VII BRIDGE LAYOUT

The following items shall be considered and adequately addressed in the layout of the grade separation underpass structure:

1. Layout of underpass structures shall indicate the limits of the Railroad right-of-way, exact locations of all existing overhead or underground utilities, pipeline locations, fiber optic locations, proposed drainage, proposed construction sequences including layout details for any temporary bridge structure such as shooflys etc. All construction must be scheduled to minimize the amount of track interference during construction.

2. <u>No</u> utility attachments will be permitted on the new structure. Existing or future fiber optic lines shall be placed underground and away from bridge structure. Refer to current Union Pacific Railroad Fiber Optic Rules Construction and Engineering Standards Manual or call 1-800-336-9193. Relocation of any existing utilities must be performed by the owners of said utility.

3. Minimum longitudinal grade of 0.2% on structure shall be provided for drainage purposes. Designer may provide drainage toward one end of structure or, when structure length is excessive, provide adequate deck grades to drain the structure to both ends. If the top of rail grades remain constant over the length of structure the depth of ballast may be varied but should be taken into account in the design.

4. For bridges located within a curve, the girders, abutments and piers shall be located with reference to chords.

5. Vandal fencing shall be provided on all underpass structures in urban areas and on underpass structures in rural areas where pedestrian traffic patterns, past history of vandalism, or other conditions near the project site may warrant.

6. Sloping embankments in front of abutments shall be paved.

7. The distance from the centerline of bridge to the nearest railroad milepost shall be shown on the plans.

8. Structures having multiple tracks shall be designed to accommodate any future shifting or relocation of track. Longitudinal members are to be evenly spaced, with no less than two support members per rail.

9. Cantilever type abutment stems shall be at least 0.2H in thickness at the base.

10. Columns shall be at least 0.2H in thickness at the base.

11. Floor beams shall be a minimum of 21 inches in depth.

12. The year of construction shall be shown at the face of backwall. Numbers shall be embedded into the concrete and be 6 inch size.

VIII SKEW OF BRIDGE

The preferred angle of roadway crossing and bridge structure relative to the centerline of track is 90°. However, in cases where a 90° crossing cannot be obtained, the maximum skew of bridge structure from 90° shall not exceed the following for various types of structures:

TYPE OF STRUCTURE	SKEW IN DEGREES
Steel spans with concrete deck (Beams, Deck Girders, Through Girders)	30° MAX.
Prestressed concrete with concrete deck (AASHTO beams)	30° MAX.
Prestressed concrete box girders	15° MAX.
Cast-in-place box girders conventionally reinforced or Post-tensioned	20° MAX.
Trough type prestressed girders	15° MAX.

Align roadway, bridge piers, and abutments as required to comply with the above maximum skew limitations.

Transverse tie rods in end blocks and interior diaphragms should be in the direction of skew. Multiple prestressed concrete girders shall be bonded together with epoxy or grout. In addition, transverse tie rods shall be installed through the end blocks and interior diaphragms. See drawing **UP9**, Appendix A

Where conditions preclude any other solution, the skew proposal will require special structural consideration and proof of adequacy. Skews in excess of 15°are not permitted for continuous structures.

At the ends of a skewed bridge, support slabs shall be provided for each track. Ends of track slab shall be perpendicular to the centerline of the track and be 12 ft. minimum width placed symmetrically to the centerline of the track. Length of track slab shall be 12 ft. minimum beyond the back face of backwall.

IX VERTICAL CLEARANCES

Underpass structures shall be designed and provide sufficient vertical clearance and protective devices to ensure that structure will be protected from oversized and unauthorized high loads. Designers and public agencies shall comply with the following vertical clearances:

STRUCTURE OVER	STEEL	CONCRETE
Freeways	16.5 ft.	17.5 ft.
Designated arterial routes	16.5 ft.	17.5 ft.
Local roads and streets	15.5 ft.	16.0 ft.
Rural roads	15.0 ft.	15.5 ft.
Pedestrian under crossing (no vehicles)	8.0 ft.	8.0 ft.
Recreational roads	12.5 ft.	12.5 ft.

