# DIVISION V
# DESIGN CRITERIA

## SECTION 5700 STRUCTURES

Approved and Adopted this 17th day of December, 1986

Kansas City Metropolitan Chapter
of the American Public Works Association

# DIVISION V
# DESIGN Criteria

## SECTION 5700 STRUCTURES

## SECTION 5701 GENERAL

**5701.1 Purpose:** The purpose of this Criteria is to provide standardization in the Metropolitan Kansas City Area for the Public Works structures which are designed and constructed for the many separate municipal and county jurisdictions included therein.

**5701.2 Scope:** This Criteria is intended to cover the bridges, culverts, retaining walls and other miscellaneous structures routinely addressed within the various jurisdictions. Bridges included herein are limited to short and moderate span structures. This Criteria may be used for guidance in the design of long span structures, however, the designer shall be responsible for addressing the numerous items unique to the proper design of long span bridges. Patented and proprietary systems are not included in this Criteria but may be appropriate for site conditions. It is not the intent of this Criteria to exclude such systems from consideration or use.

**5701.3 Definitions:**

A. **City Engineer:** The term City Engineer, as used in this Criteria, shall represent the state, county, city or other governmental body's representative responsible for technical decisions concerning the project. Such person may be the Director of Public Works, City or County Engineer, Administrator or any other person empowered by the governing agency to make such decisions.

B. **Engineer:** The term Engineer, as used in this Criteria, shall represent the Engineer or Designer who performs the actual design work. Nothing in this Criteria is intended to alter or circumvent local, state, or federal laws or regulations regarding liability and/or responsibility for such designs.

C. **Bridge:** A structure, spanning 20-feet or greater between abutment faces, providing a means of transit for pedestrians and/or vehicles above the land and/or water surface of a valley, river, stream, lake, canal, above a road, highway, railway or other obstruction, whether natural or artificial.

In general, the essential parts of a bridge are: (1) the substructure consisting of its abutments and pier or piers supporting the superstructure, (2) the superstructure slab, girder, truss, arch or other span or spans supporting the roadway loads and transferring them to the substructure, and (3) the roadway and its incidental parts functioning to receive and transmit traffic loads.

D. **Culvert:** A small structure, spanning less than 20-feet between abutment faces, normally below the elevation of the roadway surface.

E. **Curb Inlet:** A cast-in-place or precast structure constructed adjacent to or integral with the curb section of a street or highway to provide means for rain or other water accumulated upon the roadway surface to drain through it onto an open space or drainage system below the structure.



F. **Areaway:** Special structurally enclosed area under a street or sidewalk designed to function as part of a building.

G. **Retaining Wall:** A structure designed to restrain and hold back a mass of earth or other fill material.

**5701.4 Abbreviations:**

| | |
|---|---|
| **AASHTO** | **American Association of State Highway and Transportation Officials** |
| **ACI** | **American Concrete Institute** |
| **AISC** | **American Institute of Steel Construction** |
| **ASTM** | **American Society for Testing and Materials** |
| **ANSI** | **American National Standards Institute** |
| **APWA** | **American Public Works Association** |
| **AREA** | **American Railway Engineering Association** |
| **AWS** | **American Welding Society** |
| **AWPA** | **American Wood Preservers Association** |
| **CRSI** | **Concrete Reinforcing Steel Institute** |
| **FHWA** | **U.S. Department of Transportation/Federal Highway Administration** |
| **NDS** | **National Design Specifications for Stress Grade Lumber and Its Fastenings** |
| **NFPA** | **National Forest Products Association** |
| **PCI** | **Prestressed Concrete Institute** |
| **WPA** | **Western Pine Association** |
| **WWPA** | **Western Wood Products Association** |

## SECTION 5702 GOVERNING SPECIFICATIONS

**5702.1 Roadway Bridges and Miscellaneous Structures:** Design shall be in accordance with the latest edition of the following specifications and the current interim supplements thereto except as modified herein or modified for the specific project:

A. **Standard Specifications for Highway Bridges, AASHTO.**

B. **A Policy on Geometric Designs of Highways and Streets, AASHTO.**

**5702.2 Railway Bridges:** Railroad structures shall be designed in accordance with the current Manual for Railway Engineering, AREA.

**5702.3 Light Rail - Mass Transit:** Light rail - Mass Transit systems are not covered by this Criteria.

**5702.4 Inspection, Rating and Posting - Bridges:** Maintenance inspections, structural evaluations and ratings shall be in accordance with the latest edition of:

A. **Manual for Maintenance Inspection of Bridges, AASHTO.**

B. **Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, FHWA.**

C. **Bridge Inspector's Training Manual 70, FHWA.**

D. **Manual on Uniform Traffic Control Devices for Streets and Highways, FHWA.**

**5702.5 Welding:** Welding shall be done in accordance with the Structural Welding Code, ANSI/AWS D1.1, AWS.

## SECTION 5703 GEOMETRICS

**5703.1 Geometric Standards:** The geometry of the structure shall conform to the current AASHTO recommendations, whenever reasonably permitted by site conditions. When practical considerations dictate a variance from these criteria, the highest standards allowed by the site shall be provided.

## 5703.2 Horizontal Clearances:

A. **Roadway Clearance:** Roadway clearance shall conform to minimum roadway widths for bridges as shown in the current edition of A Policy on Geometric Design of Highways and Streets, AASHTO.

B. **Railway Clearance:** Railway clearance shall conform to dimensions and diagrams as promulgated by the respective railway companies and appropriate state and federal agencies.

C. **Channel Clearance:** Consideration shall be given to potential for clogging in determining size of waterway opening and location of piers.

## 5703.3 Vertical Clearances:

A. **Roadway Clearance:** Minimum vertical clearance shall be 14'-0" unless otherwise required by local, state, or federal regulations for certain classes of highways. If possible sixteen (16) feet should be provided plus six (6) inches for future surfacing.

B. **Railway Clearance:** Railway clearance shall conform to dimensions and diagrams as promulgated by the respective railway companies and appropriate state and federal agencies.

C. **Channel Clearance:** Channel clearance shall provide a minimum of two feet freeboard above the calculated 100-year high water elevation.

