SECTION 7 – STRUCTURES IN THE RIGHT OF WAY AND IN EASEMENTS

7.1 GENERAL

This section presents the structural design criteria for culverts, retaining walls, and bridges to be constructed in the ROW and easements.

7.2 ABBREVIATIONS

The following abbreviations are used in this section. Refer to the Glossary for a complete list of terms used in the Manual.

AASHTO: American Association of State Highway and Transportation Officials

AREMA: American Railway Engineering and Maintenance-of-Way Association

ACI: American Concrete Institute

ASTM: American Society for Testing and Materials

FHWA: Federal Highway Administration

MSE: Mechanically Stabilized Earth (Retaining Walls)

NCMA: National Concrete Masonry Association

7.3 CULVERTS

This section addresses the design criteria for off-site, cross drainage structures. Refer to the City of Round Rock Design and Construction Standards: Drainage Criteria Manual for further information regarding culvert hydraulics and storm sewer design.

Culverts may be precast or cast-in-place construction, and shall be constructed in accordance with the City of Round Rock Standard Specifications. Usual practice is to provide for either (alternate) precast or cast-in-place details in the contract documents. All culverts shall be designed according to the latest edition of AASHTO *LRFD Bridge Design Specifications* and HL 93 Loading. When approved by the Transportation Director, culverts may be designed and constructed in accordance with TxDOT Specifications and Standard Details.

Culvert layouts for cross drainage structures in the public ROW or easements shall be approved by the Transportation Director / Transportation Engineer. The culvert length shall be sufficient to accommodate the ultimate roadway configuration, sidewalk, shared-use path, necessary grading, utilities and railings or barriers.

Protect the ends of bridge-class pipe and box culverts by providing, in order of preference, safety end treatments, metal beam guard fence, or bridge railing.

7.4 RETAINING WALLS

7.4.1 Definitions

7.4.1.1 Conditional / Incomplete Design

In a “conditional design”, the designer defers essential elements of the design to another entity i.e. wall fabricator or Contractor’s Engineer. An example of conditional design is one in which, by a note on the drawings, the designer makes the Contractor responsible for determining whether the subsurface materials will support the applied wall footing loads. An “incomplete” design does not address all of the requirements in this section. An example of incomplete design is one in which the designer checks only global wall stability, and the internal stability of the particular wall system becomes the responsibility of the wall system manufacturer.

7.4.1.2 Excavation / Backfill Zone

The excavation / backfill zone of a utility is the wedge-shaped area above the utility formed by two inclined planar surfaces, one on each side of the utility, sloping upward at a forty five degree (45°) angle (1:1 slope) from the outermost edge of the utility to the ground surface. No retaining structure is required to retain the inclined surfaces as long as a 1:1 slope is maintained.

7.4.1.3 Fascia Wall

A fascia wall is constructed over the face of a stable slope or wall to enhance its appearance or to protect the slope from degradation due to weathering. The slope may be stable naturally or may be made stable by soil or rock nailing, tiebacks, drilled shafts, soldier piles or other forms of reinforcement. Fascia walls do not contribute to the overall stability of the slope.

7.4.1.4 Retaining Wall

A retaining wall is a structure used to support a soil or rock embankment or slope in a vertical or near-vertical configuration in which it would otherwise be unstable because of gravitational forces or applied loads.

7.4.1.5 Standard Retaining Wall

A standard retaining wall is a free-standing, cantilever or counterfort wall consisting of cast-in-place, reinforced concrete design according to the latest edition of the AASHTO LRFD Bridge Design Specifications.

7.4.1.6 Non-Standard Retaining Wall

A non-standard retaining wall is any wall not meeting the definition of a standard wall.

7.4.1.7 Wall Systems

Wall systems are described as retaining walls whose performance relies on multiple components acting together as an integral unit. Examples are MSE retaining walls or walls with underdrains, filter media and porous backfill.

7.4.1.8 Mechanically Stabilized Earth (MSE) Retaining Wall

An MSE retaining wall is a proprietary wall system composed of facing units (panels) and metal strips or geosynthetic (geogrid) reinforcement connecting to the facing units and extending behind the wall into special backfill. The internal and external stability of these walls depends on the interaction of the facing units, strips or geogrid, and backfill, acting as a system.

