70%) percent (by weight) of the binder shall be maleic modified glycerol ester of rosin. The physical and chemical properties contained in this specification shall apply regardless of the type of formulation used.

2. In paragraph 4.3 of the AASHTO specifications, add the following physical characteristics:

   The infra-red spectra of the extracted binder will be compared to the characteristic absorption bands of maleic modified glycerol ester of rosin.

3. In paragraph 6.1 of the AASHTO specifications, delete the second sentence and replace with the following:

   The containers of thermoplastic material shall weigh approximately fifty (50#) pounds (23 kg).

D. Pavement Primers.

1. The type and application rate of epoxy resin primer shall be as recommended by the thermoplastic or preformed plastic pavement marking manufacturer.

2. The epoxy resin primer material may be accepted at the job site on the basis of a manufacturers' certification, or a sample may be sent to the laboratory for testing, in which case three (3) weeks shall be allowed between sampling and intended use

E. Raised Pavement Markers.

1. Raised pavement marker shall not be less than three and a half (3.5") inches nor more than four and a half (4.5") inches in the major dimension and not more than three quarters (0.75") inches in height. The marker shall contain a retroreflective element not less than thirty eight one hundredths (0.38 $in^2$) square inch in area. The color of the marker and the retroreflective element shall match the color of the pavement marking line. The reflective quality requirements shall be at least equal to the following minimum values:

**Table 02618-5**
**RAISED MARKER REFLECTIVE QUALITY**

| Observation Angle (Degrees) | Entrance Angle (Degrees) | Specific Intensity Candlepower per Foot-Candle | |
|---|---|---|---|
| | | White | Yellow |
| 0.1 | 0 | 1.0 | 0.60 |
| 0.1 | 20 | 0.4 | 0.24 |

2. The marker shall be ceramic or plastic and shall be secured to old or new pavement using an adhesive approved by the manufacturer.

## PART 3 - EXECUTION

### 3.1 TEMPORARY PAVEMENT MARKINGS

A. Pavement Markings with (Waterborne) Paint.

1. Striping shall be done when the air and pavement temperatures are at least fifty (50º) degrees F and rising. The pavement surface and weather conditions shall be conducive to satisfactory results.

2. Equipment shall be capable of painting a reasonably clean-edged stripe of the designated width of plus or minus one quarter (± ¼") inch and shall have a bead dispenser directly behind synchronized with the paint applicator. For center lines and lane lines, an automatic skip control shall be used that will paint a stripe with a gap as shown on the plans. Machines having multiple applicators shall be used for center lines with "no passing zones." In areas where machines are not practical, suitable hand-operated equipment shall be used. All stripes shall be protected until dry.

3. Paint and beads shall be applied within the following limits:

**Table 02618-6**
**APPLICATION RATE OR COVERAGE PER GALLON OF PAINT**

| MINIMUM | | MAXIMUM |
|---|---|---|
| Paint | 100 sq. ft | 110 sq. ft.<br>(approximately 15 miles when wet) |
| Beads | 5 lbs. 13 oz | 6 lbs. 3 oz |

4. The finished lines shall have well-defined edges and be free of waviness.

B. Pavement Markings with (Alkyd) Paint.

1. Striping shall be done when the air and pavement temperatures are at least forty (40º) degrees F for alkyd paints.

2. The pavement surface and weather condition shall be conducive to satisfactory results.

3. Equipment shall be capable of painting a reasonably clean-edged stripe of the designated width of plus or minus one quarter (± ¼") inch and shall have a bead dispenser directly behind, synchronized with the paint applicator. For centerline and lane lines, an automatic skip control shall be used that will paint a stripe with a gap as shown on the plans. Machines having multiple applicators shall be used for center lines with "no passing zones." In areas where machines are not practical, suitable hand-operated equipment shall be used. Stripes shall be protected until dry.

4. Paint and beads shall be applied within the following limits:

**Table 02618-7**
**APPLICATION RATE OR COVERAGE PER GALLON OF PAINT**

| MINIMUM | | MAXIMUM |
|---|---|---|
| Paint | 100 sq. ft. | 110 sq. ft. |
| Beads | 5 lbs.13 oz. | 6 lbs.3 oz. |

5. The finished lines shall have well-defined edges and be free of waviness.

C. Pavement Marking Tape (Removable).

1. Retroreflective tape shall be suitable for temporary use on Asphaltic or Portland Cement concrete pavements. The tape shall be applied at the locations shown on the plans or as directed. The surface to which the tape is applied shall be clean, dry and free of dirt, oils and grease. The tape shall be pressed down immediately after application, until it adheres properly and conforms to the surface. Temporary marking tape shall be removed on sections where tape conflicts with revised traffic lanes prior to opening of new lanes to traffic.

2. Pavement marking tape (removable) shall be installed in accordance with the manufacturer's recommendations, and maintained throughout the required construction phase at no additional cost to the Town's Traffic Operation.

## 3.2 PERMANENT PAVEMENT MARKINGS

A. Epoxy Pavement Markings.

1. The epoxy pavement marking compound shall be applied with equipment that will precisely meter the two (2) components in the ratio specified. The equipment shall automatically shut off or warn the operator if one component is not being mixed.

2. The equipment shall produce the required amount of heat at the mixing head and gun tip to provide and maintain the temperatures specified.

3. Before mixing, the individual components A and B shall each be heated to a temperature of eighty (80º) degrees F to one hundred forty (140º) degrees F. After mixing, the application temperature for the combined material at the gun tip shall be eighty (80º) degrees F to one hundred forty (140º) degrees F. The one hundred forty (140º) degree F upper limit is the maximum temperature under any circumstances.

4. Both pavement and air temperatures shall be at least fifty (50º) degrees F at the time of epoxy pavement marking application.

5. The surface areas of new Portland Cement concrete pavement and decks that are to receive markings shall be sandblasted prior to placement of the epoxy pavement marking. The amount of sandblasting shall be sufficient to remove all dirt, laitance, and curing compound residue.

6. The surface areas of new asphalt pavement, and existing asphalt pavement, and existing concrete pavement that are to receive markings shall be cleaned with a high pressure air blast to remove loose material prior to placement of the epoxy pavement marking. Any pavement which has become dirty from tracked mud etc., as determined by the Construction Inspection Representative or Engineer, shall be cleaned prior to the placement of the epoxy pavement marking.

7. When recommended by the epoxy manufacturer, a high pressure water blast integrated into the gun carriage shall be used to clean the pavement surface prior to epoxy pavement marking application. The water blast shall be followed by a high pressure air blast to remove all residual water, leaving only a damp surface.

8. Striping shall be done when the air and pavement temperatures are at least fifty (50º) degrees F and rising. The pavement surface and weather conditions shall be conducive to satisfactory results.

