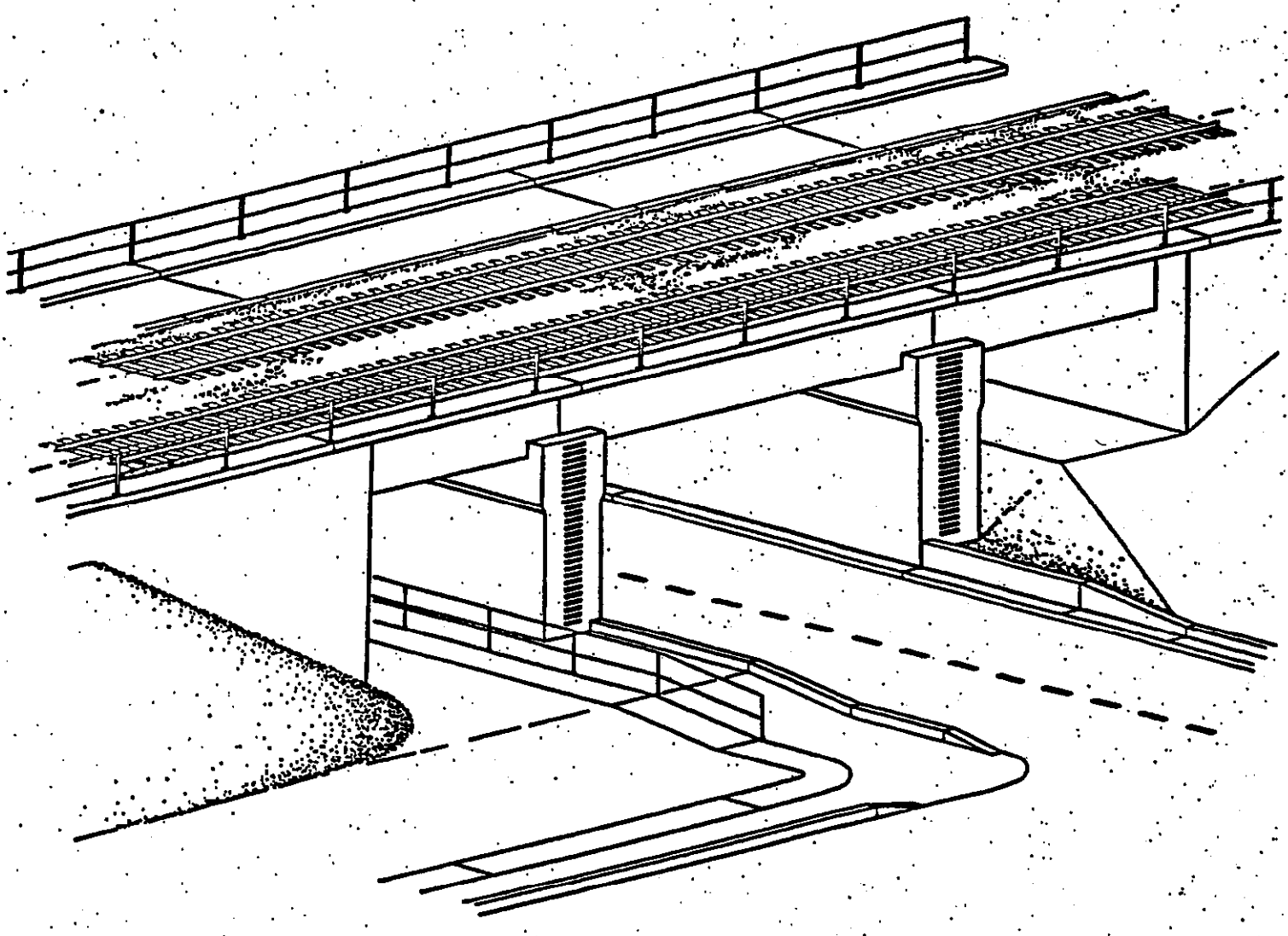
GUIDELINES FOR DESIGN AND CONSTRUCTION OF GRADE SEPARATION UNDERPASS STRUCTURES



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UNION PACIFIC RAILROAD COMPANY

UNDERPASS GRADE SEPARATION STRUCTURES

I PURPOSE AND SCOPE

The intent of this guideline is to inform public agencies, design engineers and: contractors of Union Pacific Railroad Company's current standards and requirements concerning design and construction of grade separation underpass structures.