7.4.1.9 Soil or Rock Nail

Nailing is the reinforcement of slopes by installing anchors in horizontal or near-horizontal, pre-drilled holes in the soil or rock, usually followed by shotcreting of the slope face and installation of a cast-in-place concrete closure pour and a fascia wall.

7.4.1.10 Product-Specific Information

Product-specific information describes the behavior, performance characteristics or qualities of a material or interacting materials or components and is based on results of standardized tests.

7.4.1.11 Utility Assignments

Utility Assignments refers to the pre-assigned horizontal and vertical position of the utilities in the street ROW or easement.

7.4.1.12 Wall Height

Wall height is the vertical distance from the bottom of the footing, leveling pad or lowest structural component, to the top of the wall.

7.4.2 Use of Standard / Non-Standard Walls

Any standard retaining walls or wall systems in the street ROW or easements shall meet the requirements in this Section. Non-standard walls may be considered on a case-by-case basis and shall be approved by the Transportation Director.

7.4.3 General Requirements

Retaining walls, regardless of type, over 3’ in height, must be designed by a Professional Engineer licensed in the State of Texas. Retaining walls must be constructed in accordance with TxDOT Standard Specifications. Alternatively, when approved by the Transportation Director, TxDOT Standard Specifications and Standard Drawings shall be used. Walls for which there are no published, nationally recognized, design criteria or for which there are no standard materials or test specifications will not be permitted.

Conditional or incomplete designs will only be accepted if, in the opinion of the Transportation Director, the wall system relies on proprietary manufacturer information, and the Contract Documents clearly state how the Contractor is to furnish a complete wall design for review and approval prior to constructing the wall system.

Retaining walls must be designed for global (external) stability and internal stability. The design must include, as appropriate, the effects of utilities, floodwater inundation and rapid drawdown, detention/retention, hydrostatic pressures, internal erosion, settlement, alteration of site conditions over time, behavior of foundation and backfill materials. The walls must be designed to support, where applicable, surcharge loads from traffic.

Walls consisting of pre-cast segmental units, whether these units are facing or structural elements, must have a coping or capstone at the top of the wall. The coping may be pre-cast or cast-in-place. The coping or capstone must extend above the adjacent ground at least 4 inches. Precast or cast-in-place coping shall contain reinforcing steel. Coping shall be affixed to the upper layer of the wall using epoxy, non-shrink grout or as recommended by the wall manufacturer.

Walls constructed using flexible facing elements, such as welded or woven wire, will be permitted only in drainage channel applications and not supporting roadway embankments. Metal prefabricated modular walls will not be permitted.

Where retaining walls are used as the exterior walls in stormwater detention structures, the walls must be cast-in-place reinforced concrete made watertight by using water stops in joints and using underdrains behind the walls. Where retaining walls are used as the exterior walls in stormwater detentions structures and the walls are not watertight, then the walls must be designed to provide free drainage of the backfill following drawdown.

7.4.4 Geotechnical Information

The design engineer shall furnish to the City for review a geotechnical report including the results of the field investigation, soil borings, design parameters, recommended wall type, and construction recommendations. The report shall include backfill requirements and parameters, factor of safety calculations,

underdrain recommendations, and predicted long-term performance of the system. The design engineer shall refer to TxDOT standards for boring locations.

7.4.5 Wall Location and Layout

The Transportation Director shall approve all wall locations, types, and heights for walls to be constructed in public ROW or easements.

The City will assume maintenance responsibility only for those walls in the public ROW or easement that support roadway embankment, cut slopes that require a wall for stability, or channel slopes in drainage easements.

Retaining walls that are located in the public ROW and which support private property must first be approved by the Transportation Director. A license agreement shall be required for these cases.

Wall systems such as MSE, or block walls with geogrid reinforcement shall have a minimum thirty six inches (36”) of cover to the upper layer of the reinforcement.

Utility lines shall not pass through a retaining wall at any point and must leave room to perform any future maintenance on the retaining wall and the utility line, or the utility shall have encasement where it is unavoidable.