9. Equipment shall be capable of painting a reasonably clean-edged stripe of the designated width of plus or minus one quarter (± ¼") inch and shall have a bead dispenser directly behind synchronized with the paint applicator. For center lines and lane lines, an automatic skip control shall be used that will paint a stripe with a gap as shown on the plans. Machines having multiple applicators shall be used for center lines with "no passing zones." In areas where machines are not practical, suitable hand-operated equipment shall be used. All stripes shall be protected until dry.

10. Epoxy pavement marking shall be applied to the road surface according to the epoxy manufacture's recommended methods at fifteen (15) mils minimum thickness. Glass beads shall be applied into the epoxy pavement marking by means of a pressurized bead applicator at a rate of one quarter (0.25 psi) pounds per square foot (25 pounds per gallon) minimum.

11. Epoxy pavement marking and beads shall be applied within the following limits, per gallon of epoxy pavement marking:

**Table 02618-8**
**EPOXY PAVEMENT MARKING BEADS**

| | MINIMUM | MAXIMUM |
|---|---|---|
| 15 mil marking | 100 sq. ft | 110 sq. ft. |
| Beads | 25 lbs. | |

12. The finished lines shall have well-defined edges and be free of waviness.

B. Preformed Plastic Pavement Markings.

1. This retroreflective preformed plastic strip shall be suitable for application on asphaltic or Portland Cement concrete pavement. The strip shall be applied at the locations called for on the plans or as directed.

2. If recommended by the manufacturer, an epoxy resin primer shall be applied to all pavement surfaces prior to the application of the preformed plastic pavement marking.

3. The surface of the pavement shall be clean, free of loose foreign material, dry and have no moisture for a minimum of forty eight (48) hours prior to application of the markings.

4. The surface areas of new Portland Cement concrete pavement and decks that are to receive marking shall be sandblasted prior to placement of primer and marking material. The amount of sandblasting shall be sufficient to remove all dirt, laitance, and curing compound residue.

5. The air temperature shall be at least sixty (60º) degrees F, or per manufacturers recommendations.

6. Material shall be cut and laid out prior to removal of paper backing. During application only two to three (2' - 3') feet of backing shall be removed at one time prior to application of pressure from a weighted roller of about two hundred fifty (250#) lbs. There shall be no more than three (3) splices per sixty (60 yds.) yards of length.

7. When the marking strip is applied to newly over-laid hot mix asphalt, it shall be applied immediately after breakdown rolling. The rolling shall then continue to ensure complete inlay of the marking strip and to obtain the required density of the pavement.

8. The marking strip as applied shall be in good appearance, free of cracks, and the edges shall be true and straight.

C. Preformed Thermoplastic Pavement Markings.

1. This retroreflective preformed plastic strip shall consist of a resilient white or yellow thermoplastic product with glass beads uniformly distributed throughout the entire cross sectional area. Legends and symbols shall be capable of being affixed to bituminous pavements by heating.

2. The preformed thermoplastic pavement markings shall conform to pavement contours, breaks, and faults through the action of traffic at normal pavement temperatures. The material shall have resealing characteristics with the capability of fusing with itself and previously applied thermoplastic markings under normal use.

3. Application temperature shall be as recommended by the manufacturer. The pavement and air temperature shall be as recommended by the manufacturer at the time of application. The materials shall be applied using a heating method specifically recommended by the manufacturer for the installation of preformed thermoplastic markings. The Contractor shall provide the Town a copy of the manufacturer's installation recommendations prior to beginning the work.

4. At the time of installation of thermoplastic materials, the pavement shall be clean, dry, and free of oil, dirt, grease, paint or other foreign contaminants. Pavement and ambient temperatures shall be at least fifty (50º) degrees F.

5. The preformed thermoplastic pavement markings may be installed on top of existing thermoplastic markings after all loose material has been removed. The preformed thermoplastic markings shall not be installed on top of existing preformed plastic pavement markings without first removing the existing markings to a depth that insures removal of the adhesive backing of the preformed plastic. It shall not be installed on top of pavement marking paint without first removing the paint.

6. The preformed thermoplastic pavement marking strip as applied shall be in good appearance, free of cracks, and the edges shall be true and straight

D. Extruded Thermoplastic Pavement Markings.

The extruded thermoplastic pavement marking method is not the preferred method of pavement marking and is permitted only when expressly approved by the Town Engineer. See CDOT Standard Specifications, Section 627.06 for specifications on application, when this method is approved.

E. Pavement Primers.

A primer application rate of zero (0) will not be accepted, except for thermoplastic marking placed on new asphalt surfaces as recommended by the manufacturer and approved in writing by the Engineer. However, if the Engineer determines that a new asphalt surface has become soiled, prior to placement of the pavement markings, pavement primer will be required and shall be applied as approved. All concrete surfaces shall be primed per the manufacturer's recommendations.

F. Raised Pavement Markers.

Raised pavement markers (temporary) shall be installed on centerlines, edge lines, and lane lines where specified in the plans. Single markers shall be installed at five (5') feet intervals for solid lines. A group of four (4) markers at three (3') feet spacing and at forty (40') feet intervals shall be installed for skip lines.

**END OF SECTION**

## SECTION 03310

## CURBS, GUTTERS, SIDEWALKS, VALLEY GUTTERS, BIKEWAYS, DRIVEWAYS, AND ALLEY APPROACHES

### PART 1 – GENERAL

### 1.1 DESCRIPTION

The Work covered by this section concerns the furnishing of all labor, equipment, supplies, and materials necessary including transporting, placing, finishing, curing, and performing all operations in connection with the construction of curbs, gutters, sidewalks, valley gutters, bikeways, driveways and alley approaches on a firm and stable foundation base, within the public right-of-way.

The Work shall consist of constructing these non-structural concrete appurtenances within the Urban Growth Area of the Town of Windsor in accordance with these specifications and in conformance with the lines, grades, typical cross sections, and thicknesses as shown on the applicable plans and drawings.

### 1.2 QUALITY ASSURANCE

Quality Assurance shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.C, and as modified herein:

A. Mix Designs. The Contractor/Owner shall furnish to the Town Engineer concrete mix designs meeting the requirements of these Standards a minimum of five (5) working days prior to intended use of the mix. The mix design shall be reviewed and accepted by the Town Engineer prior to use. If a mix design not accepted by the Town is used, the Town may require removal of all improvements placed with the unaccepted material.

B. Test Reports. Test reports submitted to the Town shall include all tests performed on the project. Reports shall bear the seal and signature of a Professional Engineer registered in the State of Colorado and competent in the required testing practice. All test reports shall show the location where the test was performed or at which the work or batch represented by the test was located.

   Test reports shall include all information specified in the AASHTO, ASTM, CDOT, or Colorado Test Procedure used. Improperly completed reports will not be accepted. Acceptance will not be complete until all final reports indicating compliance with these specifications are reviewed and placed on file by the Town.

C. Warranty Period. The warranty period for the completed non-structural concrete appurtenances cannot start until all required test reports, record drawings, inspection reports, and other documentation are submitted in the proper format and accepted by the Town.

