

General Features of Design

Determination of Waterway Area, Restricted Waterways, Channel Openings

All information needed by the designer relative to the above three subjects will be set forth in the Preliminary Report.

Size of Culvert Openings

See "Culvert Design," Highway Design Manual.

Length of Culverts

See "Physical Standards for Culverts," Highway Design Manual.

Structural Design of Culverts

The Office of Structure Design shall be responsible for the Structural adequacy of all drainage structures.

Standard Box Culvert sheets are available for a large range, 4' to 14' span, of single and multiple box culverts. A standard Arch Culvert sheet is available for arches ranging in size from 6' to 22' span. Structural fill height tables are also available for corrugated metal pipe, structural plate pipe and reinforced concrete pipe.

Special designs of any drainage structure are to be prepared or reviewed by the Office of Structure Design to assure structural adequacy. All information needed for the structural design of special culverts (i.e., those outside the range of size and load capacity available in standard corrugated metal pipe and reinforced concrete not covered by the Standard Box or Arch Culvert sheets) will be furnished by the Districts.

Bridge Roadbed

1. Width

The width of bridge roadbed shall be measured normal to the centerline between the bottoms of curbs or if curbs are not used, the clear width shall be the minimum measured between the nearest faces of the bridge railing or barrier.

The width of bridges shall be as outlined by page 10-8 of this manual, Memo to Designers 14-2, and Topic 208 of the Highway Design Manual and in agreement with the geometric plan approved by the District Reviewer.

2. Medians on Bridges

Medians on multilane divided highways shall be decked over where the bridge median is 36 feet wide or less, or where prior approval of a wider deck median is given by Headquarters.

Where the median width exceeds 36 feet and prior approval is not given, an economic analysis should be made. In general, the most economical structure, with either a closed or open median, shall be used.

A median slab that might be used as a roadway at some later date shall be designed for the full live load. A median slab or open grating to be constructed above the general deck level may be designed for a allowable overstress of 50%

| See Chapter 7 of the Traffic Manual for requirements of median barriers.

3. Bridge Sidewalks

Bridge sidewalks shall be provided where justified by pedestrian traffic. See page 10-16 of this manual or Index 208.4 of the Highway Design Manual.

4. Pedestrian Overcrossings - Undercrossings - Bicycle Paths

The minimum clear width of deck for pedestrian and bicycle overcrossings shall be 8 feet. For bikeway bridges, the actual clear width shall be the paved width of the approach bikeway.

| The width of pedestrian undercrossings requires individual analysis and requires approval of Headquarters Office of Planning and Design. (See Index 105.2 of the Highway Design Manual.)

The details of pedestrian ramps are governed to a large extent by the requirements for the handicapped as issued by the Office or the State Architect and are included in the Memo to Designers.

5. Equestrian Undercrossings

Such structures shall normally provide a clear opening 10 feet high and 10 feet wide in cross section.



Clearance At Structures

A. Bridge Columns, Abutments, Retaining Walls and Barriers

1. Horizontal Clearance:

The horizontal clearance to bridge columns, abutments, retaining walls and barriers for freeways and expressways shall be determined upon the basis of engineering judgment with the objective of eliminating fixed objects from near the edge of shoulder wherever economically feasible. A horizontal clearance of 30 feet or more from the edge of the traveled way is desirable. Lesser clearances may be used where span length, median width or other controls make the desired clearance unreasonable.

The following are minimum horizontal clearance standards for bridge columns, abutments, retaining walls and barriers which, in the case of freeways and expressways, may be used only under very restricted conditions, upon individual analysis and with Headquarters' approval. Additional horizontal clearance shall be provided where necessary to meet sight distance requirements.

Clearances are measured from the edge of the traveled way.

- a) *Two-lane State Highways* – 10 feet minimum on each side.
- b) *Multi-lane Divided Highways* – For the through roadbed on divided highways and for freeway facilities including the through roadbed, auxiliary lanes, ramps and collector roads, the minimum clearance to the left of traffic shall be 9 feet. On the right side, the minimum clearance shall be 11 feet. In the case of extensive walls, 10 feet may be used on the right and 8 feet may be used on the left of traffic.
- c) *Other Roads and Frontage Roads* – On all other roads, including frontage roads, the minimum clearances to the face of the bridge columns, abutments, retaining walls and other obstructions shall be as follows:
 - Two-way traffic: 6 feet minimum on each side.
 - One-way traffic: 4½ feet minimum on the left and 6 feet minimum on the right in the direction of traffic.