Continuity of safe rail operations shall be required' for the duration of the project'. and construction work shall in no way impede the train operations of the Union. Pacific Railroad.

The specific requirements adressed in this document should be followed for structures on which the Union Pacific Railroad'operates regardless of whether it is maintained by Union Pacific Railroad. Compliance with these requirements will help to expedite the completion of design and construction reviews.

Designs of all public works projects shall be prepared either by the engineering. staff of that agency oi a consulting engineer who has been approved by both Union Pacific Railroad Company and that public agency.

Selection of consultants shall be limited to those who are familiar with the design of railroad bridges, and particularly with the special requirements and operating conditions of the Union Pacific Railroad Company.

Public Agency, or their representative shall provide information requested on attached data sheet to, the Manager of Industry and Public Projects of the district that project is located in the preliminary stages of the project. See Data Sheet, Appendix A.

This guideline supplements the applicable sections of the American Railway Engineering Association (AREA) Manual of Recommended Practice in connection with the design of ballast deck railway bridges.

II STRUCTURE SELECTION CRITERIA

1. Grade separation underpass structures shalt be ballast deck type structures. Open deck type structures shall not be used, as permanent structures; Open deck type structures can be used only for temporary structures built in

conjunction with shoofly construction.

2. When possible, simple span structures should be used.

3. Continuous span, deck or through truss type, structures are to be avoided.

4. Trough type p&t-tensioned simple or continuous structures are not acceptable.

5. Grade separation structures may require inside guard rail. Refer to Union Pacific Railroad Company standard drawing 4005 (Double Inside Guard Rail for Timber Ties) or 4015 (Double Inside Guard Rail for Concrete Ties) for details and requirements. See Appendix A.

III LIST OF PREFERABLE UNDERPASS STRUCTURES

Following is a list of underpass structures preferabie'to Union Pacific Railroad Company in priority order. The Union Pacific Railroad Company will require the most preferred alternative in all cases, unless the agency can provide sufficient reasons for proposing a less preferred alternative.

1. Steel plate girders with cast-in- place concrete deck. See drawing UP1, Appendix A.

2. Rolled beams with c&t-in-place, concrete dock. See drawing UP2, Appendix A.

3. Prestressed concrete box girders single or double cell. See drawing UP3, Appendix A.

4. Prestressed concrete "AASHTO" type girders with cast-in-place concrete deck. See drawing UP4, Appendix A.

5. Cast-'in-place concrete box girders conventionat reinforced. See drawing UP5, Appendix A.

6. Post-tensioned concrete box girders. See drawing UP6, Appendix A.

7. Through type simple supported steel girder spans with'concrete or steel deck will be considered by the office of the Chief Engineer when conditions preclude' any other solution. See drawing UP7, or UP8, Appendix A.

8. Grade separation underpass structures of deck, or through truss design are not preferable. However, in unusual circumstances, they will be considered by the office of the Chief Engineer Design if conditions preclude the use of any other type of structure.

IV ACCESS TO UNDERPASS STRUCTURE

For all grade separation underpass structures, an access roadway, or bridge maintenance structure shall be provided for Union Pacific Railroad Company off-track maintenance equipment.

Access roadway with a turnaround shall be designed and constructed in conjunction with the grade separation bridge structure. Turnaround pad shall start no further than 30 ft. from the ehd of bridge structure and with embankment shoulder 66 ft. minimum from centerline of track, Roadway grade should not exceed 10% and shall terminate at the'sub ballast elevation: Roadway shall have sufficient width to provide for one 12 ft. wide road, drain ditch and shoulder. Roadway and turnaround shall be constructed on compacted material and have a 12 inch thick minimum base and 6 inch thick A.C. pavement. Turnaround pad and roadway shall be sloped to drain. away from track subgrade and dispose water to drainage system or existing right-of-way ditches. All down slopes of turnaround pad and roadway shall be protected with A.C. curbs to prevent embankment erosion.