## 5703.4 Other:

A. **Turning Radii:** Turning radii should conform to geometric design requirements of the roadway.

B. **Utility Accommodation:** Utility companies should be consulted to determine requirements for carrying utility lines across structures. Utility facilities shall not be installed to infringe upon structure clearances.

C. **Aesthetics:** Recognizing that bridges are relatively permanent, highly visible structures, aesthetic values should be considered including proportion, function, location, design details, and workmanship to provide a structure that is visually pleasing and in harmony with its surroundings.

## SECTION 5704 BRIDGE SUPERSTRUCTURES

**5704.1 Lane Widths:** In general, bridge superstructures should be designed such that the clear distance between curbs will accommodate 12-foot lane widths plus three feet of additional width for each outside or median lane. Lesser lane widths may be used, however in no case should they be reduced below the recommended minimum, specified in the latest edition of A Policy on Geometric Design of Highways and Streets, AASHTO

**5704.2 Railings:** Railings shall be provided along the edges of bridge superstructures for protection of traffic and pedestrians. A pedestrian walkway may be separated from an adjacent roadway by a traffic railing or barrier with a pedestrian railing along the edge of the bridge superstructure. The height, design loading and other requirements for the railings and barriers shall be in accordance with AASHTO Standard Specifications for Highway Bridges.

**5704.3 Traffic Barriers:** The height, design loading and other requirements for traffic barriers and combination traffic barrier and pedestrian railings shall be in accordance with AASHTO Standard Specifications for Highway Bridges.

**5704.4 Sidewalks:**

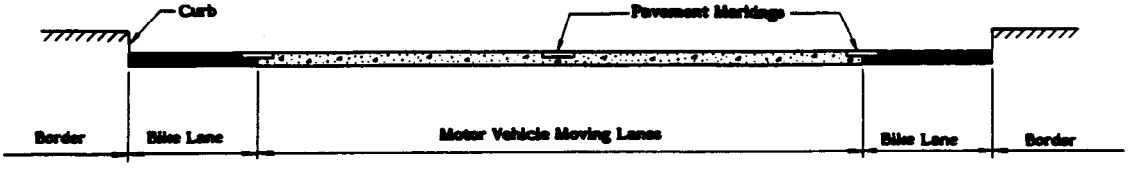
A. **Width:** The width of sidewalks on bridge superstructures shall be 4-feet minimum with a desirable width of 5-feet.

B. **Design Loading:** The design live load for sidewalks and their supporting members shall be in accordance with AASHTO Standard Specifications for Highway Bridges.

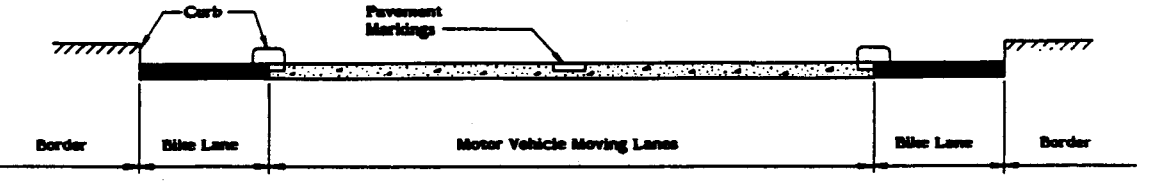
**5704.5 Bikeways:**

A. **General:** Bikeways on bridges shall be bicycle lanes in which a portion of the roadway has been designated for preferential or exclusive use by bicycles. They shall be distinguished from the portion of the roadway for motor vehicular traffic by a paint stripe, curb or other similar device. The bicycle lane shall carry one-way traffic and shall be a minimum of 4.0-feet wide with a desirable width of 4.5-feet. The lane width shall be increased a minimum of 0.5 foot when it is separated from traffic by a raised curb, but an increase of 1.0-foot is desirable. The bicycle lane surface shall be of asphalt or concrete similar to the material used for the adjacent roadway or pedestrian walkway.

One-Way Bicycle Lanes on Bridges




(a) Bicycle lane separated from Motor Vehicles by Pavement Markings.




(b) Bicycle lane separated from Motor Vehicles by Curb.

## 5704.6 Bridge Decks:

**A. General:** Bridge decks should generally be constructed of reinforced concrete. The deck slabs shall be designed with adequate stiffness to limit deflections or deformations that may be detrimental to the structure at service load.

**B. Materials and Components:**

1. **Concrete:** Concrete for bridge decks shall be air entrained. Generally, a concrete mix providing an $f_c'$ value of 4,000 psi should be used for design.

2. **Reinforcing Steel:** All reinforcing steel used in reinforced concrete bridge decks shall be deformed bars and shall comply with ASTM Designation A615, Grade-60 reinforcing steel. The reinforcing bars in the deck, sidewalks and barriers shall be epoxy coated.

5704.6

A minimum clear distance of 1 inch measured from the bottom of the slab to the reinforcing steel shall be provided. A minimum clear distance of 2½-inches measured from the top of the slab or integral wearing surface shall be provided.

The clear distance between parallel bars shall not be less than 1½ times the nominal diameter of the bars, 1½ times the maximum size of coarse aggregate, nor 1½-inches.

3. **Wearing Surface:** A wearing surface shall be provided on bridge decks. A separate course, wet bonded to the structural concrete bridge deck, such as a high density concrete mix or trap rock aggregate mix is recommended. The thickness of the wearing course shall be 1½-inches minimum.

4. **Surface Finish:** Concrete bridge decks shall be finished with an appropriate mechanical, self propelled finishing machine after consolidation of the concrete.

5. **Surface Texture:** Before the concrete obtains initial set, the finished bridge deck shall be textured by means of transverse wire brooming.

6. **Deck Drainage:** Transverse drainage of the bridge deck shall be obtained by means of a suitable crown in the roadway. Longitudinal drainage shall be obtained by means of drain scuppers, floor drains, or an enclosed drainage system where desirable. Drainage shall be directed away from bearing and expansion devices.