All concrete structures in above table except pedestrian under crossing without vehicular traffic shall be protected with collision impact devices installed over the full width of traveled lanes and attached to the bridge soffit. All structures with vertical clearances less than 17.5 ft. shall be protected with a steel sacrificial beam. Sacrificial beam shall be installed a minimum of 5 ft. ahead of the collision impact devise or ahead of the main supporting member and shall not carry railway loads. Sacrificial beam shall be of steel shape (wide flange or tubing) and of sufficient strength to limit horizontal deflection to 6 inches caused from the impact from oversized vehicle or load. Additionally it shall be anchored sufficiently to bridge seat at an elevation of at least 6 inches below the bridge soffit. For more details see drawing **UP16** Appendix A.

If resurfacing or any other activity is to be performed below the underpass structure, the owner of the roadway must submit a request for approval from Union Pacific Railroad Company. This request must provide the existing **measured** and posted clearances of the structure and the proposed configuration after work is completed.

The owner of the roadway shall be responsible of posting and maintaining structure sign clearances and any advance street notifications as required.

X DESIGN LOADS

1. Underpass bridge structures shall be designed for all loads specified in Chapters 8, 9, or 15 of the AREA Specifications.

   The design of underpass structures shall comply with the seismic criteria of the current edition of AREA, Chapter 9 - Seismic Design for Railway Structures.

2. Live Load and Impact as specified in the AREA Specifications.

3. All underpass structures shall be designed for a maximum thirty (30) inches of ballast (top of deck to top of tie) to account for future track raises. Structures shall be constructed to the required grades with the minimum depth of ballast under the tie of eight (8) inches for timber, and twelve (12) inches for concrete.

4. Under normal working loads, composite action may be expected between a concrete deck and its supporting steel members, when shear transfer devices are used. The bottom of the deck slab shall be placed at least one inch below top of supporting steel members. For design purposes, the supporting steel members shall be proportioned to carry E65 live, impact, and dead loads without taking into account any composite action, and E80 live, Impact, and dead loads taking into account composite action. Composite action may be taken into account when satisfying the deflection-length ratio requirement of Chapter 15, Article 1.2.5 of the AREA Specifications provided shear transfer devices are installed.

5. Live load distribution for precast prestressed single or double cell boxes shall be in accordance with Part 2, Reinforced Concrete Design, Article 2.2.3.c.(1) of the AREA specifications. Live load shall not be assumed to be distributed to the number of boxes supporting the tracks.

   For multiple track structures, live load shall be distributed based on the assumption of the track being in any location.

XI SPECIAL REQUIREMENTS FOR PRECAST PRESTRESSED BOX OR AASHTO TYPE GIRDERS

1. Box shaped (Single or Double void) or AASHTO type precast prestressed girders for all spans shall be designed with end and interior diaphragms. Interior diaphragms shall be spaced equally across the span length. Provide diaphragms as follows for various span lengths:

SPAN IN FEET	NUMBER OF INTERIOR DIAPHRAGMS
35-50	1
51-75	2
Over 76	3

Above number of diaphragms per span is minimum required. The definite number to be considered in each case depends on the particular design, span lengths, member rigidities, etc.. Diaphragm spacing should not exceed 25 ft. center to center.

2. Transverse tie rods shall be installed at the end and each interior diaphragm. Minimum size of tie rod to be 1-1/4 inches in diameter. Tie rod to be protected in one of the following ways:

   a) Rod, plates and nuts shall be hot dip galvanized per ASTM A123 and A153.

   b) All assembly parts left plain, but void between rod and hole to be pressure grouted. Tie rod anchor assembly shall be recessed into the concrete and shall have one (1) inch minimum grout cover.

3. Strands at the ends of precast prestressed members shall be cut one (1) inch minimum into the member and the resulting recessed pocket filled with grout.

4. For AASHTO beams the designer shall provide eighteen (18) inches minimum gap between bottom flange of beams to accommodate inspections and repairs.

5. The keyway for precast concrete box girders shall be bonded with high strength epoxy or non shrink cementitious grout. Strength of epoxy or grout to be at least equal to the strength of concrete member being bonded. For details see drawing **UP9**, Appendix A.

XII SPECIAL REQUIREMENTS FOR POST-TENSIONED CONCRETE STRUCTURES

All post-tensioned structure ducts shall be bonded (grouted).

