

DIVISION 5

STRUCTURAL SYSTEMS

5.1 General Information - This chapter defines general design criterion that applies to the design of structural systems at DFW Airport. Chapter 1 should be consulted for specific Airport regulations and standards that also apply.

5.2 Building Structures - This section shall apply to all building structures at the Airport which provide for pedestrian access in any form.

5.2.1 Loads - The following special loadings shall take precedence over those mentioned in the current Building Code for the special cases mentioned:

5.2.1.1 Live Loads – Live loads shall be approved by DFW.

5.2.1.1.1 Live loads shall be modified as needed due to additional requirements.

5.2.1.2. Wind Loads

5.2.1.2.1 Basic Wind Velocity: 90 mph.

5.2.1.2.2 Exposure Category: C

5.2.1.3. Wind load for Terminal buildings at the airside face only shall be 50 psf applied to any 15 square foot area for components and cladding, per FAA AC 150/5300-13, Chapter 8, "The Effects and Treatment of Jet Blast. This load need not apply at inset penthouse structures forty (40) feet above the apron level. This load is a result of aircraft jet blast plus meteorological conditions.

5.2.1.3 Roof Loads - Live loads for roof levels where additional future floors will be constructed shall be 100 psf minimum.

5.2.2 Materials and Unit Stresses

5.2.2.1 Concrete - Non-prestressed concrete for structural elements shall be designed for a minimum twenty-eight (28) day compressive strength (fc') of 4000 psi, or as dictated by design requirements. All exposed concrete shall be designed with entrained air. Adequate equipment shall be provided for heating concrete materials and protecting concrete during freezing or near-freezing weather.

5.2.2.1.1 Prestressed concrete for structural elements shall be designed for a minimum twenty-eight (28) day compressive strength (fc') of 4000 psi.

5.2.2.1.2 Concrete subject to freezing temperatures while wet shall have three 3.5 percent to 6.5 percent air entrainment at point-of-placement, unless noted otherwise. Admixtures shall be used with care and compatibility shall be verified by testing laboratories.

5.2.2.2 Structural Steel - Structural steel shall conform to the following:

1. W, WT Shapes: ASTM A 572, Grade 50, ASTM A 992.
2. S, M, HP, and Channels: ASTM A 36, A 572 Grade 50.
3. Angles and Plates: ASTM A 36, A 572 Grade 50.
4. Pipes: ASTM A 53, Grade B.
5. Tubes: ASTM A500. Grade B.
6. Erection Bolts: ASTM A 307.

7. High Strength Bolts: ASTM A 307
8. Anchor Bolts and Rods: ASTM A 36, A 307, A 193, A 1554.
9. High Strength Low Alloy (HSLA) Steel: ASTM A 588 steel will be allowed with prior approval for high-mast light poles and base plates. HSLA steel shall not be used in areas of high moisture or water unless a proper surface treatment is utilized. Concrete pier pedestals for high-mast light poles shall be at least thirty six (36) inches above finish grade.

5.2.2.3 Prestressing Tendons - Tensile stress in prestressing tendons due to jacking force shall not exceed $0.94 f_{py}$ (specified yield strength of prestressed tendons), psi. Prestressed members shall be designed using 7-wire strand having an ultimate tensile strength of 270,000 psi and conforming to ASTM A-416.

5.2.2.3.1 Low relaxation strands may be considered in design if they meet ASTM A421, ASTM A-416, and ACI Building Code 3.5.5 and Commentary.

5.2.2.4 Reinforcing Steel - All reinforcing steel shall be ASTM A615. Number 4 bars and smaller may be Grade 40 or Grade 60, and Number 5 bars and larger shall be Grade 60, except all mild reinforcement in prestressed concrete elements shall be Grade 60. Grade 60 shall be bent at shop prior to placement.