7. **Approach Slabs:** Reinforced concrete approach slabs shall be provided for all structures in accordance with the lines, grades, and typical section that shall be included in the contract plans. The ends of the approach slabs adjacent to the structure shall be supported on a seat constructed with the abutment backwall. The minimum thickness of the approach slab shall be 12-inches. The approach slab may be constructed of the same class of concrete used in the bridge deck or in the approach pavement.

8. **Expansion Joints:** Bridge superstructures shall be designed to accommodate thermal expansion and contraction movements.

Watertight expansion devices shall be used at all joint locations except for integral end bents. The requirements for the expansion devices shall be in accordance with the governing agency policy or specifications.

9. **Bearing Devices:** Bearing devices shall be provided to transmit loads to the substructure elements and accommodate thermal movement and/or rotation. The requirements for the bearing devices shall be in accordance with the governing agency policy or specifications.

C. **Stay-In-Place Steel Deck Forms:** Permanent steel forms for cast-in-place concrete decks may be used in lieu of removable forms for decks supported on steel beams or girders. The stay-in-place forms may be used between exterior girders. Conventional forming methods shall be used for the cast-in-place concrete deck overhang of the exterior girders.

If permanent steel deck forms are used, shop drawings of the forms and their installation shall be prepared by the Contractor and submitted to the Engineer for approval prior to use of the forms. Complete typical details, showing minimum acceptable clear distances to form faces and any alterations to the deck slab design with the use of permanent steel deck forms, shall be shown on the shop drawings.

Permanent steel deck forms, support closure elements and accessories shall be fabricated from steel conforming to ASTM Specification A446 (Grades A through F) having a coating class of G165 in accordance with ASTM Specification A525. All other form components and accessories shall be galvanized in accordance with ASTM Specification A123.

D. **Precast Prestressed Concrete Deck Panels:** Permanent precast, prestressed concrete panels may be used in lieu of removable forms for decks supported on steel beams or girders and on prestressed concrete beams. If used, the deck panels shall be designed to act compositely with the cast-in-place portion of the structural concrete slab. The panels may be used between exterior girders. Conventional forming methods shall be used for the cast-in-place concrete deck overhang of the exterior girders.

Design, construction and installation of the panels shall be in accordance with the governing agency policy and specifications. Particular attention shall be given to provide positive support for the panels, using grout or cast-in-place deck concrete.

## 5704.7 Structural Systems:

A. Selection of the superstructure type shall be based on the most suitable and economical system for the particular project and conditions at the site. Preparation of a preliminary design and cost estimate for each type being considered is the preferred process for forming the basis of the final selection.

### B. Steel Rolled Beams:

1. **Span Lengths:** Generally, steel rolled beams may be used for span lengths up to 90-feet. Economy will generally be realized if shear connectors are used on the top flange to provide composite action with the concrete deck slab.

2. **Materials:** Structural steel conforming to ASTM A36 or ASTM A572 shall be painted. Structural steel conforming to ASTM A588 may be unpainted. Welded stud shear connectors shall conform to the requirements of ASTM A108.

3. **Specifications:** Allowable stress levels shall be in accordance with AASHTO Standard Specifications for Highway Bridges. Welding shall be in accordance with AWS Specifications as modified by AASHTO Standard Specifications for Highway Bridges.

4. **Connections:** All connections and splices shall be designed in accordance with appropriate governing specifications and the details shall be shown on the contract plans. Field connections shall be made with ASTM A325 High Strength Bolts. All welded connections shall be designed in accordance with AWS and AASHTO Standard Specifications for Highway Bridges.

5. **Shop Drawings:** Prior to fabrication, the Contractor shall provide to the Engineer for review, complete shop drawings for all members and connections to assure conformance with the intent of the plans and specifications.

### C. Welded Steel Girders:

1. **Span Lengths:** Generally, welded steel girders are economical for span

lengths in excess of 90-feet. However, under certain conditions such as curved and skewed alignments, and variable depth structures, they may be economical for lesser ranges of span length. Economy will generally be realized in multiple girder layouts if shear connectors are used on the top flange to provide composite action with the concrete deck slab.

2. **Floor Systems:** Generally, multiple steel girders with a cast-in-place concrete deck should be used for superstructure span lengths up to approximately 125 feet. For longer spans, a structural floor system comprised of fewer girders with transverse floor beams and stringers should be considered.

3. **Materials:** Structural steel conforming to ASTM A36 or ASTM A572 shall be painted. Structural steel conforming to ASTM A588 may be unpainted. Welded stud shear connectors shall conform to the requirements of ASTM A108.

4. **Specifications:** Allowable stress levels shall be in accordance with AASHTO Standard Specifications for Highway Bridges. Welding shall be in accordance with AWS Specifications as modified by AASHTO Standard Specifications for Highway Bridges.

5. **Connections:** All connections and splices shall be designed in accordance with appropriate governing specifications and the details shall be shown on the contract plans. Field connections should generally be made with ASTM A325 High Strength Bolts. All welded connections shall be designed in accordance with AWS and AASHTO Standard Specifications for Highway Bridges.

6. **Shop Drawings:** Prior to fabrication, the Contractor provide to the Engineer for review, complete shop drawings for all members and connections to assure conformance with the intent of the plans and specifications.

## D. Prestressed Concrete Beams:

1. **General:** Various standard beam sections have been developed by the State Highway Commission or Department of Transportation. The common types are the various sizes of I-beams and the Double Stem Tee Beam. Span lengths up to approximately 50-feet may be attained with the Double Stem Tee Beam. Span lengths up to approximately 110-feet may

be attained with the I-Beams. Economy will be realized if a means of shear transfer is provided between the top flange of the I-Beam and the concrete cast-in-place deck to attain composite action.

2. **Specifications:** Allowable stress levels and design criteria shall be in accordance with AASHTO Standard Specifications for Highway Bridges and the policies of the governing local and state jurisdiction.

3. **Concrete:** The Contractor shall be responsible for the design of the concrete mix in prestressed concrete beams including the proportions of water, cement and aggregates and the ratio of fine to coarse aggregate. The minimum twenty-eight (28) day compressive strength of the concrete shall be 5,000 psi. The Contractor's proposed design mix shall be submitted for approval prior to casting any of the prestressed concrete beams. The use of calcium chloride is specifically prohibited.