A. Simple Spans

1. Post-tensioned simple spans shall be designed such that a minimum compressive force of 100 psi is maintained in the topmost regions of the element, and to maintain a minimum compressive force of zero in the lower most regions of the element. At no time either during construction or under any load configuration shall these minimum requirements be violated. In addition there shall be sufficient straight tendons top and bottom to produce a uniform compression of 200 psi over the cross-section. Prestress can be applied in a single stage for spans 80 ft. and under, stressing the straight tendons first, sequentially alternating between top and bottom tendons to maintain a uniform stress pattern over the cross-section, then continuing stressing operations on the draped tendons until of all post-tensioning is complete.

2. Simple spans over 80 ft. in length, shall be prestressed in two stages. The first stage of postensioning shall be applied when the most recent concrete has attained a minimum compressive strength of 1500 psi as determined by compression cylinder tests and shall consist of tensioning the straight tendons, alternating sequentially between top and bottom tendons, to maintain a relatively uniform compression of 200 psi over the cross-section. The second stage of post tensioning shall be the application of the remaining portion of design prestress force when the last placed concrete reaches the minimum compressive strength as required at transfer by the AREA Specifications.

B. Continuous Spans

1. Post-tensioned, continuous structures shall be designed for a minimum compressive force of 200 psi in the topmost regions of the element, and 50 psi minimum compressive force at lowermost regions of the element in the positive moment regions of the structure. In the negative moment regions of the structure the requirement will be reversed such that a minimum compressive force of 50 psi will be required in the topmost regions of the element and a minimum compressive force of 200 psi in the lower most regions of the element. These minimum compressive force requirements must be maintained during any stage of construction or any loading case.

2. Cast-in-place, continuous, post-tensioned structures shall have sufficient straight tendons placed both in top and bottom fibers to produce a calculated uniform compression over the entire section of 200 psi. The prestress in the straight tendons (1st stage prestress) to be applied when the most recent and final concrete has reached a minimum compressive strength of 1500 psi as determined by compression cylinder tests. The stressing of these straight tendons shall be applied by alternating sequentially between top and bottom tendons to maintain a relative uniform stress as possible over the cross-section during the postensioning operations. The second stage shall be the application of the remaining portion of design prestress force when the most recent concrete reaches the minimum compressive strength as required at transfer by the AREA Specifications.

3. The above procedures 1) and 2) are to be applied in conjunction with a concrete placement schedule for the structure in which the positive moment regions are placed first and the negative moment regions are placed second. This two-stage procedure applies to spans 100 ft. or less. Placement schedule shall be three-stage for longer spans; positive moment regions to within four (4) ft. of inflection point first; negative moment regions to within four (4) ft. of inflection point second; and closure section eight (8) ft. long at the inflection points last. On the longer spans it may be required to subdivide the sequence steps into placement sections depending on the structure type and amount of non prestressed reinforcement used to control shrinkage cracking. For each stage of concrete placement, the entire structural cross-section shall be completed before moving to the next stage. When casting the stage over supports, the concrete placement shall proceed from the outer ends to the support.

4. The radius of curvature for any post-tensioning duct must not be less than 60 ft.

XIII MATERIAL REQUIREMENTS FOR STEEL STRUCTURES

1. Thickness of structural steel (except for fillers), shall not be less than 0.335 inch thick. Parts subject to corrosive influences shall be of greater thickness than otherwise specified or steps taken to protect same against such influences.

2. The thickness of gusset plates connecting the chords and web members of a truss shall be proportional to the force being transferred but not less than ½ inch.

3. Minimum size of high strength bolt for bolting structural members shall be 7/8 inch diameter

4. The allowable bearing pressures as contained in AREA Chapter 15 are to be used for steel superstructure bearing on concrete substructure.

5. All fracture critical members shall be designated as FCM on the plans. Fracture critical members shall be designed for a minimum service temperature of - 30°F corresponding to Zone 2.

6. Designer shall provide details such that all exposed parts will be accessible for inspection, cleaning and painting. Preferably not less than 18 inches clear shall be provided between the flanges of parallel lines of beams having depths in excess of 38 inches.

7. All designs must provide drain holes for pockets or depressions that may hold water so that steel areas drain effectively. Structural members shall not be sealed by welding except as approved by the Engineer.