   The Contractor/Owner shall guarantee curb, gutter, walks, driveways, and crosspans for the warranty period after completion against defective workmanship and materials and shall keep the same in good order and repair.

   The determination of the necessity, during such guarantee period, for the Contractor to repair said curb, gutters, walks, driveways, or crosspans, or any portion thereof, shall rest entirely with the Town Engineer, whose decision upon the matter shall be final and obligatory upon the Contractor.

D. Quality Control Testing and Reporting Procedures. All testing methods and procedures performed by the Geotechnical Engineer personnel shall be done in accordance with the applicable AASHTO, ASTM, ACI, or Colorado Procedure requirements and procedures, as specified. Test reports shall include the AASHTO, ASTM, ACI, and Colorado Procedures (CP) test designations of all tests taken. All testing and retesting services shall be done at the expense of the Contractor/Owner.

When changes in materials or proportions are encountered during construction, or when the work fails to pass tests or fails to meet these Standards, additional tests shall be taken as directed by the Town Engineer. Failure of the Contractor/Owner to furnish satisfactory test data shall be sufficient cause for rejection of the work in question.

E. Testing Program.

1. Specification. All testing shall be done in accordance with AASHTO, ASTM, ACI or Colorado Procedures (CP), as designated throughout this section and in accordance with **Table 03310-1**, below. Concrete that does not meet strength in twenty eight (28) days is subject to removal.

**Table 03310-1**
**MATERIAL TESTING**

| Portland Cement Concrete | AASHTO | ASTM | Frequency |
|---|---|---|---|
| Sampling | T141 | C172 | |
| Mold & Cure | T23 | C31 | |
| Transportation of cylinders | T23 | C31 | |
| Slump | T119 | C143 | First 3 loads each day |
| Temperature | | C1064 | First 3 loads each day |
| **Air Content:** | | | |
| Pressure | T152 | C231 | 1/50 cy |
| Volume | T196 | C173 | |
| Gravimetric | T121 | C138 | |
| **Concrete Cores:** | | C174 | |
| Obtaining Cores | T24 | C42 | |
| Compressive Strength | T22 | C39 | 4 cylinders per 100 cy |
| Air Content | | C457 | |
| Cement Content | T178 | C85 | |

2. Concrete Testing.

a. Sampling and testing shall be required on all concrete work including curb and gutter, sidewalk, crosspans, pavement, ramps, driveway and alley approaches, slope paving, retaining walls, inlets, manholes, or any other non-structural concrete appurtenances.

b. Maximum time allowed between sampling and casting cylinders shall not exceed ten (10) minutes. If the concrete cannot be taken to the laboratory and cylinders cast within fifteen (15) minutes, the cylinders shall be cast in the field. Cylinders shall be transported to the laboratory within twenty four (24) hours of casting but after the concrete has hardened, (see AASHTO T23). All cylinders shall be six (6") inches in diameter or four (4") inches in diameter by eight (8") inches tall.

c. The slump and air content tests shall be performed in accordance with **Table 03310-1**, above. Slump and air content test measurements shall be taken with each cylinder series. Concrete design criteria and slump and air content shall be done in accordance with CDOT Table 601-1. Concrete for non-structural concrete appurtenances shall conform to the following requirements:

i. Concrete Strength. The furnished concrete shall have a minimum twenty eight (28) day compressive strength of four thousand (4,000 psi) pounds per square inch.

ii. Water/Cement Ratio. The concrete furnished shall have maximum water/cement ratio of forty five hundredths (0.45).

d. Concrete cylinders shall be load-tested and broken at the times listed in **Table 03310-2**, below:

**Table 03310-2**
**CONCRETE CYLINDER BREAKS**

| **Number of Cylinders** (Series of four) | **Break Interval (Days)** |
|---|---|
| 1 | 7 |
| 2 | 28 |
| 1 | 56 |

NOTE: Additional cylinders may be required, as directed by the Town Engineer.
56-day cylinder used if 28-day cylinder strength less than required design strength.

e. Compressive Strength Cylinders. At least four (4) compressive strength cylinders shall be taken from the same concrete delivery truck to provide design compliance testing at the laboratory. Two (2) of the four (4) specimens will be tested at twenty eight (28) days for acceptance and one (1) shall be tested at seven (7) days for information. The fourth ($4^{th}$) cylinder shall only be necessary if the twenty eight (28) day fails. This is required for each pour per day with at least one (1) strength test series for each fifty (50 cy) cubic yards of concrete placed. Additional cylinders may be required to determine the rate of strength gain on high-early concrete mixes.

f. Other Tests. Slump, water/cement ratio, air content, unit weight, and mix temperature shall be tested for each pour per day with at least one (1) test for each fifty (50 cy) cubic yards of concrete placed.

g. Low Strength Test Results. If compressive strength of cylinders and beams does not meet the specified values, the Design and/or Testing Engineer shall recommend and the Town Engineer shall approve the necessary mitigation measures needed.

i. The Town Engineer and Testing laboratory shall determine the areas of concrete with potentially low strength and clearly denote the areas to the Contractor/Owner.
ii. The Contractor/Owner shall have an independent testing laboratory, acceptable to the Town Engineer, obtain and cure core samples per ASTM C42 or AASHTO T24. A minimum of three (3) samples shall be taken for each one hundred (100 cy) cubic yards or fraction thereof of concrete in question.
iii. Concrete in the area represented by the core tests shall be considered to have adequate strength if the average of the three (3) cores is equal to at least ninety one (91%) percent of the design compressive strength and no single core is less than eighty five (85%) percent. To check testing accuracy, locations represented by erratic core strengths may be retested.
iv. If the concrete is determined not to have adequate strength, the Town Engineer may require the low strength areas to be replaced.

h. Coring. Coring is not generally permitted unless approved by the Town Engineer and, if approved, the section cored shall be repaired to the Engineer's satisfaction.

F. Concrete Mix Design. Concrete mix design shall be performed in accordance with the provisions of CDOT Specifications 601.05. A separate mix design shall be provided if pumped concrete is to be used. Mix designs shall be submitted no less than five (5) working days prior to placement of any concrete.

## 1.3 JOB CONDITIONS

Job Conditions shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.I.

## 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

Product Delivery, Storage and Handling shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.D, and as modified herein:

A. Batching. Measuring and batching of materials shall be done at a batching plant in accordance with AASHTO M157 and shall be in accordance with the provisions of CDOT Specifications 601.06.

B. Mixing. Mixing of all concrete products shall be performed be in accordance with the provisions of CDOT Specifications 601.07.

C. Air Content Adjustment. When a batch of concrete delivered to the project site does not conform to the minimum specified air content, an air entraining admixture conforming to CDOT Specification 711.02, may be added, one (1) time only for the batch, at the Contractor's option prior to consideration for rejection. After the admixture is added the concrete shall be re-mixed for a minimum of twenty (20) revolutions of the mixer drum at mixing speed. The concrete shall then be re-tested and if found acceptable may be placed in accordance with the specifications. A maximum of three (3) batches per day may be adjusted by adding air entraining admixture at the delivery site.