Utility lines that are located beneath a wall shall be installed in an encasement pipe meeting the specifications of the utility owner. The encasement pipe must extend far enough beyond the wall such that future excavation, if needed will not affect the wall stability.

Utilities, utility appurtenances, pavement, sidewalks, and related roadway improvements have priority over retaining walls in street ROW and easements. As a consequence, retaining wall layout must take into account utility assignments in addition to allowing for future utility installation and future excavation for utility maintenance and repair, including mains and service laterals. No component of the retaining wall that is essential to the stability of the wall or wall system (footings, underdrains, reinforcement, etc) can be within the excavation / backfill zone of any utility main or service regardless of the type of utility. The wall or wall system must be stable under any scenario involving utility excavation in the excavation / backfill zone. External components of the retaining wall, such as geogrid, anchors, strips, tie bars or buried pre-cast units, which are essential to stability of the wall, cannot extend beyond the back of curb, under the street, or into utility easements unless the external components are at least ten feet (10’) below the street surface and at least three feet (3’) below the deepest utility.

The distance between the street-side face of the wall and the back of curb must be such that sidewalk and ramps can be accommodated, but in no case can this distance be less than ten feet (10’), with provisions for pedestrian and vehicular railing, as needed.

7.4.6 Structural Design Criteria

The design engineer shall submit design calculations for all walls taller than three feet (3') to the City for review and approval.

Retaining wall backfill must be free-draining, non-expansive material. Weep holes and underdrains must be provided as necessary to prevent hydrostatic pressures caused by local groundwater seepage, surface water infiltration, floodwater inundation or by water and wastewater line breaks. Geotextile fabric or graded granular filters must be provided as necessary to prevent migration of fine-grained soil particles from the surrounding soils into the backfill and drainage media. The fabric or granular filter must be designed not only to prevent migration of fine-grained soil particles but also not to become clogged. Underdrains shall not discharge where drainage can flow onto an adjacent sidewalk or into the street. Weep holes in MSE walls are not permitted.

Surface runoff that flows toward the retaining wall must be collected in a vegetated or paved interceptor ditch behind the wall and transmitted away from the wall.

Retaining walls shall be designed in accordance with current and interim AASHTO *LRFD Bridge Design Specifications*. The following additional design criteria shall apply:

7.4.6.1 Design Life

The design life for all retaining walls shall be a 100-year service life, that from a structural standpoint, is essentially maintenance-free.

7.4.6.2 Cast-In-Place Concrete Walls

All concrete and reinforcing steel shall be in accordance with current and interim AASHTO LRFD *Bridge Design Specifications.*

Concrete, reinforcing and joints, including waterstops, must be provided according to the latest edition of the CRSI *Manual of Standard Practice*

Walls shall be designed assuming a unit weight of soil = 120 pcf, and coefficient of active horizontal earth pressure = 0.33 unless specific values are provided by a geotechnical engineer.

The minimum sliding factor of safety shall be 1.5.

The minimum overturning factor of safety shall be 2.0.

The base pressure resultant shall fall within the middle third of the retaining wall.

7.4.6.3 Conventional Segmental Gravity Walls (with or without mechanically stabilized backfill)

Internal stability of segmental gravity retaining units must be analyzed according to NCMA *Design Manual for Segmental Retaining Walls*, latest edition.

Walls may be constructed without earth reinforcements if all stability criteria are met with the blocks alone. If all stability criteria are not satisfied, earth reinforcements shall be provided.

The minimum sliding factor of safety along the base of the structure shall be 1.5.

The minimum overturning factor of safety shall be 2.0.

Walls shall be designed based on the following design parameters unless specific parameters have been provided by a geotechnical engineer:

Random Backfill or Select Backfill: Unit weight = 120 pcf

Embankment or Existing Soils: $\phi = 30°$ c=0 psf

Select Backfill: $\phi = 34°$ c=0 psf

The base pressure resultant shall fall within the middle third of the retaining wall.

Wall batter shall be a maximum of three inches per foot (3”/1’). Blocks shall be placed horizontally, and a positive means of obtaining batter such as pins, keyways, or concrete lips shall be provided.