4. **Steel Materials:** Steel material used in the fabrication of the beams shall conform to the following requirements:

| Item | Specification |
|---|---|
| Prestressing Strands | *ASTM A416, Grade 270 |
| Reinforcing Steel | ASTM A615, Grade 60 |
| Welded Wire Fabric | ASTM A185 |
| Structural Steel | ASTM A36 |

*Low Relaxation Strands preferred.

5. **Surface Finish:** Surface finish for prestressed concrete members shall begin immediately following removal of the forms. fins and irregular projections shall be removed. Form tie cavities, holes, honeycomb spots, and other defects, shall be thoroughly cleaned, saturated with water, and carefully pointed with mortar matching the color of the member. Repaired surfaces shall be satisfactorily cured.

6. **Connections:** All connections and splices shall be designed in accordance with appropriate governing specifications and the details shall be shown on the contract plans.

7. **Shop Drawings:** Shop drawings showing in detail the type, size, number of units, location of tendons, method and sequence of releasing the strands, anchorage details, and details of proposed lifting loops and lifting procedure shall be submitted to the Engineer for review and

approval. The shop drawings shall also tabulate critical design stresses and parameters including initial tension and total prestress load. No beams shall be cast until the shop drawings have been approved by the Engineer.

**E. Reinforced Concrete Superstructures:** Cast-in-place reinforced concrete superstructures may be suitable and economical for some applications, particularly for short span and special structure types. Allowable stress levels, material types and design criteria shall be in accordance with AASHTO Standard Specifications for Highway Bridges and the policies of the governing agency.

**F. Timber Superstructures:** Timber superstructures may be suitable and economical for some applications, particularly for temporary and special structure types. Allowable stress levels, material and design criteria shall be in accordance with AASHTO Standard Specifications for Highway Bridges and the policies of the governing agency. Additional references include the A.R.E.A. Manual of Recommended Practice and the National Design Specifications for Wood Construction.

## SECTION 5705 BRIDGE SUBSTRUCTURES

**5705.1 Type:** The type and configuration of substructure elements shall be selected to meet project and site requirements. Foundation, aesthetic, economic and maintenance considerations shall be evaluated in the design process.

**5705.2 Location:** Substructure units shall be located to provide clearances as noted in Section 5703 and optimum sight distances allowed by site conditions. Where practical, they shall be situated to avoid conflict with utilities. When practical considerations allow, substructure elements at stream crossings shall be located beyond the low water channel.

**5705.3 Foundation Requirements:** A subsurface investigation shall be made to determine foundation requirements and available foundation options. The foundation type selected shall reflect economic considerations, ease of construction, disruption to adjacent properties and minimization of damage to adjacent facilities.

**A. Spread Footings:** The bearing capacity of the foundation soil may be

estimated using accepted theories. Such theories are based on the measurement of soil parameters such as cohesion and angle of friction or on the results of field tests such as the standard penetration test or the shear vane test.

The bearing capacity may also be determined by load tests in excavated foundation pits. Load tests have a limited depth influence and may not disclose long-term consolidation. For this reason load tests shall not be used without drilling or probing to determine the soil profile below the foundation.

Where testing is not carried out, the bearing capacity and angle of friction of broad basic groups of materials given in Tables A and B may be used. These values are taken from AASHTO Standard Specifications for Highway Bridges. These values should be used conservatively; for example, in determining lateral pressures, the minimum angle of friction shall be taken.

**TABLE A - BEARING CAPACITY**

| Material | Safe Bearing Capacity Tons per Square Foot | |
|---|---|---|
| | Minimum | Maximum |
| Alluvial Soils | 1/2 | 1 |
| Clays | 1 | 4 |
| Sand, confined | 1 | 4 |
| Gravel | 2 | 4 |
| Cemented sand and gravel | 5 | 10 |
| Rock | 5 | - |

**TABLE B - ANGLE OF FRICTION**

| Material | Angle | Material | Angle |
|---|---|---|---|
| Earth, Loam | 30° to 45° | Gravel | 30° to 40° |
| Dry Sand | 25° to 35° | Cinders | 25° to 40° |
| Moist Sand | 30° to 45° | Coke | 30° to 45° |
| Wet Sand | 15° to 30° | Coal | 25° to 35° |
| Compact Earth | 35° to 40° | | |

**B. Pile Foundations:** Piling should be considered when footings cannot economically be founded on rock or other solid foundation material.

Piles may be used as a protection against scour at locations where soil conditions would normally permit the use of spread footings.

Bearing values and other requirements shall be in accordance with AASHTO Standard Specifications for Highway Bridges for the particular type of pile used.

**5705.4 Frost Depth:** The frost depth to be used for foundation design shall be four feet. Practical site considerations will be used to determine the minimum cover, if any, over the footings.

**5705.5 Scour:** Substructure elements shall be designed to minimize detrimental effects of scour in stream beds. Piers and abutments subjected to scour shall be provided with some form of protection specifically designed to withstand the maximum scour anticipated.

**5705.6 Collision Protection:** Substructure elements with the potential for collision damage shall be provided with separate positive crash protection or be designed to resist the forces induced by a collision. Armoring shall be considered for areas subjected to impact.

**5705.7 Berms at Abutments:** A berm shall be provided in embankment end slopes at non-integral abutments. The berm shall be at least three feet wide and provide one foot minimum clearance to the superstructure.

**5705.8 Slope Protection at Abutments:** Embankments shall be provided with slope protection at abutments. The protection shall extend at least one foot beyond the limits of the superstructure and shall be designed so that storm drainage on the protected area does not run across the sides to unprotected areas.

**5705.9 Maximum End Slope:** The maximum embankment end slope at abutments shall be determined by the stability of the embankment material. This slope should generally not be steeper than 2:1.

**5705.10 Abutment Wingwalls:** The length and position of abutment wingwalls shall be designed to accommodate site conditions and earthwork

slopes so that soil and other materials do not extend onto abutment bearing seats.