# PART 2 – MATERIALS

## 2.1 CONCRETE

Concrete shall be composed of cement, coarse and fine aggregate, water, and entrained air. The concrete shall contain a minimum of six (6) sacks of cement per cubic yard or an equivalent cement/fly ash combination not to exceed twenty (20%) percent cement replacement (when approved), a maximum of five (5 gal) gallons of water per sack of cement, an air content between five (5%) percent and eight (8%) percent by volume, and a maximum coarse aggregate size of one and a half (1½") inches.

Any admixture (except air entraining agent) must be approved by the Town Engineer. Other high-early strength concretes may be used only where special conditions warrant, subject to written approval by the Town Engineer.

## 2.2 PORTLAND CEMENT

Portland cement shall comply with the CDOT requirements. The type of cement shall be Type II, unless sulfate conditions necessitate otherwise. ACI 201 indicates recommendations for sulfate resistance.

## 2.3 FINE AGGREGATES

Fine aggregates for Portland Cement non-structural concrete appurtenances shall meet CDOT Specifications 703.01, CDOT Table 703-1 and **Table 03310-3**, below:

**Table 03310-3**
**FINE AGGREGATES FOR PORTLAND CEMENT CONCRETE**

| Sieve Size or Test Procedure | Percent Passing or Test Requirement |
|---|---|
| Friable Particles, % | 1.0%, Maximum |
| Coal and Lignite, % | 1.0%, Maximum |
| Deleterious Material (AASHTO T-11), % | 3.0%, Maximum |
| Sand Equivalent (AASHTO T176), % | 80%, Minimum |
| Fineness Modulus | 2.50 – 3.50 |
| Sodium Sulfate Soundness, % | 20.0%, Maximum |

## 2.4 COARSE AGGREGATES

Coarse aggregates for Portland Cement non-structural concrete appurtenances shall meet the requirements of CDOT Specifications 703.02 and **Table 03310-4**, below:

**Table 03310-4**
**COARSE AGGREGATES FOR PORTLAND CEMENT CONCRETE**

| Sieve Size or Test Procedure | Percent Passing or Test Requirement |
|---|---|
| 2" | 100% |
| 1-1/2" | 95% - 100% |
| 3/4" | 35% - 70% |
| 3/8" | 10% - 30% |
| #4 | 0% - 5% |
| #200 | 1.0%, Max. (1.5% if crusher fines) |
| % Wear | 45.0%, Maximum |
| Clay Lumps and Friable Particles, % | 2.0%, Maximum |
| Coal and Lignite, % | 0.5%, Maximum |
| Sodium Sulfate Soundness, % | 12.0%, Maximum |

## 2.5 FLY ASH

Fly ash for Portland Cement concrete pavements shall comply with CDOT Specifications 701.02.

## 2.6 WATER

Water for Portland Cement concrete pavements shall meet the requirements of CDOT Specifications 712.01.

## 2.7 AIR ENTRAINING AND CHEMICAL ADMIXTURES

A. Air entraining and chemical admixtures for Portland Cement concrete pavements shall meet the requirements of CDOT Specifications 711.02 and 711.03. No additive manufactured with the purposeful addition of chloride shall be permitted. Water-reducing admixtures are used when concrete temperatures are as follows: Type A is used between fifty (50°) degrees and ninety (90°) degrees F; Type D is used when over ninety (90°) degrees F.

B. Additives for concrete, other than those specified in the mix design, shall not be used without prior written approval of the Engineer. When approved for use, chemical admixtures or additives shall comply with applicable ASTM or AASHTO standards. Application of admixtures shall be as per manufacturer's specifications.

C. Coloring for colored concrete shall be accomplished by the addition of an approved commercially pure or synthetic mineral pigment as specified in the contract documents. Windsor Red concrete shall be similar to Davis Red 160, but use three (3#) pounds per ninety-four (94#) pound sack cement.

## 2.8 CURING MATERIALS

Curing materials for Portland Cement non-structural concrete appurtenances shall meet the requirements of CDOT Specifications 711.01.

## 2.9 MIX DESIGN

A. All concrete shall be ready mixed concrete. Concrete mix designs consist of selecting the aggregates appropriate for the concrete application, and performing a mix design to determine the properties of the proposed mix. The proposed mix shall be tested in accordance with ACI code requirements. The Contractor must submit one (1) mix design per each concrete type intended for use within the public rights-of-way at the start of each calendar year. **No concrete shall be placed prior to the submittal of such mix designs.**

B. Concrete for bikeways shall be fiber reinforced. The fibers shall be between three quarter to one (¾" - 1") inch in length and shall be used at a rate of one and a half (1½) lbs. of fibers per cubic yard of concrete.

## 2.10 EXPANSION JOINT MATERIAL

Expansion joint material shall be non-extruding preformed joint filler and shall conform to ASTM Specification D1751 or D1752 or AASHTO M-59.

## 2.11 JOINT SEALER

Joint sealer material shall be Sikaflex or approved equal, TT-S-00230C, Type II, Class A, ASTM Specification C-920 Type S, Grade NS, Class 25.

## 2.12 DETECTABLE WARNING SURFACE

All handicap access sidewalk ramps shall contain a detectable warning surface, two (2') foot deep by full width of walking surface (five (5') foot minimum), constructed of cast iron which shall contrast visually with adjoining surfaces, either light-on-dark or dark-on-light, with raised, truncated domes meeting federal access requirements, and per the Town of Windsor Standard Detail Drawings.

## 2.13 SIDEWALK CHASE

Where provisions for drainage require concentrated surface runoff to be directed across sidewalks, provision shall be made to direct the runoff through the sidewalk via a sidewalk chase. The sidewalk chase shall consist of five eighths (5/8") thick, raised pattern, non-skid, galvanized steel plate (AASHTO M-111). Steel plates shall be a maximum of two and a half (2½') feet wide, with a length equal to the width of the sidewalk, set flush with the walk and anchored (with three eighths (3/8") inch brass screws at eighteen (18") inches on center) to a three inch by two inch by three eighths (3" x 2" x 3/8") inch galvanized angle iron countersunk into the sidewalk as shown on the Town of Windsor Standard Detail Drawings.

# PART 3 – EXECUTION

## 3.1 WEATHER LIMITATIONS

A. Hot Weather Limitations. Placing of concrete during hot weather shall be limited by the temperature of the concrete at the time of placing. Mixed concrete which has a temperature of ninety (90°) degrees F or higher, shall not be placed. The Contractor shall provide fogging equipment and keep the concrete surface moist at all times by fogging with an approved atomizing nozzle until the curing material is in place.