5.2.2.4.1 Clear concrete cover on reinforcing shall be as follows, unless otherwise shown:

Concrete cast against sand and permanently exposed to earth	3 inches
Concrete exposed to earth or weather:	
#6 through #18 bars	2 inches
#5 bar, W31 or D31 wire, and smaller	1-1/2 inches
Concrete not exposed to weather or in contact with ground:	
Slabs, walls, joists:	
#14 and #18 bars	1-1/2 inches
#11 bar and smaller	3/4 inches
Beams, columns:	
Primary reinforcement, ties, Stirrups, spirals	1-1/2 inches
Shells, folded plate members:	
#6 bar and larger	3/4 inches
#5 bar, W31 or D31 wire, and smaller	1/2 inch
Beams and girders	1-1/2 inch interior, 2" exterior

5.2.3 Structural Foundation Systems

5.2.3.1 Foundations - Allowable foundation capacities shall be determined from geotechnical investigations under the direction of a professional structural engineer registered in the State of Texas.

5.2.3.1.1 Foundations shall be designed to prevent uplift and differential settlement, as well as load bearing requirements.

5.2.3.1.2 Minimum ground cover over footings shall be 12".

5.2.3.1.3 The subgrade for all buildings shall be pressure injected with lime slurry or Cement Treated Base (CTB). The lime slurry shall be pressure injected at least three (3) feet beyond the building line. The requirements for injection grid density, depth of injection, additional injections, curing times, and stabilization or pH results shall be based upon geotechnical recommendations.

5.2.3.2. Horizontal Framing Systems - Floor systems at Terminal buildings shall be designed to eliminate excessive vibrations from pedestrian and people-mover car traffic.

5.2.3.2.1 Framing systems shall be designed considering requirements for future floor openings. Future beam and column connections shall not be drilled expansion bolts, but embedments with adequate shear and tensile capacities. Existing beams, columns, walls and slabs shall not be connected with explosive or dry powder inserts.

5.2.3.3 Precast Double-Tees:

5.2.3.3.1 No bottom connections into legs.

5.2.3.3.2 Side penetrations into legs shall utilize pre-drilled holes where possible.

5.2.3.3.3 No powder actuated inserts into legs or decks.

5.2.3.3.4 Existing double-tee roof and floor systems shall be evaluated for loads, penetrations, or attachments by a registered structural engineer, licensed to practice in the state of Texas.

5.2.4 Detailing - Detailing for structural steel shall comply with the latest edition of AISC "Detailing for Steel Construction".

5.2.4.1 Connections - Steel moment connections shall be designed using the Allowable Stress Design (ASD) Specification or the Load and Resistance Factor Design (LRFD) Specification for Structural Steel Buildings.

5.2.4.1.1 Concrete embedments shall have sufficient anchorage ties to prevent cracking or rapid failure. Corrosion resisting finishes shall be used on all structural embedments.

5.2.4.1.2 All connections, whether designed by the consulting engineer, the suppliers, or structural detailers, shall be designed and sealed by a professional structural engineer registered in the State of Texas.

5.2.4.2 Openings - Openings in structural slabs shall be detailed such that spalling of concrete edges shall be prevented. Diagonal reinforcement shall be provided at corners, re-entrant slabs and floor penetrations.

5.2.4.3 Expansion Devices and Materials - In addition to ACI 318, the designer should refer to ACI 504.R for various joint treatments and to ACI 224.R and ACI 224.1R for crack controls.

5.3 Parking Structures - All criteria specified in Section 5.2 - Building Structures shall also apply to parking structures except as amended in the following.

5.3.1 Material Selection - Structural steel shall not be considered for the vertical and horizontal framing system unless approved by the Building Official.

5.3.2 Steel - All exposed miscellaneous steel used for concrete supports and connections shall be galvanized and retouched after installation.

5.3.3 Corrosion Protection - Calcium chloride and admixtures containing chlorides should not be used in concrete for parking structures. Admixtures shall be used with care and compatibility shall be verified by testing laboratories.

5.3.3.1 Protection of embedded metals including concrete cover over reinforcement, post-tensioning tendons, pretensioned connections for precast systems, dissimilar metals, and embedded metal conduit should meet or exceed the minimum ACI 318 requirements.

5.3.3.2 ACI 362.1R, Guide to the Design of Durable Parking Structures should be consulted for pertinent information concerning corrosion inhibitors, cathodic protection and protection of concrete. The guidelines for applied sealers or membrane treatments shall be followed.