**5705.11 Superstructure Storm Drainage:** Provisions shall be made to insure that storm drainage from the superstructure and its approaches does not cause erosion of the embankments at abutments.

**5705.12 Abutment Backfill:** Backfill material behind abutments shall be compacted select material. A positive drainage system (weepholes, transverse drains) shall be provided to relieve hydrostatic pressures.

**5705.13 Fixity:** The structural analysis of substructure elements shall reflect a condition of fixity at footings and joints which is consistent with the actual embedment of piling, reinforcement details and connection to the superstructure.

**5705.14 Substructure Concrete:** Concrete for substructure units extending above the ground line shall be air entrained. Concrete for footings below the ground line need not be air entrained. In general, a concrete mix with an $f_c'$ value of 4000 psi should be used for design purposes.

**5705.15 Reinforcing Steel:** Grade-60 reinforcing steel shall be used for substructures.

**5705.16 Structural Steel:** ASTM A36 steel shall be used for structural steel bents and piles. Exposed steel members shall be painted. Field connections, except pile splices, shall be bolted.

## SECTION 5706 LOADINGS

**5706.1 General:** Structures shall be designed to carry the following loads and forces:

Dead load.
Live load.
Impact or dynamic effect of the live load.
Wind loads.

Other possible loads and forces for consideration are:

Longitudinal forces, centrifugal force, thermal forces, earth pressure,

buoyancy, shrinkage stresses, rib shortening, erection stresses, ice and stream current pressure, and earthquake loads.

The influence of future adjacent development upon the loads to the structure shall be considered in the design whenever such loads can be reasonably anticipated.

**5706.2 Dead Load:** The dead load shall consist of the weight of the entire structure, including the roadway, sidewalks, car tracks, pipes, conduits, cables, and other public utility services.

**5706.3 Future Dead Load:**

A. **Roadway Bridges:** A minimum allowance of twenty-five pounds per square foot shall be provided for a future wearing surface.

B. **Railway Bridges:** An allowance of thirty pounds per square foot shall be provided for track raising on ballasted deck structures.

**5706.4 Live Load:** The live load shall be the weight of the applied moving vehicles and pedestrians.

A. **Roadway Bridges and Miscellaneous Structures:** Structures subjected to vehicular loadings shall be designed for the HS20-44 loading as a minimum load condition. A more severe loading condition shall be used when warranted by specific conditions. Consideration shall be given to additional loads resulting from the presence of sidewalks on the structure.

B. **Railroad Structures:** Structures subjected to railway loadings shall be designed for the Cooper E-80 loading unless otherwise specified by the railroad company.

**5706.5 Impact:** Impact allowance or increment shall be expressed as a fraction of the live load stress and shall be determined and applied according to the current governing specifications as listed in Section 5702.

**5706.6 Wind Loads:** Wind loads shall be determined and applied according to the current governing specifications as listed in Section 5702.

**5706.7 Longitudinal Forces:** The applicable longitudinal forces shall be

determined and applied according to the current governing specifications as listed in Section 5702, except the determination of the longitudinal braking force shall be modified as follows:

Provision shall be made for the effect of braking (or acceleration) in all lanes that may be expected to carry traffic traveling in the same direction during the life of the bridge. The specified reduction in load intensity for multiple-loaded lanes may be applied.

The longitudinal load due to braking in one lane shall be equal to 80% of the load of the design truck. The coincident longitudinal load in each other traffic lane shall be 5% of the lane load, including concentrated load for moment. The longitudinal force shall be applied 6-feet above the roadway surface.

**5706.8 Seismic Loads:** Structures shall be designed for Zone 2 seismic loadings. The current governing specifications, as listed in Section 5702, shall be used to determine the magnitude and application of the seismic load.

**5706.9 Other Forces:** The following forces when they exist shall be determined and applied according to the current governing specifications as listed in Section 5702:

**A. Thermal Forces**
**B. Earth Pressure**
**C. Buoyancy**
**D. Shrinkage Stresses**
**E. Rib Shortening**
**F. Ice and Current Pressure**
**G. Erection Stresses**
**H. Uplift**

**5706.10 Sidewalk, Curb and Railing Loading:** Sidewalk, curb and railing loadings where applicable shall be determined and applied according to the current governing specifications as listed in Section 5702.

**5706.11 Unusual Vehicle Loads:** The term "Unusual Vehicle Loads" describes various types of transportation vehicles that can be placed on bridge structures other than the standard design truck outlined in AASHTO.

Bridge structure live loads resulting from "Unusual Vehicle Loads" encompass the following modes of transportation: (1) railroads; (2) aircraft; (3) mining and "off-road" vehicles; (4) light rail transit; (5) other transit systems; (6) military; and (7) construction.

The live loads associated with this category of loads, except railroads, are not specifically covered by this specification. The determination and application of these loads shall be the responsibility of the Engineer.

## SECTION 5707 ROADWAY DRAINAGE

**5707.1 General:** Drainage of stormwater at bridge locations shall be designed in a manner consistent with the criteria used for design of the adjacent street storm drainage system. Reference is made to Section 5600 of the Standard Specifications and Design Criteria, APWA, K.C. Metro Chapter.

**5707.2 Design Considerations for Deck Drainage:** Provisions shall be made to drain the deck surface of bridges by means of scuppers, longitudinal drains, or other suitable means. The design storm shall be the storm suitable for design of the adjacent roadway storm sewer system. Roadway grade shall be designed to provide positive longitudinal drainage.

**5707.3 Discharge:** Discharge points shall be selected to minimize erosion, hazard to traffic beneath the bridge, or damage to the bridge structure. Where possible, runoff shall be conveyed in pipes to the roadway storm sewer system. Refer to Section 5705, Bridge Substructures, on prevention of damage to embankments, and abutment protection.

## SECTION 5708 FLOODWAY HYDRAULICS - URBAN AREAS

**5708.1 General:** Design of bridge waterway openings shall conform to all special requirements imposed by Federal, State and local agencies. Often, conditions exist where more than one method of analysis will be required to provide the information and data needed for review and approval by the various agenices. Design shall consider present and potential land use upstream and downstream. Data gathered, prior to design, shall include available historic information concerning flood flows, Flood Plain Information reports, Flood Insurance Study reports and studies or plans for any possible flood improvement projects in or near the proposed site.