The aggregate stockpiles shall be kept moist at all times

B. Cold Weather Limitations.

1. The Contractor is responsible for the strength and quality of the concrete placed during cold weather. Before starting non-structural concrete appurtenance construction operations, the Contractor shall be prepared to protect the concrete from freezing. Maturity meters, to monitor and record time and pavement temperature, may be required to be installed at the time of placement when the air

temperature is expected to fall below forty (40°) degrees F during the next three (3) days or as requested by the Engineer when the air temperature is expected to fall below forty five (45°) degrees F during the next three (3) days. The Contractor shall maintain the temperature of the non-structural concrete appurtenances at or above forty (40°) degrees F until they have attained a compressive strength of at least two thousand (2,000 psi) pounds per square inch. The compressive strength of the concrete shall be determined by the use of maturity meters. Maturity meters shall meet the requirements of CDOT Specifications 412.15.

2. Concrete shall not be placed on frozen ground. Before concrete placement, all ice, snow, and frost shall be completely removed from within formwork. Salt shall not be used to thaw ice, snow, or frost.

3. The mixed concrete temperature shall be between fifty (50°) degrees and ninety (90°) degrees F at the time of placement. Water, aggregates, or both shall be heated when necessary, under such control and in sufficient quantities to avoid fluctuations in the temperature of the concrete of more than ten (10°) degrees F from batch to batch.

4. Heating equipment or methods which alter or prevent the entrainment of the required amount of air in the concrete shall not be used. The equipment shall be capable of heating the materials uniformly. Aggregates and water used for mixing shall not be heated to a temperature exceeding one hundred fifty (150°) degrees F. Materials containing frost or lumps of frozen material shall not be used.

5. Electrically heated curing blankets or insulation blankets may be used in cold weather to maintain specified curing temperature and to retain moisture in concrete. Blankets shall be lapped at least eight (8") inches and shall be free of holes. Blankets shall be secured at laps and edges to prevent moisture from escaping.

## 3.2 PLANNING AND PREPARATION

A. Non-structural concrete appurtenance construction requires careful planning and preparation. The surface course or base course must be properly prepared. Enough vehicles and equipment, in good operation, and adequate, trained personnel must be available to provide a steady flow of materials and progress without delays. Batch plant production must be closely coordinated with the operation.

B. Before spreading (placing) operations, the engineer and inspectors should confer with the contractor's superintendents and foremen and carefully plan the entire operation. Some important details that should be discussed include:

1. Continuity and sequence of operations,
2. Number and description of equipment needed for the project,
3. Number of mixer trucks required,
4. The chain of command for giving and receiving instructions,
5. Reasons for possible rejection of the mix,
6. Weather and temperature requirements, and
7. Traffic control.

## 3.3 EQUIPMENT

Equipment and tools shall be capable of handling materials, performing the Work, producing a product of specified quality, and shall be approved. The equipment shall be at the job site sufficiently ahead of the start of paving operations to be examined and approved.

A. Hauling Equipment. Concrete may be hauled and placed with nonagitator equipment. Bodies of nonagitating equipment shall be smooth, mortar tight containers, and shall be capable of discharging the concrete at a controlled rate without segregation.

B. Consolidating and Finishing Equipment. Concrete may be spread, struck-off and finished by hand, either from fixed forms or by slip form method, unless otherwise permitted. Consolidation shall be accomplished by vibrators for the full width of the work. The vibrators shall be the internal type meeting the requirements of CDOT Specifications 412.07(b).

C. Concrete Saw. When sawed joints are required, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimension and at a rate that will control cracking. The Contractor shall provide at least one (1) standby concrete saw in good working order at all times. An ample supply of saw blades shall be maintained at the site of the Work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of the equipment shall be on the job during concrete placement. Wastewater generated from concrete saw operations shall be contained and disposed of in an approved manner.

## 3.4 BATCHING

Batching of concrete shall conform to CDOT Standard Specifications, Section 601.06.

## 3.5 MIXING

A. Mixing of concrete shall conform to CDOT Standard Specifications, Section 601.07.

B. The Contractor shall submit to the Town the ready mix delivery ticket for each load upon request by the Town indicating the following:

1. Supplier's name and date.
2. Truck number.
3. Project number and location.
4. Concrete class designation.
5. Cubic yards batched.
6. Mix design identification.
7. Type, brand, and amount of cement.
8. Brand and amount of all admixtures.
9. Weights of fine and coarse aggregates.
10. Moisture content of fine and coarse aggregates.
11. Gallons of batch water.
12. Time at which water was added.
13. Elapsed time between when water was added and concrete load was in place.
14. Amounts of initial water and the maximum number of gallons of supplemental water allowed to be added for each truck at the job site.
15. Name of individual authorizing supplemental water.
16. Numerical sequence of delivery by indicating cumulative yardage delivered on each ticket.
17. Provide the following titles with blank space to record discharge time, water-cement ratio, air content, slump, and revolutions.

## 3.6 PREPARATION OF SUBGRADE

A. Subgrade preparation. Subgrade preparation shall be completed in accordance with **Section 02225**, Subsection 3.1 of these specifications entitled "Preparation of Subgrade".

B. Bedding. No pea gravel, sand, or other material with less than ten (10%) percent passing the #100 sieve will be allowed as bedding beneath any concrete within the Town right-of-way.

C. Foundation. If in the opinion of the Town, the foundation soil is of such character that it will swell or shrink with changes in its moisture content to such an extent that the concrete may be damaged; the soil shall be excavated as directed by the Town, refilled, and compacted with material which meets the requirements of these specifications.

D. Conformity. The subgrade and/or sub-base shall be brought to a firm and unyielding condition with a uniform density. All soft and yielding material and other portions of the subgrade that will not compact readily when rolled or tamped shall be removed and replaced with suitable material. Concrete shall not be placed on a soft, spongy, frozen, or otherwise unsuitable subgrade. Before placing any concrete, the subgrade shall be tested for conformity with the cross-section shown on the plans, using an approved template, or other approved method. The finished subgrade shall be kept smooth, damp, and compacted prior to placing concrete.

E. Construction Sequence. All curb, gutter, valley gutters, and sidewalk (where attached) shall be constructed after installation of sanitary sewer and storm sewer mains, laterals, and service lines have been installed and properly compacted in accordance with these specifications. Water mains and service lines which cross curb, gutter, attached walks, and driveways shall also be installed and properly compacted prior to installation of said curb, gutter, attached walks, and driveway approaches. Tunneling under curb, gutter, and walks will not be allowed. Water valve boxes and manholes should be adjusted to final grade after installation of curb and gutter and pavement. Electrical services should be installed after water services, but prior to installation of curb radii except where previous arrangements for use of conduit have been made and approved by the electric company

F. Subgrade. Prior to constructing the infrastructure, the area in the right-of-way should be brought to plus or minus six (±6") inches of finished subgrade.

## 3.7 FORMS

A. Design.

1. Forms shall be mortar tight and sufficiently rigid to prevent distortion due to the pressure of the concrete and other loads incidental to the concrete operations, including vibration.

2. The rate of depositing concrete in forms shall be controlled to prevent deflections of the form panels in excess of the deflections permitted by these specifications.