5.3.4 Expansion Devices and Materials - Expansion joint seals and isolation joints shall be designed to prevent the following defects or failures:

5.3.4.1 Migration, bleeding into or staining abutting materials.

5.3.4.2 Deformation sufficient to become unsightly or cause leakage.

5.3.4.3 Chalking, picking up dust or excessive color change.

5.3.4.4 Adhesive or cohesive failures.

5.3.4.5 In addition to ACI 318, the designer should refer to ACI 504.R for various joint treatments and to ACI 224.R and ACI 224.1R for crack controls.

5.3.5 Elastomeric Bearings - Bearings shall be designed as a plain pad with a seventy (70) durometer elastomer or laminated pads with a sixty (60) durometer elastomer.

5.3.6 Parapet Systems - Systems which are integral or monolithic with supporting structural systems shall be designed such that damage to the parapet will not adversely affect the supporting system. The use of isolation joints and membrane protection is important at roof connections.

5.3.7 Drainage Systems - Systems shall be designed and located such that structural elements (i.e., reinforcing steel, tendons, beam flanges, lighting column base plates, etc.) shall take precedence. Use the least number of bends for unimpeded flow.

5.4 Aircraft Bridge Structures - This section shall apply to all bridges, tunnels, culverts, vaults and all other structures supporting aircraft or under runways, taxiways or aprons. Such structures shall conform to the minimum requirements set forth in this Manual and FAA AC 150/5300-13.

5.4.1 Airplane Design Group - Structures shall be designed and proportioned to accommodate Airplane Design Group VI as defined in FAA AC 150/5300-13.

5.4.1.1 Each element of the structure shall be designed to accommodate the most demanding airplane under this design group. This may result in more than one airplane being used in designing a particular structure (i.e., bridge width may be controlled by the airplane with the longest wing span, whereas another airplane may have higher wheel loads, thus controlling beam design).

5.4.2 Live Loads - Structures shall be designed for the following airplane loads:

5.4.2.1 Spans under two (2) feet in the shortest direction, including manholes lids and grates - uniform live load of 250 psi.

5.4.2.2 Span lengths two (2) to ten (10) feet in the shortest direction - the greater of a uniform live load varying between 250 psi and 50 psi in inverse proportion to the span length or the maximum number of wheel loads for the airplane which can be applied to the structure.

5.4.2.3 Span lengths greater than ten (10) feet in the shortest direction - wheel loads for the design airplane.

5.4.3 Impact - For those elements listed in Group A (defined below), the live load shall be increased by the following percentages. This increase will account for impact loads and vibration:

- 30 percent - Parking aprons and low speed taxiways.
- 40 percent - High speed taxiways and runways.
- 100 percent - Touchdown areas of runways.

5.4.3.1 Live loads shall not be increased by impact for those items in Group B (defined below):

GROUP A

1. Superstructure, columns and pedestals which support the superstructure with rigid, fixed or expansion bearings, or which are rigidly attached to the superstructure, and legs of rigid frames.
2. The portions above the ground line of piers that are rigidly connected to the superstructure as in rigid frame or continuous structures.

GROUP B

1. Abutments, retaining walls, piers, pile caps and pilings which are not rigidly connected to the superstructure.
2. Buried foundations, footings and supporting soil, and structures with three (3) feet or more of earth cover.

5.4.3.2 Impact for structures covered with fill shall vary from the percentage shown at ground level to zero (0) percent at a depth of ten (10) feet.

5.4.4 Braking Force - Longitudinal forces due to braking shall be included in the design of all structures subject to direct wheel loads. This braking force shall be the following percentages of live load without impact:

- 30 percent - Parking aprons and low speed taxiways.
- 70 percent - High speed taxiways and runways.

5.4.5 Clearances - Vertical clearances for aircraft bridges over roadways and horizontal clearances to piers from these roadways shall be the same as those described in Section 2.4.6 - Obstruction Clearances.

5.4.6 Materials - Construction material specifications, strengths, handling, storage and testing shall comply with the latest version of the American Association of State Highway and Transportation Officials (AASHTO) "Standard Specifications for Highway Bridges".