The elevation in Figure 10-3 on page 10-11 illustrates the required distances from edge of traveled way to face of columns, abutments, walls, and other obstructions. Barrier-mounted walls shall meet the clearance requirement for bridge barriers.



2. Vertical Clearance:

Freeway and Expressway – The minimum vertical clearance shall be 16½ feet over the entire width of traveled way and shoulders on the through facility, speed change lanes, ramps and collector roads on all parts of the freeway and expressway system. Exceptions to this may apply when standard or existing routes having lower clearances make the higher standard impractical or where due to unusual conditions the cost of the higher standard becomes excessive. In such cases the minimum vertical clearance shall be 15 feet over the ultimate traveled way and 14 feet above the ultimate shoulders.

Non-Freeway or Expressway – The minimum vertical clearance at all other structures shall be 15 feet over the ultimate traveled way and 14 feet above the ultimate shoulders.

Pedestrian Overcrossings – The vertical clearance for pedestrian overcrossings shall be 2 feet greater than the vertical clearance provided for major structures on the portion of highway involved. If a pedestrian overcrossing is protected by a major structure, a clearance greater than that of the major structure need not be provided.

Sign Structures – All sign structures shall have a vertical clearance of 18 feet.

B. Highway Clearance in Tunnels

Tunnel construction is so infrequent and costly that the width should be considered on an individual basis.

Normally, the minimum horizontal clearance on high volume freeways in urban areas shall include the full roadbed width of the approaches.

In one-way tunnels on low volume freeways, freeways in rural areas, and on conventional highways, the minimum side clearance from the edge of the traveled way shall be 4½ feet on the left and 6 feet on the right. For two-way tunnels, this clearance shall be 6 feet on each side.

The minimum vertical clearance shall be 15 feet measured at any point over the traveled way and 14 feet above the lip of the gutter. The vertical clearance shall be 16½ feet on those routes selected for this clearance.

C. Clearance for Railroads

1. Railroad Tracks:

Minimum clearances, both horizontal and vertical, for structures over or adjacent to railroad tracks are established by the Public Utilities Commission of the State of California and are



set forth in their General Order No. 26-D, effective February 1, 1948, and in subsequent orders. This minimum vertical clearance over railroad tracks, as required by General Order No. 26-D and subsequent orders, for all new construction shall be 22 feet 6 inches except for electric railways carrying passengers only, and unless otherwise specifically directed. The Office of Structure Design is to increase this minimum vertical clearance by 6 inches to provide for future minor changes in track grades. The minimum vertical clearance shown on the plans shall be 23 feet 0 inches.

Horizontal clearances shall be as outlined on this page and as shown in Memo to Designers 17-105 and 17-115.

All curbs, including median curbs, shall be designed with 10 feet minimum clearance from the track centerline measured normal thereto.

It should be noted that collision walls may be required for the clearances given on page 2 of Memo to Designers 17-105. Usually no collision walls are required if the clearance is 10 feet or more on tangent track and 11 feet or more on curved track.

2. Off-Track Maintenance Equipment:

Eighteen foot horizontal clearance from centerline of track is required for sections of railroad where the railroad company is using or definitely plans to use off-track maintenance equipment. This clearance is provided on one side of the railroad tracks; the railroad company will specify on which side.

3. Approval of Railroad Clearances:

All plans involving railroad clearances shall be submitted to the railroad for approval. Such clearances are also subject to approval by the Public Utilities Commission.

D. Falsework Use

In many cases it is necessary to have falsework over traffic during construction in order to have support-free open area beneath the permanent structure. The elimination of permanent obstructions usually outweighs objections to the temporary inconvenience of falsework during construction.

The minimum width of traffic opening through falsework for various lane and shoulder requirements is shown on Table 10-1.