3. Forms for drainage inlets may be constructed of any suitable material that will produce a structure with the inside dimensions and at least the wall thicknesses shown on the plans. Undulation of finished interior wall surfaces shall not exceed one half (0.5") inch.

B. Material.

1. Forms shall be made of wood, metal or other material as approved by the Town Engineer.

2. Approved flexible forms shall be used for construction where the radius is two hundred (200') feet or less. Unexposed surfaces shall have wood forms of No. two (2) common (or better) lumber.

3. Metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms shall be free from rust, grease or other foreign matter

C. Construction.

1. Forms shall be constructed and maintained so as to prevent the opening of joints due to shrinkage of the lumber. The use of ties consisting of twisted wire loops to hold forms in position will not be permitted.

2. The inside surfaces of forms shall be cleaned of all dirt, mortar, and foreign material. Forms which will later be removed shall be thoroughly coated with form oil prior to use. The form oil shall be a

commercial quality form oil or other equivalent coating which will permit the ready release of the forms and will not discolor the concrete.

3. Forms which do not present a smooth surface or do not line up properly shall not be used.

4. Forms shall have a depth equal to or greater than the specified edge thickness of the concrete, without horizontal joint.

5. Top surface of the forms shall be set flush with the proposed concrete surface. The top face of the form shall not vary from a true plane by more than one eighth (1/8") inch in ten (10') feet, and the vertical leg shall not vary more than one quarter (1/4") inch from vertical.

6. Forms shall be provided with adequate devices for secure setting so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be staked securely to line and grade to the satisfaction of the Engineer.

7. Concrete shall not be deposited in the forms until all work connected with constructing the forms has been completed; all materials required to be embedded in the concrete have been placed, unless otherwise specified on the plans or approved; and the Engineer has inspected said forms and material. Such work shall include the removal of all dirt, chips, sawdust, water and other foreign material from the forms.

8. In lieu of construction by form method, the concrete may be placed with an approved, self propelled slip form curb forming machine capable of spreading, consolidating, screeding, and finishing the freshly placed concrete with one pass of the paver. The curb forming machine shall be capable of providing a dense and homogenous infrastructure with an even texture and no porous areas, and to the slope and elevation specified.

D. Removal of Forms.

1. The forms for any portion of the non-structural concrete appurtenance shall not be removed until the concrete is strong enough to withstand damage when the forms are removed.

2. Removal of forms shall not occur before twelve (12) hours after concrete pour. When the ambient temperature is below forty (40°) degrees F, the time shall be twice that duration.

3. If high-early-strength (Type III) cement or accelerating admixtures are used, the above periods may be reduced as approved.

## 3.8 CONSTRUCTION OF CURBS, GUTTERS, SIDEWALKS, VALLEY GUTTERS, BIKEWAYS, DRIVEWAYS AND ALLEY APPROACHES

A. Construction requirements for concrete curbs, sidewalks, and bikeways shall conform to **Section 02585, Portland Cement Concrete Pavement**, except as modified by these specifications.

B. All detached sidewalks less than eight (8') feet in width and not within driveways shall be a minimum of four (4") inch thick concrete. All detached sidewalks eight (8') feet and greater in width shall be a minimum of six (6") inches thick. All sidewalks within a driveway shall be a minimum of six (6") inches thick. All attached sidewalks shall be a minimum of six (6") inches thick. Sidewalks shall be a minimum of eight (8") inches thick where crossed by commercial traffic.

C. Concrete curbs shall either be vertical curb and gutter with attached or detached sidewalk, or drive-over curb, gutter and sidewalk.

D. Where a section of concrete sidewalk, curb and gutter, valley gutter, bikeways, driveway, or alley approach has been disturbed, it shall be removed to a joint, if the joint is situated within five (5') feet of the proposed or existing cut, otherwise a full depth straight line shall be saw cut prior to replacement.

E. Where new construction abuts existing, the work shall be accomplished so that the variance in grade between the old and new work does not exceed one quarter (¼") inch.

## 3.9 PLACING CONCRETE

A. Construction Stakes.

1. The Contractor/Owner shall provide all construction stakes required for curbs, gutters, sidewalks, and structures and will furnish all necessary information relating to lines and grades.

2. The Contractor shall be held responsible for the reasonable preservation of all such stakes.

3. The Contractor shall not remove stakes until three (3) working days after placement of the concrete unless approved by the Town.

4. Temporary grade pins, or screed points, used to establish flowline, shall be removed from the concrete prior to curing.

B. Placing Concrete.

1. Concrete pavement may be placed using slip form methods or fixed forms.

2. The alignment and grade elevations of the forms shall be checked by the Contractor immediately ahead of concrete placement and necessary corrections will be made. Any forms that have been disturbed or subgrade that has become unsuitable shall be corrected, forms reset, and rechecked. Any variations in grade and alignment shall be subject to approval by the Town prior to placing the concrete.

3. Forms shall be oiled prior to placement of concrete.

4. The subgrade shall be moist but not wet prior to placing concrete. After the Town has approved the forms and subgrade, the concrete shall be deposited on the subgrade to the required depth and width in successive batches and in a continuous operation. The concrete shall be placed as uniformly as possible to minimize the amount of spreading necessary. Reasonable care shall be taken to prevent any segregation of the concrete materials and the displacement of any reinforcement.

5. Concrete shall not be dropped more than five (5') feet, unless confined by closed chutes or pipes. Concrete shall be placed in lifts not to exceed eighteen (18") inches.

6. While being placed, the concrete should be consolidated or vibrated with suitable tools to prevent the formation of voids or honeycomb. Any evidence of lack of consolidation shall be regarded as sufficient reason for requiring the removal of the section involved and its replacement with new concrete. The Contractor shall be responsible for any defects in the quality and appearance of the completed work.

7. All curves with radii less than two-hundred (200') feet shall be constructed with flexible forms.

8. Curb ramps shall not have a lip between the flowline of the gutter and the ramp approach.

9. The flowline of all new valley gutters shall be a straight-line grade between the gutters at each end of the new valley gutter. The Contractor is required to set finishing screed points (or temporary grade pins) at minimum intervals of ten (10') feet along the flowline to control the finished elevation. The

screed points shall be removed or driven through the plastic concrete into the subgrade after the concrete has been finished to the required elevation. The use of timber screed points is **expressly prohibited**.

10. No low spots, which cause water to pond, will be acceptable.

11. Sidewalks, curb and gutter, valley gutters, bikeways, driveways, and alley approaches shall be formed and placed true to line, grade, and cross section. The finished surface must be straight and true to within one-quarter (1/4") inch along any ten (10') foot length of the new concrete in the vertical or horizontal plane. Forms for sidewalks (attached or detached) shall be so set that the sidewalk shall have a slope toward the street of one to fifty (1:50) or two (2%) percent. Bikeways shall have a side slope of one to fifty (1:50) or two (2%) percent.

12. The maximum extended running slope of sidewalks (attached or detached) and bikeways shall not exceed one to twenty (1:20) or five (5%) percent unless approved otherwise by the Town Engineer in writing.