5.4.7 Design Load Combinations - In addition to live and dead loads, the following loadings shall be taken into account: earth pressure, buoyancy, wind (including jet blast and uplift), shrinkage, temperature, longitudinal force, stream flow, construction loads and any special loads. Loads shall be applied in such a manner as to produce the maximum stresses.

5.4.7.1 Loading combinations shall be the same as those described in latest version of the AASHTO's "Standard Specifications for Highway Bridges," and interim specifications.

5.5 Highway Bridges - This provision shall apply to structures with spans greater than twenty (20) feet and whose function is to carry roadway traffic. This section does not apply to parking structures or ramp systems within them.

5.5.1 Specifications - Highway bridges shall be designed in accordance with AASHTO's "Standard Specifications for Highway Bridges," with interim specifications.

5.5.2 Live Loads - All bridges on arterial roads shall be designed for an HS20-44 live load plus impact.

5.5.2.1 Bridges along secondary roads shall be designed for an HS20-44 live load plus impact unless waived by the Building Official, in which case the design live load shall be HS15-44 plus impact.

5.5.3 Bridge Widths - Generally, bridge width from face of rail to face of rail shall be at least as wide as the approach roadway's usable shoulder.

5.5.4 Clearances - For horizontal and vertical clearance requirements, see Section 2.4.6 - Obstruction Clearances.

5.5.5 Materials - This section shall govern materials used in the construction of highway bridges and incidental items relating to these structures.

5.5.5.1 Concrete - Concrete materials, quality, classes of, and proportioning shall comply with the applicable sections of the Texas Department of Transportation (TxDOT) "Standard Specifications for Construction of Highways, Streets, and Bridges".

5.5.5.2 Structural Steel - Structural steel, forgings, castings, anchor bolts, pipe, tubing, bolting of and welding of shall comply with the applicable sections of the TxDOT "Standard Specifications for Construction of Highways, Streets, and Bridges".

5.5.5.3 Reinforcing Steel - Reinforcing steel material and bending shall comply with the applicable sections of the TxDOT "Standard Specifications for Construction of Highways, Streets and Bridges".

5.5.5.4 Prestressing Steel - Prestressing steel, packing, storing, handling, working drawings and construction methods shall comply with the applicable sections of the TxDOT "Standard Specifications for Construction of Highways, Streets, and Bridges".

5.6 Pedestrian Bridges - Pedestrian bridge length, width, height and construction materials shall comply with the Building Code.

5.6.1 Materials - Construction material specifications, strengths, handling, storage and testing shall comply with the TxDOT "Standard Specifications for Construction of Highways, Streets and Bridges".

5.6.2 Design Loads and Loading Combinations - The minimum live load shall be 100 psf. Where equipment and small vehicles are anticipated to use this structure, live loads shall be increased accordingly.

5.6.2.1 In addition to live and dead loads, the following loadings shall be taken into account: earth pressure, buoyancy, wind (including jet blast and uplift), shrinkage, temperature, stream flow, construction loads and any special loads. Loads shall be applied in such a manner as to produce the maximum stresses.

5.6.2.2 Loading combinations shall be the same as those described in AASHTO's "Standard Specifications for Highway Bridges", and interim specifications.

5.6.3 Clearances - Vertical clearances over roadways shall be one (1) foot greater than outlined in Section 2.5.6 - Obstruction Clearances.

5.7 Retaining Walls - Retaining wall design and materials shall comply with the applicable sections of the Building Code and the geotechnical investigation report for that project.

5.7.1 The effect of wall movement due to expansive soils shall be taken into account and, when necessary, appropriate design steps shall be taken to minimize them.

5.7.2 The factor of safety for overturning shall be 1.5 minimum and 2.0 maximum. The factor of safety for sliding and circular soil arc failure shall be a minimum of 1.5. Expansion joints shall be provided every ninety (90) feet maximum and contraction joints every thirty (30) feet maximum.

5.8 Tunnels - Tunnels shall include all below grade, enclosed structures used by pedestrians, vehicles or to hold utilities.

5.8.1 Due to the varied applications of tunnels, the design criteria shall be established on a project to project basis.

5.8.2 Items of particular interest which should be addressed are: waterproofing, ventilation, lighting and utilities, drainage, exiting, fire protection, cathodic protection/corrosion control and overburden loading.

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