Table 10-1. Falsework Span Requirements

Facility To Be Spanned	Minimum Width of Traffic Opening	Opening Width Provides For
Freeway	25'	1 Lane + 8' & 5' Shoulders
	37'	2 Lane + 8' & 5' Shoulders
	49'	3 Lane + 8' & 5' Shoulders
	61'	4 Lane + 8' & 5' Shoulders
Non-Freeway	20'	1 Lane + 2 – 4' Shoulders
	32'	2 Lane + 2 – 4' Shoulders
	40'	2 Lane + 2 – 8' Shoulders
	52'	3 Lane + 2 – 8' Shoulders
Special Roadway (1)	64'	4 Lane + 2 – 8' Shoulders
	20' (2)	1 Lane + 2 – 4' Shoulders
	32' (2)	2 Lane + 2 – 4' Shoulders

NOTES: (1) Uses such as fire utility access or quasi public roads with very light traffic.
(2) No temporary railing provided.

When temporary K railings are used to protect the falsework, space must be provided for a two-foot deflection in the railing. Other forms of protection are available which may require less space for deflection.

In special cases, where existing restraints make it impractical to comply with the minimum widths of traffic openings set forth in the table above, a lesser width may be approved by the Chief of the Office of Project Planning and Design.

The minimum temporary vertical clearance over freeways shall be 15 feet 0 inches, with the following exceptions: Minimum temporary vertical clearances of 14 feet 6 inches may be used over freeways for bridge widenings or other special cases when approved by the Chief of the Office of Project Planning and Design.

In the case of falsework over conventional highways or streets, careful consideration may be given to the use of vertical clearance of 14 feet 0 inches where falsework clearances control the grade line and where trucks may be diverted. Substantial savings are possible with a lower grade line. In choosing between 14 feet 0 inches and 15 feet 0 inches clearance, each case shall be considered on its merits. Careful attention shall be given to the relative cost of the higher clearance as compared with the cost of adequate traffic control by advance warning devices; the



nature, volume and speed of traffic; the safety of traffic; the effect of an increase in vertical clearance on the grades of other sections of roadway; the feasibility of closing the local street to all traffic during construction or closing the local street to all truck traffic, but leaving it open to automobiles; the use of detours; the feasibility of carrying local traffic through construction on subgrade or lowering the existing facility temporarily or permanently. Over height buses in use in Los Angeles and San Francisco areas may affect vertical clearance requirements. Applications for impaired falsework clearances should include a cost savings over the 15 feet 0 inches standard.

Where the vertical falsework clearance is less than 15 feet, advance warning devices shall be specified or shown on the plans. Such devices may consist of flashing lights, overhead signs, overheight detectors, or a combination of these or other devices. (Providing for these devices is usually the responsibility of the District.)

To establish the grade of a structure to be constructed with a falsework opening, allowance must be made for the depth of the falsework. The minimum falsework depth required for a given traffic opening is dependent on the falsework span and the superstructure depth. Table 10-1 lists the falsework opening widths required for various roadways. Table 10-2 on page 10-8 lists the falsework depths required for the openings shown in Table 10-1. Falsework depth requirements for traffic openings not listed in Table 10-1 may be derived from Figure 10-1 on page 10-9.

Falsework depths listed in Table 10-2 and shown in Figure 10-1 are based on tangent structures which are supported on falsework stringers placed parallel to the superstructure. Structures which are horizontally curved, or are skewed to the traveled way being spanned, frequently require falsework stringer placement perpendicular to the traveled way as depicted in Figure 10-2 on page 10-10. When falsework is constructed in this manner, the point of minimum vertical clearance may be located at an exterior falsework stringer outside the edge of deck of the structure.

The Office of Structure Construction should be consulted when there are questions about falsework depth requirements or when falsework spans exceed 90 feet.

Where vertical clearances, either temporary or permanent, are critical, the District and the Office of Structure Design shall work in close conjunction during the early design stage when the preliminary grades, structure depths and falsework depths can be adjusted without incurring major design changes.



Table 10-2. Falsework Depth Requirements

Table 10-2 is derived from the curves in Figure 10-1 on page 10-9 and is a tabulation of the minimum falsework depth requirements for the specific traffic width openings included in Table 10-1, "Falsework Span Requirements." The falsework depth values are based on optimum falsework stringer size selection for the various listed structure depths.