**5708.2 Flood Design Frequency:** In general, all bridge openings should be designed to pass the 100-year flood. Lesser magnitude of floods may be considered under certain circumstances such as:

Flow over the roadway.
Land use.
Relief structures.
Severe restrictions upsteam or downstream that are not likely to be removed during life of the proposed structure.

**5708.3 Backwater Control:** Increase in backwater elevation caused by the proposed structure shall be limited to 1.0-foot above existing backwater elevation unless restricted by other considerations. Lesser increases in backwater may be required due to land use, defined floodways under the National Flood Insurance Program, or undesirable velocities through the proposed opening. Consideration shall be given to downstream structures and land use when a substantial increase in flood carrying capacity is contemplated for a given site.

Backwater analyses shall be performed using current state of the art methods such as the Department of the Army Corps of Engineers, HEC-2 program; Federal Highway Administration Hydraulic Design Series No. 1, Hydraulics of Bridge Waterways method; or other methods that are approved by reviewing agencies.

**5708.4 Erosion Protection:** Existing conditions at the proposed bridge site shall be reviewed for erosion and scour problems. In-depth scour studies may be warranted at certain sites. The bridge opening and substructure shall be protected against damage from scour.

Channel velocities for existing and proposed conditions shall be determined. Adverse changes in velocities through the site may warrant bank and embankment protection. Front slopes of bridge abutments or end bents that intersect or nearly intersect the channel bank or channel bottom shall be protected up to the design high water elevation. Roadway embankment protection, parallel to the roadway shuld extend to the end of the wingwalls.

The roadway embankment shall be protected against erosion at locations where high velocities or turbulence may occur such as side ditches, bridges with severe skew, channel meander, relief structures, and overflow sections where the roadway is frequently overtopped. See Section 5605.2.C for design velocity with respect to conditions of channel lining material.

Removal of natural channel and bank protection shall be avoided if possible.

If the design solution includes a roadway overflow section that is frequently overtopped, road closure gates, warning devices and lighting shall be provided to protect the public.

## SECTION 5709 EVALUATION OF EXISTING STRUCTURES

**5709.1 Scope:** This section governs the procedures and policies for determining the physical condition and maintenance needs of existing structures according to the current governing specifications as listed in Section 5702.4 except as modified herein.

**5709. 2 Posting:**

**A. Weight Limit:** The safe load for posting shall be calculated as greater than 55% but less than 75% of the yield strength of the bridge member controlling the rating. The rating should be calculated as the lesser of the values of either the Standard H-truck or the 352 semi-trailer configuration unless otherwise specified by the City Engineer.

**B. Closure Limit:** No bridge shall be posted for a weight of less than three (3) tons. A bridge shall be closed if not capable of carrying three (3) tons.

**C. Exceptions:**

1. **Speed Limit:** A reduced speed limit may be used to allow bridges to carry heavier loads by decreasing impact or by avoiding high speed collisions on structures with limited roadway clearance. The speed limits established should be limited only to vehicles which are affected by the need to reduce impact.

2. **Special Load Permit:** A special permit should be required by the local governing agency for all vehicles with a gross weight in excess of the posted load limit. Such weights should not exceed the Operating Rating for the structure.

**5709.3 Sufficiency Rating for Metro Area:** A Sufficiency Rating for each structure shall be determined using the formula described in Appendix A, Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges. The percentage number obtained by the use of this formula can be used as a guideline for the decision to replace or repair a structure.

Recommended guidelines are as follows:

| | |
|---|---|
| Sufficiency Rating $<50$ | Replace |
| Sufficiency Rating $\geq 50$ but $\leq 80$ | Repair or Rehabilitaiton |
| Sufficiency Rating $>80$ | Annual Maintenance |

## SECTION 5710 MISCELLANEOUS STRUCTURES

**5710.1 Scope:** This section governs the design of miscellaneous structures which includes retaining walls, areaways, reinforced concrete box culverts, curb inlets, field basins and junction boxes.

**5710.2 Retaining Walls:**

A. **General:** Retaining walls shall be designed to withstand earth pressure, including any live load surcharge where appropriate, and the weight of the wall.

Stone masonry and plain concrete walls shall be gravity type. Reinforced concrete walls may be a cantilever, counterforted, buttressed, or cellular type.

B. **Loads:**

1. **Earth Loads:** Structures which retain fills shall be proportioned to withstand pressure as determined by Rankine's formula. No structure shall be designed for less than an equivalent fluid weight of 30-pounds per cubic foot. A vertical earth load of 120-pounds per cubic foot shall

be used in the absence of soil tests. Consideration shall be given to increased pressure due to sloping fill behind the wall.

2. **Vehicular Surcharge Loads:** Vehicular surcharge loads shall be considered when applied within a horizontal distance from the top of the wall equal to or less than one-half its height. This surcharge pressure added with the live load surcharge pressure shall be equal to or greater than the pressure generated by 2-feet of earth for streets or 10-feet of earth for railroads.

   When loads are applied at a horizontal distance in excess of one-half of the wall height, the application of surcharge pressures shall be at the discretion of the Engineer.

   Pressures shall be modified as required when the surcharge load is above the top of the wall.

3. **Concentrated or Partial Loads:** Concentrated or partial loads which are located within a distance less than the full height of the wall shall be converted to equivalent soil height loads and appropriate horizontal pressures shall be calculated and applied in addition to the normal earth load pressures.

## C. Design Considerations:

1. **Sliding and Overturning Factor of Safety:** The desired safety factor for both sliding and overturning is 2.0 and the minimum safety factor for both is 1.5.

2. **Coefficient of Friction:** In the absence of soil tests, a friction coefficient of 0.40 may be used in coarse granular soil.

3. **Force of Friction:** The total frictional force on the base of a footing is $F = fN$ where f is the friction coefficient and N is the normal force of the footing against the soil.