XIV PAINTING OF STEEL STRUCTURES

All underpass steel structures shall be painted except where galvanized or weathering steel is used.

Painting of steel structures shall comply with the requirements of current AASHTO specifications and recommendations of Steel Structures Painting Council Manual (SSPC).

Paint shall be applied in accordance with the Manufacturer's recommendations or in compliance with the recommendations of SSPC, whichever is most restrictive.

Painting system including primer and top coats shall be submitted by the agency for review and approval by the Chief Engineer Design.

XV BALLAST DECK BRIDGE STRUCTURE

For typical cross section of superstructures see drawings **UP1 - UP8** Appendix A.

1. **Deck width:**

For a single tangent track bridge structure the width of the deck shall be not be less than 17 ft. wide, measured from inside face of parapet to inside face of parapet. The clear distance from centerline of track to the inside face of parapet shall not be less than 8'-6" for tangent track and 9'-6" for track on curve. For multiple tracks an allowance of 20 ft. shall be provided for each existing track or future track.

2. **Curb Height:**

The top of ballast curb or walkway shall be approximately the same elevation as the base of highest rail plus eight (8) inches to accommodate possible future track raises.

3. **Walkway:**

In general, walkways shall not be less than 2 ft. wide. Ballast structures do not require walkway in most cases. Structural members (such as floor beam knee braces) shall not be considered an obstruction to the walkway.

Walkways on bridges over highways or other locations where spillage of ballast or lading is possible shall be constructed of solid material and a curb or toe board shall be provided. The clear distance from centerline of track to ballast retainer for bridges with walkway shall be 6'-6" minimum.

To prevent cracking under live loads, provide 1/4 inch wide joints at 10 ft. maximum spacing on concrete curbs, walkways, and ballast retainers.

4. **Handrail:**

Handrails shall be provided on both sides of deck. Horizontal clearances from the centerline of the nearest track shall not be less than 8'- 6" for tangent track, and 9'-6" for track on curve. Handrails shall be simple designs that require minimum maintenance. Union Pacific Railroad Company recommends the following types of handrails:

a) Chain link fencing. See drawing **UP10**, Appendix A.
b) Tubular style fencing. See drawing **UP11**, Appendix A.
c) Picket style fencing. See drawing **UP12**, Appendix A.

Variations from the above suggested fencing shall be submitted for approval by the office of the Chief Engineer Design.

5. **Depth of Ballast:**

The depth of ballast under the lowest rail shall be eight (8) inches minimum for timber ties and twelve (12) inches minimum for concrete ties. Structures shall be designed to accommodate thirty (30) inches of ballast for future track raises.

6. **Drainage:**

The top of concrete ballast trough for steel beams or multiple girders shall be sloped transversely not less than 1%. Low points on top of the trough shall be located not less than 6'-0" from the centerline of any track and shall be within the outside beams or girders.
A longitudinal collection system shall be provided to dispose of drainage without permitting it to enter the ballast section and backfill beyond the limits of the bridge structure.

All concrete ballast troughs shall be sloped transversely not less than 1%. A longitudinal collection system shall be provided on top of waterproofing along the face of parapet or curb to drain water. Longitudinal drains shall be connected to the storm drain system or properly discharged at the toe of embankment slopes. See drawing **UP13**, Appendix A for details.

If an approach grade descends toward the bridge, drainage from the approach shall be intercepted by appropriate means so that it will not drain onto the bridge.

7. **Waterproofing and Protective Panels:**

Waterproofing and protective panels shall comply with the recommendations of Chapter 29 of the AREA Manual. The waterproofing shall be one layer of Butyl Rubber or EPDM membrane and shall be bonded to the bridge deck with adhesive applied to the entire surface in accordance with the recommendations of the membrane manufacturer. Butyl Rubber or EPDM membrane shall be 0.06" thick minimum. Field splices shall be the tongue and groove type per AREA Chapter 29, Part 2, detail No.3 Figure 2-2.

Protective asphaltic panels shall be in two layers with total thickness not less than 3/4 of an inch and shall be laid with joints staggered. Protective panels shall be bonded to the membrane and to each other with the same adhesive used for bonding the membrane and be compatible to materials.
For waterproofing details see drawings **UP14** and **UP15** Appendix A.