C. Vibrating. (Optional)

1. Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies by means of suitable mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate consolidation.

2. Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and imbedded fixtures and into corners and angles of the forms. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form.

3. Vibrators shall not be used as a means to cause concrete to flow or run into position in lieu of placing. The vibration at any point shall be of sufficient duration to accomplish consolidation, with care taken to bring only a continuous film of mortar to the surface, but shall not be prolonged to the point where segregation occurs.

4. Any evidence of lack of consolidation or over-consolidation shall be regarded as sufficient reason for requiring the removal of the section involved and its replacement with new concrete at the Contractor's expense.

5. Following placement, the concrete shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the appurtenance will be at the elevation shown on the plans or established.

## 3.10 FINISHING CONCRETE

A. Finishing.

1. After the concrete has been placed and consolidated in the forms, it shall be finished. A wood float shall be used to bring the surface of the concrete to its final form; excessive working of the surface will not be permitted. The Contractor is cautioned against the use of a steel trowel for floating the finished concrete. This practice can excessively seal and trap moisture beneath the surface. Premature surface spalling may occur. Repair of such spalling will be the Contractor/Owner’s responsibility.

2. The final texture of all exposed surfaces shall be obtained by light brooming. For sidewalks, bikeways, and driveway, broom the surface in the direction perpendicular to the main traffic flow. For all concrete surfaces that are designed to carry storm water; such as, curbs and gutters, valley gutters, and crosspans, broom the surface in the direction of flow.

3. After completion of brooming and before the concrete has taken its initial set, all edges in contact with the forms shall be tooled with an edger having a one-quarter (¼") inch radius. No dusting or topping of the surface or sprinkling with water to facilitate finishing will be permitted.

4. Wastewater generated from concrete finishing operations shall be contained and disposed of in an approved manner.

B. Markings. Impressions delineating the location of sewer and water services (S for sanitary sewer and W for potable water) shall be located on the curb face at all service crossings. Letters shall be not less than three (3") inches tall and three eighths (3/8") inches deep. Impressions shall be made with a prefabricated device (approved by the Engineer) in the concrete at the end of each pour.

C. Remove Forms. Face forms for concrete curb may be removed for finishing curb face and fillets as soon as the concrete will retain its shape. Do not remove the back forms for concrete curbs until the concrete has been in place for at least six (6) hours.

## 3.11 JOINTS

A. Transverse Joints. (See Standard Details).

1. Transverse joints (construction joints) shall be located at intervals of a maximum of ten (10') feet in curbs, gutters, sidewalks, and crosspans. When combination curb, gutter, and sidewalk are used, the joint shall be continuous through all three (3) elements.

2. Joint depth shall be a minimum of one quarter (¼) the thickness of the concrete. Joint width shall be a maximum of one-quarter (¼") inch wide except at expansion joints. For tooled joints, the edges adjacent to joint shall be rounded with an edger of one-quarter (¼") inch radius.

3. Joints for Bikeways shall be removable plastic dummy joint strips or saw-cut at ten (10') feet intervals; tooled joints shall not be allowed on any bikeway except at expansion joints. See Standard Details.

4. Saw cutting of joints shall be performed as soon as the concrete surface is hard enough to allow the sawing operation without otherwise marring the concrete surface, prior to any development of shrinkage cracks. Saw-cutting shall proceed around the clock if necessary to meet these requirements.

5. After the proper curing period, the sawed joint shall be thoroughly cleaned.

B. Expansion Joints. Expansion joints shall be required as shown on Standard Details and where new concrete abuts existing structures, fire hydrants, poles, inlets, sidewalk underdrains, midblock ramps, radius points at intersections, and other fixed objects.

1. Expansion joints, where required, shall be filled with one-half (½") inch thick, full depth, preformed expansion joint material as per CDOT Standard Specifications, Subsection 705.01.

2. Expansion joint material must be set vertical and with the top edge three quarter (¾") inch below the finished surface. The joint shall be edged with a one-quarter (¼") inch radius edging tool.

3. All expansion joints shall be caulked as per Details with approved joint sealing material.

## 3.12 CURING

Immediately after the finishing operations have been completed, the entire surface, and exposed sides of the newly placed concrete, shall be sprayed uniformly with an impervious membrane curing compound. The

impervious membrane curing compound shall meet the requirements of AASHTO M148, Type 2 and shall be volatile organic content (VOC) compliant. The new concrete shall not be left exposed for more than thirty (30) minutes before being covered with curing compound. Failure to cover the surface of the concrete within the thirty (30) minutes shall be cause for immediate suspension of the concreting operations. The freshly placed concrete shall be protected from premature drying and excessive cold or hot temperatures as well as rain, flowing water, and mechanical injury. In hot, dry, and windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporative-control material.

A. Curing compound shall be applied under pressure by mechanical sprayers at the rate of not less than one (1) gallon per one hundred fifty (150 $ft^2$) square feet of concrete surface. Curing compound may be applied in two (2) passes, one forward and one backward. The spraying equipment shall be fully atomized, equipped with a tank agitator, and a wind guard. During application, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle and the compound shall be stirred continuously by effective mechanical means. Hand spraying of irregular widths or shapes and surfaces exposed by removal of forms may be permitted. Curing compounds shall not be applied to the inside faces of joints to be sealed.

B. Should the curing film become damaged from any cause, within seventy two (72) hours after application, the damaged portions shall be repaired immediately with additional compound.

C. The sides of concrete exposed when the forms are removed shall be immediately sprayed with curing compound.

D. Curing compound shall not be used on construction joints.

E. The minimum curing period shall be one hundred twenty (120) hours. The coating shall be protected against marring. Any coating marred, or otherwise disturbed, shall be given an additional coating.

F. It shall be the Contractor's responsibility to protect the concrete being cured from the elements, traffic, and vandalism.

G. The Contractor is responsible for the strength and quality of the concrete placed during cold weather. When the ambient temperature is below thirty five (35°) degrees F, the Contractor shall maintain the concrete temperature above fifty (50°) degrees F during the curing period. It is the Contractor's responsibility to determine for himself the necessity for undertaking protective measures.

## 3.13 DRIVEWAY INSTALLATIONS

See Standard Details. All driveways constructed of concrete within public right-of-way shall conform to the requirements of these specifications. When constructed of concrete, the thickness shall not be less than six (6") inches. Driveways abutting a curb, gutter, and sidewalk combination or drive-over curb and gutter or driveway gutter pan or any cross gutter shall have a strip of non-extruding expansion joint material one-half (½") inch thick, conforming to the cross-sections of the driveway, placed between the driveway and the sidewalk or curb or cross gutter so as to provide for the expansion of the concrete driveway. See Standard Details.

## 3.14 ALLOWABLE CURB CUTS

See Standard Details. Curb cuts will be allowed only with authorization from the Town. The Town may permit valley gutter or any other types of curb cuts which best serve the property owner.