7.4.6.4 Mechanically Stabilized Earth Wall (MSE Wall)

The minimum sliding factor of safety along the base of the structure shall be 1.5.

The minimum overturning factor of safety shall be 2.0.

The base pressure resultant shall fall within the middle third of the retaining wall.

The minimum factor of safety against pullout of the earth reinforcements shall be 1.5 at each level. Pullout resistance shall be determined from test data evaluated at three quarter inch (3/4”) strain.

Corrosion Criteria: The earth reinforcement elements shall be designed to have a minimum design life of one hundred (100) years. Stress calculations (rupture) shall be done on the calculated earth reinforcement

section remaining after one hundred (100) years. Pullout calculations may be based on non-corroded section.

The design of the MSE wall shall be based on the following design parameters unless specific parameters have been provided by a geotechnical engineer:

Random Backfill, Foundation Soil:
unit weight = 125 pcf
ϕ = 30° c = 0 psf

Select Backfill
unit weight = 105 pcf for pullout, sliding, overturning, eccentricity
unit weight = 125 pcf for rupture, bearing
ϕ = 34° c = 0 psf

Cement Stabilized Select Backfill:
unit weight = 125 pcf
ϕ = 45° c = 0 psf

Stress in steel and concrete shall be in accordance with current and interim AASHTO *LRFD Bridge Design Specifications.*

The minimum length of earth reinforcements shall be eight feet (8') or 70% of the wall design height, whichever is greater.

Panel size, configuration, and surface finish shall be as approved by the Transportation Director. Provide a coping at the top of all walls.

Provide two-foot (2') minimum cover from the top of the leveling pad to finish grade at the bottom of the wall.

7.4.6.5 Soil or Rock Nail Walls

Soil nail walls must be designed according to FHWA Report No. FHWA-NHI-14-007 Geotechnical Engineering Circular No. 7 "Soil Nail Walls – Reference Manual", latest edition. Rock Nail Walls must be designed according to University of Texas Center for Transportation Research Report 1407-1F, "Rock Nail Design Guidelines for Roadway Cuts in Central Texas, latest edition.

To control groundwater seepage, composite geosynthetic face drains must be installed on the exposed rock face before shotcreting. The face drains must extend the full height of the wall and must connect to a base drain that discharges from behind the wall in a manner that water is not directed onto the adjacent sidewalk or street.

7.4.7 Material Requirements and Technical Specifications

Materials used in retaining walls shall meet the requirements of the City of Round Rock Standard Specifications Manual, where applicable. Alternatively, TxDOT Standard Specifications may be used, with prior approval of the Transportation Director.

Unless otherwise approved by the City, use the MSE Wall Systems or Concrete Retaining Wall Systems on the current TxDOT's pre-approved list.

Railing type and aesthetic considerations shall be approved by the Transportation Director.

7.4.8 Maintenance Provisions

A twenty foot (20') wide, truck-accessible maintenance access zone must be provided at the base of walls higher than ten feet (10') that support roadway embankment. The maintenance access zone must be free of obstacles to vehicles, relatively smooth and level, all-weather accessible, and able to support loads from maintenance vehicles. The maintenance access zone may be ROW or an easement, or both.

7.4.9 Safety Provisions

Railing or fence must be provided to shield pedestrians or bicyclists from drop-off hazards. Refer to Section 4 for safety considerations related to drop-off hazards.

Fencing materials shall conform to the requirements of City of Round Rock Standard Specification RR701 – Fencing, and shall be reviewed and approved by the Transportation Director.

A roadside barrier such as concrete barrier or metal beam guard fence shall be provided for retaining walls located within the clear zone of an adjacent roadway. Refer to Section 1 for additional information concerning clear zones and appropriate design criteria.

7.4.10 Warning Devices

All retaining walls having structural components such as geogrid, strips, tie bars, or pre-cast units extending behind the wall must have plaques placed in the coping or capstone along the top of the wall at 100-foot intervals. The plaques must be made of durable metal, at least eight inches by five inches (8" x 5"), with half inch (1/2") lettering that reads "Do not excavate between the retaining wall and street / No excave entre el muro de contención y la calle". The plaque shall be permanently mounted to the top of the wall.