4. **Force of Cohesion:** When the foundation rests on clay, the cohesion should be used to determine the force resisting sliding. This cohesion

force may be calculated using one-half of the unconfined compressive strength of the soil as the unit cohesion.

5. **Stability:** When resistance to sliding cannot be adequately provided by friction resistance of the footing, a soil shear key, piling or other positive restraint shall be considered. When pile footings are used, the outer row should be battered to resist horizontal forces.

**D. Joints:** Contraction joints shall be provided at intervals not exceeding 32-feet and expansion joints at intervals not exceeding 96-feet for gravity or reinforced concrete walls.

**E. Drainage and Backfill:** All retaining walls shall be designed to withstand earth pressure. Walls are generally not designed to resist water pressure in addition to the earth pressure. To relieve the hydostatic pressure, drains commonly consisting of pipes known as weepholes with a diameter of 2 to 4-inches shall extend through the stem of the wall. Weepholes shall be protected against clogging by pockets of wrapped gravel in the backfill. These drains shall be spaced at suitable intervals, not to exceed 12-feet both vertically and horizontally. In counterfort walls, there shall be at least one drain in each pocket between adjacent counterforts.

Granular materials such as clean sands and gravels shall be used for backfill adjacent to the wall.

## 5710.3 Curb Inlets, Field Basins and Junction Boxes:

**A. General:** Curb inlets, field basins, and junction boxes shall be designed to withstand earth pressure, including any live load surcharge and vehicular wheel loads where appropriate.

**B. Loads:**

1. **Earth Loads:** The structure shall be proportioned to withstand pressure as determined by Rankine's formula and no structure shall be designed for less than an equivalent fluid pressure of 30-pounds per cubic foot.

2. **Live Load Surcharge:** A surcharge pressure of not less than 2-feet of earth shall be added to the normal earth pressure to compensate for vehicular traffic effects.

3. **Vehicular Wheel Loads:** All structures which are subjected to vehicular traffic shall be designed to carry a 16,000-pound wheel load distributed according to AASHTO guidelines.

C. **Design:** Standard curb inlets, field basins or junction boxes which have been adopted by local authorities may be used in lieu of special designs required by this specification.

**5710.4 Areaways:**

A. **General:** Areaways shall be designed to withstand all imposed loads.

B. **Loads:**

1. **Dead Loads:** When calculating dead loads, the recommended unit weights for soil and pavement are 120-pounds per cubic foot and 150-pounds per cubic foot respectively.

   The structure shall be designed to withstand pressure as determined by Rankine's formula in addition to any hydrostatic pressure. No structure shall be designed for less than an equivalent fluid pressure of 40-pounds per cubic foot.

2. **Vehicular Wheel Loads:** The top slab of an areaway which is subjected to vehicular traffic and which has less than 2-feet of cover shall be designed for a 16,000-pound wheel load distributed according to the governing specifications as listed in Section 5702.

   When the depth of fill is 2-feet or more, the design analysis shall include a concentrated 16,000-pound wheel load uniformly distributed over a square with sides equal to 1-3/4 times the depth of fill.

   When pressure distribution areas from several concentrations overlap, the total load shall be uniformly distributed over the area defined by the outside limits of the individual areas, however the total width of distribution shall not exceed the total width of the supporting slab. For

single spans, the effect of live load may be neglected when the depth of fill is more than 8 feet and when the depth of fill exceeds the span length. For multiple spans the effect of live load may also be neglected when the depth of fill exceeds the distance between end support faces.

A minimum lateral surcharge pressure equal to 2-feet of additional earth shall be used to compensate for vehicular live loads.

3. **Sidewalk Loads:** All sidewalk areaway structures which are not subjected to vehicular traffic shall be designed for a combined dead load, soil pressure and uniform live load of 250-pounds per square foot with a concentrated live load of 2,000-pounds. The concentrated load shall be applied according to paragraph (2) of this subsection.

## 5710.5 Reinforced Concrete Box Culverts

### A. Reinforced Concrete Box (Cast-in-Place):

1. **Materials:**

   a. **Concrete:** The minimum 28- day compressive strength ($f_c'$) shall be greater than 3,000-pounds per square inch.

   b. **Reinforcement:** Reinforcing steel bars shall be deformed new billet steel conforming to ASTM A-615-Grade-60. Welded-wire fabric shall conform to ASTM A-185 Grade-65.

2. **Design:**

   a. **General:** All structures shall be designed in accordance with the governing specifications as listed in Section 5702.

   b. **Loading:** The appropriate HS20 live load or Cooper E-80 live load along with all applicable dead loads and soil loads shall be applied as required. Special care shall be taken to insure the proper determination of the concentrated live load distribution through any fill material over the box.

c. **Earth pressures:** Vertical and horizontal earth pressures shall be computed by recognized or appropriately documented analytical techniques based on the principles of soil mechanics and soil structure interaction. Minimum design pressures shall be calculated based upon the following equivalent fluid weight for boxes supported on yielding foundations:

For vertical earth pressure - 120 pounds per cubic foot

For lateral earth pressure - 30 pounds per cubic foot
(granular, drained backfill)

For boxes on unyielding foundations,
a special analysis shall be made.

If actual design conditions would produce larger than minimum design pressures the larger pressures shall be used.

d. **Reinforcement Cover Requirements:** The following minimum concrete cover shall be provided for reinforcement, except that appropriate typical state highway or approved local standard reinforced concrete box designs may be used in lieu of this specification.

| Casting Type | Minimum Cover Inches |
|---|---|
| Concrete cast against & permanently exposed to earth | 3 |
| Concrete exposed to earth or weather | |
| Primary reinforcement | 2 |
| Stirrups, ties, and spirals | 1-1/2 |
| Top slab | |
| Top reinforcement | |
| Slab with 2-feet or less cover | 3 |
| Slab with more than 2-feet cover | 2 |
| Bottom reinforcement | 1 |

| Casting Type | Minimum Cover Inches |
|---|---|
| Concrete not exposed to weather or in contact with ground | |
| Primary reinforcement | 1-1/2 |
| Stirrups, ties, and spirals | 1 |

**B. Reinforced Concrete Box (Precast):**

1. **General:** Boxes may be manufactured using conventional structural concrete and forms (formed) or with dry concrete and vibrating form pipe making methods (machine-made). Standard dimensions shall meet appropriate current governing specifications as listed in Section 5702.