## 3.15 PROTECTION/DEFACED/DAMAGED OR DEFECTIVE CONCRETE

A. Limitations. The Contractor shall be responsible for taking adequate steps to protect concrete placed during precipitous, hot, or cold weather. Limitations on the placing and protecting of concrete shall conform to these specifications and **Section 02585, Portland Cement Concrete Pavement**. Any

concrete damaged by precipitation or extreme temperatures or otherwise defective shall be removed and replaced at the Contractor/Owner's expense.

B. Potential Frost Damage. The following procedures shall be followed if the temperature of the surface of the concrete falls below thirty two (32º) degrees F before the concrete reaches the required compressive field strength of four thousand (4000 psi) pounds per square inch.

1. The Contractor will take cores at locations designated by the Town.

2. The Town will take immediate possession of the cores and submit the cores to a petrographer for examination in accordance with ASTM C 856.

3. All costs associated with coring, transmittal of cores, petrographic examination, and reports shall be born by the Contractor regardless of the outcome of the petrographic examination.

4. Concrete damaged by the frost as determined by the petrographic examination shall be removed and replaced at the Contractor's expense.

## 3.16 BACKFILLING

Once the concrete has gained sufficient strength to not be damaged, the space adjoining the concrete shall be backfilled with suitable material, properly compacted, and brought flush with the surface of the concrete and adjoining ground surface.

In embankments, the backfill shall be level with the top of the concrete and the maximum slope shall be four to one (4:1). Where detached walks occur, the space between the curb and walk shall be backfilled on a straight line from the top of walk to the top of curb not to exceed four to one (4:1) slope.

## 3.17 FIELD QUALITY CONTROL

Field Quality Control shall be as specified in **Section 01010, Summary of Work**, Subsection 1.3.J; except subsection 1.3.J. shall be modified to include the following:

A. Mix Design.

The Contractor shall submit a Concrete Mix Design Report consisting of design mix proportions, laboratory trial mix and aggregate data for each class of concrete being placed on the project. Concrete shall not be placed on the project before the Concrete Mix Design Report has been reviewed and approved by the Town Engineer. The design mix proportions shall show the weights and sources of all ingredients including cement, fly ash, aggregates, water, additives and the water cement ratio (w/c). When determining the w/c, cement (c) shall be the sum of the weight of the cement, the weight of the fly ash and the weight of silica fume.

The laboratory trial mix data shall include results of all the information requested in CDOT Standard Specifications 601.05.

Mix Design requirements may be waived by the Town Engineer (in writing), when in his opinion, this prerequisite is not a necessity for the particular project.

B. Field Acceptance Tests.

These provisions apply to all concrete placed in the field:

1. Air Content. At any time during the placement of the concrete, when a batch deviates from the minimum or maximum percent of total air content by more than one (1%) percent, the entire batch shall be rejected.

2. Slump. At any time during the placement of the concrete pavement, when a batch deviates from the maximum slump specified by more than one and one half (1½") inch, the entire batch shall be rejected. Portions of loads incorporated into structures prior to determining test results which indicate rejection as the correct course of action shall be subject to acceptance or removal as determined by the Engineer.

3. Strength. The concrete will be considered acceptable when the running average of three (3) consecutive strength tests is equal to or greater than the specified strength and no single test falls below the specified strength by more than five hundred (500 psi) pounds per square inch.

   a. A test is defined as the average strength of three (3) test cylinders cast in plastic molds from a single sample of concrete and cured under standard laboratory conditions prior to testing. If the compressive strength of any one (1) test cylinder differs from the average by more than ten (10%) percent, that compressive strength will be deleted and the average strength will be determined using the compressive strength of the remaining two (2) cylinders.

   b. When the compressive strength test is below the specified strength by more than five hundred (500 psi) pounds per square inch but not more than one thousand (1,000 psi) pounds per square inch, the concrete represented will be evaluated by the Town Engineer for removal, corrective action, or acceptance. When the compressive strength is below the specified strength by more than one thousand (1,000 psi) pounds per square inch, the concrete represented shall be rejected.

   c. The Contractor/Owner may take cores at its own expense and in accordance with Colorado Procedure 65 to provide an alternative determination of strength.

C. Testing Frequency.

Testing shall be performed by an independent testing company acceptable to the Town and results shall be provide to the Town Engineer within two (2) working days of completion of testing and prior to the next phase of construction. Testing shall be performed according to the schedule given in **Table 03310-5, Minimum Testing Frequency**, given below:

**Table 03310-5**
**Minimum Testing Frequency**

| ITEM | TYPE OF TEST | MINIMUM FREQUENCY |
|---|---|---|
| **All Excavation Backfill** | | |
| Backfill | Moisture/Density (Compaction Test) | 1 per 150 lineal feet, per vertical foot of fill, min, 2 tests per lift. |
| **Inlets/Structures** | | |
| Soil Testing | Moisture/Density (Compaction) | 1 test per vert. foot, min. 2 per lift |
| Concrete Testing | Air and Slump | 1st 3 loads, every 5th load thereafter |
| | Cylinders | 1 set of 4 per 100 cy, or fraction of. |
| **Sidewalk, Curb & Gutter** | | |
| Soil Testing | Moisture/Density (Compaction) | 1 per 150 lf, per 2 vert. feet of fill Min. 2 tests per lift |
| Concrete Testing | Proof-roll | All subgrade |
| | Air and Slump | 1 per day min. – machine placed<br>2 per day min. – hand placed<br>Plus 1 per 500 sy. |
| | Cylinders | 1 set of 4 per 100 cy, or fraction of. |

D. Surface Tolerance.

The Engineer may determine that the exposed surfaces of the concrete curb, gutters, sidewalks, valley gutters, bikeways, driveways and alley approaches shall be tested with a ten (10') foot straightedge laid along the exposed surface in a longitudinal direction. The Contractor shall furnish an approved ten (10') foot straightedge and provide an operator to aid in testing the exposed surfaces. All surfaces shall be measured in a longitudinal direction. Deviation of any exposed surface in excess of that specified shall be corrected at the Contractor's expense. Variations of concrete surface shall not exceed one eighth (1/8") inch in ten (10') feet.

E. Waiver for Small Loads.

If, in the opinion of the Engineer, the Work consists of a minor project, less than five (5 cy) cubic yards of concrete for the entire project, the testing procedures described above may be waived.

## 3.18 OPENING TO TRAFFIC

Walks and bikeways shall not be opened to pedestrian or bicycle traffic for at least twenty-four (24) hours after placement; driveways, curb, gutter, and valley gutters shall not be opened to vehicular traffic for at least seven (7) days after placement or until field-cured test cylinder breaks show an average compressive strength of eighty (80%) percent of the twenty eighth ($28^{th}$) day mix design strength, psi. Exception will be made where high-early quick strength cement is used. In cases where high-early strength cements are used, the Contractor shall request a variance from the Engineer for opening to traffic sooner. The Contractor shall maintain suitable barricades to comply with the foregoing requirements.

**END OF SECTION**

**END OF DIVISION**

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