Walls not supporting roadway embankment, but having structural components such as geogrid, strips, tie bars, or pre-cast units extending behind the wall must have warning plaques as described above but which say "Do not excavate behind the wall within ___ feet / No excave detrás del muro de contención dentro de una distancia de ___ meters".

Warning tape must be placed six inches above the uppermost layer of reinforcement. The tape shall be placed in a criss-cross pattern on twenty four inch (24") spacing.

7.4.11 Supplemental Construction

Provide two, four-inch (4") PVC conduits behind retaining walls that support roadway embankment. Install pull-boxes at each end of the retaining wall and at intermediate points not to exceed two hundred feet (200') between pull-boxes. Provide additional conduits or sleeves as required by the City.

7.5 BRIDGES

7.5.1 Preliminary Design Considerations

Bridge width for proposed bridges shall carry the full roadway width including shoulders across the bridge. Bridge width shall also be sized to accommodate the full width of sidewalk or shared-use path across the bridge.

Bridge length and span configuration shall consider existing topography, width of roadway, railroad, or floodplain being crossed, roadway alignment, highway design criteria, and economics.

Vertical alignment shall be determined based on the roadway geometric criteria and shall consider deck drainage.

Bridge skew, if necessary should be limited to thirty degrees (30°) or fifteen degrees (15°), if possible.

Horizontal and vertical clearance envelopes shall be in accordance with the design criteria for the roadway or railroad being crossed.

Cross slope for bridges is one percent (1%) minimum and two percent (2%) desirable. The cross slope of the bridge shall match the cross slope of the approach roadway. If required by roadway design, cross slope transitions may be located on the bridge with approval from the Transportation Engineer. It is desirable to begin and end transitions at bent locations to ease deck construction.

Bridge low chord elevation shall be determined based on the design high water elevation. Maintain two feet (2') of freeboard.

If a bridge is being replaced, it must be determined if the existing bridge will be closed during construction. If the bridge is to remain open during construction, it must be determined if the bridge will be constructed in phases or if the roadway alignment will be shifted to accommodate full-width bridge construction.

Alternate bridge types may be considered that utilize precast, modular elements, upon approval of the City of Round Rock.

7.5.2 Structural Requirements

Vehicular bridges must be designed according to the current and interim AASHTO *LRFD Bridge Design Specifications*. TxDOT CAD Standards may be used to develop bridge designs and are available for download on the TxDOT website.

Railroad bridges must be designed according to the current AREMA *Manual for Railway Engineering*.

Bridge layouts for bridges in public ROW shall be approved by the City prior to proceeding with detail design. See Section 9 for checklists of the minimum information to be provided on Bridge Layouts or on bridge detail sheets.

Bridge decks may be constructed with precast, prestressed deck panels per TxDOT standards.

A geotechnical engineer should be consulted to provide soil test boring logs, foundation recommendations and design parameters.

Projects that include a highway-rail grade separation must have an executed railroad agreement prior to letting the project for bids.

All bridges shall be assigned a National Bridge Inventory (NBI) Number. This includes both on-system and off-system structures.

All bridge rails shall be crash tested and approved by the City. Design speeds of 50 mph and greater require a rail rated at least TL-3. Design speeds of 45 mph and less require a rail rated at least TL-2. Refer to the TxDOT Bridge Railing Manual for crash tested rails and ratings.

7.5.3 Material Requirements

Materials must meet the requirements for bridge construction in the latest TxDOT Standard Specifications For Construction And Maintenance Of Highways, Streets, And Bridges or the City of Round Rock Standard Specifications (DACS) as appropriate.

All precast, prestressed concrete girders shall be TxDOT Class H with a minimum 28-day compressive strength of f'c = 5,000 psi and a maximum desirable of f'c = 8,500 psi, as dictated by the design requirements. The concrete strength required at release should not be greater than 6,000 psi. Design strength for Class H concrete shall be noted clearly on the plans. All girders will be designed with 0.6 in diameter strands.

The use of No. 14 or No. 18 reinforcing bars should generally be avoided. The use of these bars shall be approved by the City of Round Rock during the design phase.

List names and address of manufacturers of proprietary designs, approved for use by TxDOT.