2. **Design, Materials, and Loading Requirements:** Manufacture and design shall be in accordance with ASTM C789, "Precast Reinforced Concrete Box Sections for Culverts, Storm Drains and Sewers" or ASTM C850, "Prestressed Reinforced Concrete Box Structures for Culverts, Storm Drains and Sewers with Less Than Two Feet of Cover Subject to Highway Loadings." Clearances to reinforcement as specified by ASTM shall be approved by the City Engineer.

## SECTION 5711 PLAN REQUIREMENTS

**5711.1 Scope:** This section governs the preparation of construction plans for bridges, culverts, retaining walls and other miscellaneous structures.

**5711.2 General:** The plans shall include all information necessary to build the structure in accordance with the design and specifications. The plans shall be arranged as required by the City Engineer. Standard Plans of the City may be included by reference to Standard Plan Number and Title. The Cover Sheet or Title Sheet of the plan set shall bear the seal of a Professional Engineer registered in the State of the City or governing agency. The plans shall be submitted to the City Engineer for review and approval.

**5711.3 Scales:** Plans shall be drawn at the following minimum scales. Larger scales may be needed and shall be used where necessary to clearly present the design. Bar scales shall be shown on each sheet for each scale used.

| | |
|---|---|
| Plan: | 1-inch = 50-feet |
| Profile: | |
| Vertical: | 1-inch = 10-feet |
| Horizontal: | 1-inch = 50-feet |
| Structural Plans: | 1/4-inch = 1-foot |
| Graphic Drawings: | Varies |

**5711.4 Required Information:**

A. **Cover or Title Sheet:** A Cover or Title Sheet shall be included and shall contain the following minimum information:

1. City, County, and State of agency responsible for the project.
2. Project name, identification and project number.
3. List of drawings in the plan set.
4. Location Map showing the general area and directional orientation of the project.
5. List of Utility Companies with facilities in the project site.
6. Approval block for signature by City Engineer, Director of Public Works or other Officials.

B. **General Plan and Elevation Drawing:** The General Plan and Elevation drawing shall show to scale the alignment, grade, span layout, roadway and sidewalk widths, general construction type and other principal features of the structure. The drawing shall contain the following additional minimum information:

1. General notes indicating the governing design loadings, design specifications, construction specifications, material requirements, and allowable stress levels for the principal materials of construction. Other notes shall include the following:

   a. Hydraulic data that is the basis for design of the structure.
   b. Traffic data and design speed.
   c. Datum used for the structure and/or project.
   d. Other miscellaneous notes pertaining to principal features of the structure such as concrete compressive strength ( $f'_c$ ) and yield strengths or grades of reinforcement.

2. North arrow and bar scale.
3. Ties to permanent reference points for the structure.
4. Right-of-way, property, and easement lines.
5. Existing, man-made, and natural topographic features, such as streets, buildings, fences, trees, channels, ponds, streams, etc., and all existing and proposed utilities.
6. Location of test borings.
7. Existing and finish grade contours at intervals of 2.0 -feet or less in elevation; or equivalent detail indicating existing and finish grades and slopes.
8. A uniform set of symbols subject to approval by the City Engineer.
9. The centerline of any open channels including the direction of flow.
10. A cross section view of the structure showing roadway configuration and dimensions if requested by the City Engineer.
11. A tabulation of material quantities and bid items, if not included in the project specifications, and if requested by the City Engineer.

C. **Design Information For Each Element of the Structure:** The plans shall present design and detail information as necessary to construct each abutment, pier, and superstructure system included in the completed structure. The drawings shall include the following minimum information:

1. **Reinforced Concrete Members:**

   a. Overall dimensions of the concrete element or member to an accuracy of 1/8-inch.
   b. Reinforcing bar size location and spacing.
   c. Reinforcing bar splice locations and lap dimensions.
   d. Clear distance to outside faces of member or minimum concrete cover requirements for reinforcing bars.
   e. Full details of all connections and joint requirements.
   f. A station and alignment reference, including north arrow for each abutment or pier.
   g. A detailed list of reinforcing bars, weights and bending diagrams if requested by the City Engineer.
   h. Chamfer and fillet dimensions.
   i. All other details and requirements for construction of the member in accordance with the design.

2. **Structural Steel Members:**

   a. Overall dimensions of the structural steel elements or members to

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an accuracy of 1/16-inch.

b. Framing plan for main members and cross bracing.
c. Girder elevation details showing material widths and thickness for flanges and webs.
d. Diagrams for required camber in members and tables or diagrams showing dead load deflections in members.
e. Generally, dead load deflections shall be shown at 1/4-points for rolled beam spans and 1/10-points for welded girder spans. Deflections shall be shown for the weight of the structural steel only and also for the total dead load of the completed superstructure.
f. Complete details for all connections, and weld sizes and requirements.
g. Complete details for all splices including splice material dimensions, and bolt size and spacing.
h. All other details and requirements for fabrication of the member in accordance with the design.

3. **Prestressed Concrete Members:**

a. Overall dimensions of the members to an accuracy of 1/8-inch. The maximum use shall be made of State Standard Sections, Standard Drawings, and fabrication procedures.
b. Size, material grade, spacing and layout of all prestress tendons.
c. Section views showing the location of all tendons between harp points and at the ends of the member.
d. Size, spacing, location and bending diagrams for all mild steel reinforcement in the member.
e. Table showing the theoretical camber for each girder and the concrete slab haunch dimensions at 1/4-points of the spans. Values shall be shown for the theoretical camber of the girder after erection and after the deck has been placed.
f. Other information as required for fabrication of the members in accordance with the design.

4. **Other Drawings:** Other drawings shall be included in the plans to present requirements for the structure. These drawings may include the following:

a. Pile size, spacing and other foundation requirements, including subsurface boring logs.
b. Expansion Joints.
c. Bridge railing and guardrail.
d. Traffic maintenance and detour requirements.
e. Lighting and signing plans.