Bridge maintenance structure may be part of the railway supporting structure or a' completely separate structure. If bridge maintenance structure is part of the main railway structure, the structure shall be designed for E-30 load to accommodate any future track needs or modifications. If bridge maintenance structure is a totally. separate structure it shalt be, designed for HS20-44 live load. The bridge maintenance width shall accommodate one 12 ft. paved lane with Curbs and railing. Deck of bridge structure shall be concrete with 6 Inches thick AC. pavement. Bridge deck shall provide curbs, railing; drainage, and joint seals as required;." Pavement of deck shall extend 20 ft. past the end of the structure and be placed over a 12 Inch thick minimum base.

Access roadway With turnaround or bridge maintenance structure shall be shown in the preliminary plans and complete design shall be 'included in all subsequent,: s u b m i t t a l s .

V SPECIFICATIONS

A. Design Specifications:

Underpass grade separation structures shall be designed and'construcied in accordance with the most current edition of the American Railway Engineering. Association (AREA) Manual of Recommended Practice.

Separate bridge maintenance structure shall be designed and constructed in accordance with the current edition of the American Association Of State Highway and Transportation Officials (AASHTO) standard specifications for highway bridges.

B. Construction Specifications:

Technical specifications for bridge construction shall comply with following:

1. AREA Specifications for Fabrication and Erection of Structural Steel (Chapter 15).
2. AREA Specifications for Concrete Structures and Foundations (Chapter 8)
3. AREA Specifications for Waterproofing (Chapter 29).
4. The Standard Specifications of the State% Highway Department or local agency responsible for the design and construction of highway bridges.
5. Standard Specifications of Public Works Departmen.
6. American Association of State transportation and Highway Officials (AASHTO).

VI UNITS

Grade separation underpass projects that require the use of metric units shall indicate all controlling dimensions, elevations., design criteria assumptions, and material stresses in dual units. English units to be in parenthesis., Controlling dimensions refer to length of structure, span length, thickness of ail deck elements; Controlling elevations refer to top of rail, rail profile, bridge seats, and footings., Design criteria or assumptions refer to live load, design speed etc;

VII BRIDGE LAYOUT

The following itemsshall 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. No 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.Manuai 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 iength .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 bc varied but' should be taken into account in the design,

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

5. Vandal fencing shall be provided on ail 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 design&-to accommodate any future shifting or relocation of track. Longitudinal members are to be evenly' spaced, with' no less than two support membersper raft.

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 foliowing, 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 block6 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 erids'of a skewed bridge, support slabs shall be provided for each track. End6 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 beydnd the back face of backwail.

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)	6.0 ft.	8.0 ft.
Recreational roads	12.5 ft.	12.5 ft.

Aii 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. Ail 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 iimit'hoiizontai 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.4

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 toads specified in . Chapters.9 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'requiredgrades with the minimum depth of ballast under the'tte of eight (8) inches for timber', and twelve (12) inches for concrete.

4. Under normal working loads, composite actiori 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 toads 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 prestiessed 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. Llve 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-j;	1
51-75.	2
Over78	3

Above number of diaphragrris 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 di.p galvanited'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 loadconfiguration 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 PO 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 shalt 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-se&n. The second stage of post tensioning shall be the application of the remaining portion of design prsstress 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 mast 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 (lst'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 unifoim 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 point&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 shalt be completed before moving' to the next stage. When casting the stage over supports, the concrete placement shall proceed from the outei 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 allowabie 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 'plane. 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.

i.' . 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 seated by welding except as approved by the Engineer.

XIV PAINTING OF STEEL STRUCTURES

All underpass steel structures shalt 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 Fainting 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 iess 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 Helght:

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 joint6 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.