Facility to be Spanned	Minimum Width of Traffic Opening	Depth Of Superstructure			
		Up to 6'	Up to 8'	Up to 10'	Up to 12'
		Minimum Falsework Depth			
Freeway	25'	1'-10½"	2'-1"	2'-1"	2'-8½"
	37'	2'-9"	2'-11½"	3'-0"	3'-3"
	49'	3'-3"	3'-3½"	3'-3½"	3'-3"
	61'	3'-5"	3'-5"	3'-7"	3'-7½"
Non-Freeway	20'	1'-9"	1'-10"	1'-10"	1'-10½"
	32'	2'-0"	2'-8½"	2'-9"	3'-0"
	40'	3'-0"	3'-0"	3'-2½"	3'-3"
	52'	3'-3"	3'-3½"	3'-3½"	3'-4"
Special Roadway	64'	3'-5"	3'-7½"	3'-7½"	3'-8"
	20'	1'-9"	1'-10"	1'-10"	1'-10½"
	32'	2'-0"	2'-8½"	2'-9"	3'-0"

Because the width of traffic openings through falsework can significantly affect costs, special care should be given to determine opening widths. The following should be considered: staging and traffic handling requirements, the width of approach roadbed that will exist at the time the bridge is constructed, traffic volumes, desires of the local agencies, controls in the form of existing facilities, and the practical problems of falsework construction, such as skew of roadway, direction of falsework stringers, extension of falsework beneath existing deeper girder bridges, etc.

The placement and removal of falsework requires special consideration. During these operations, traffic shall either be stopped for short intervals or diverted away from the span where the placement or removal operations are being performed. The method of traffic handling during these operations shall be included in the Special Provisions.

Impaired clearances for falsework over railroads are permissible under special conditions, but are subject to the rules and regulations of the Public Utilities Commission of the State of California and the requirements of the operating railroad.

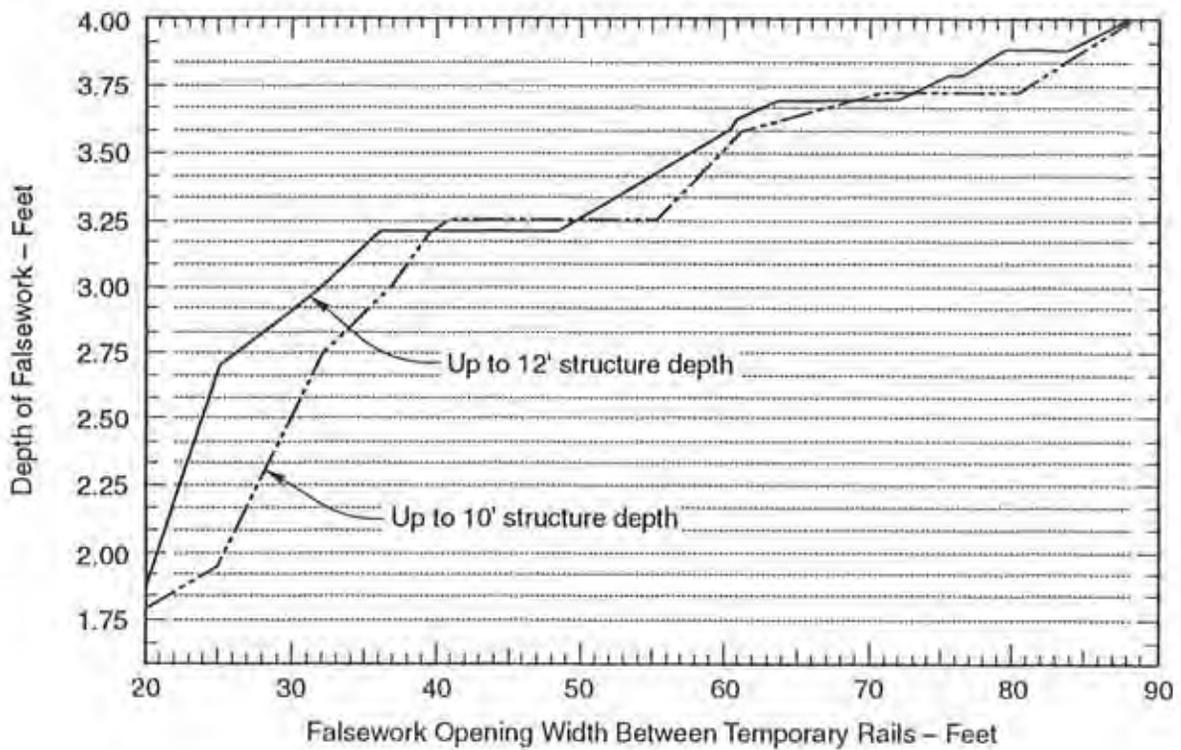
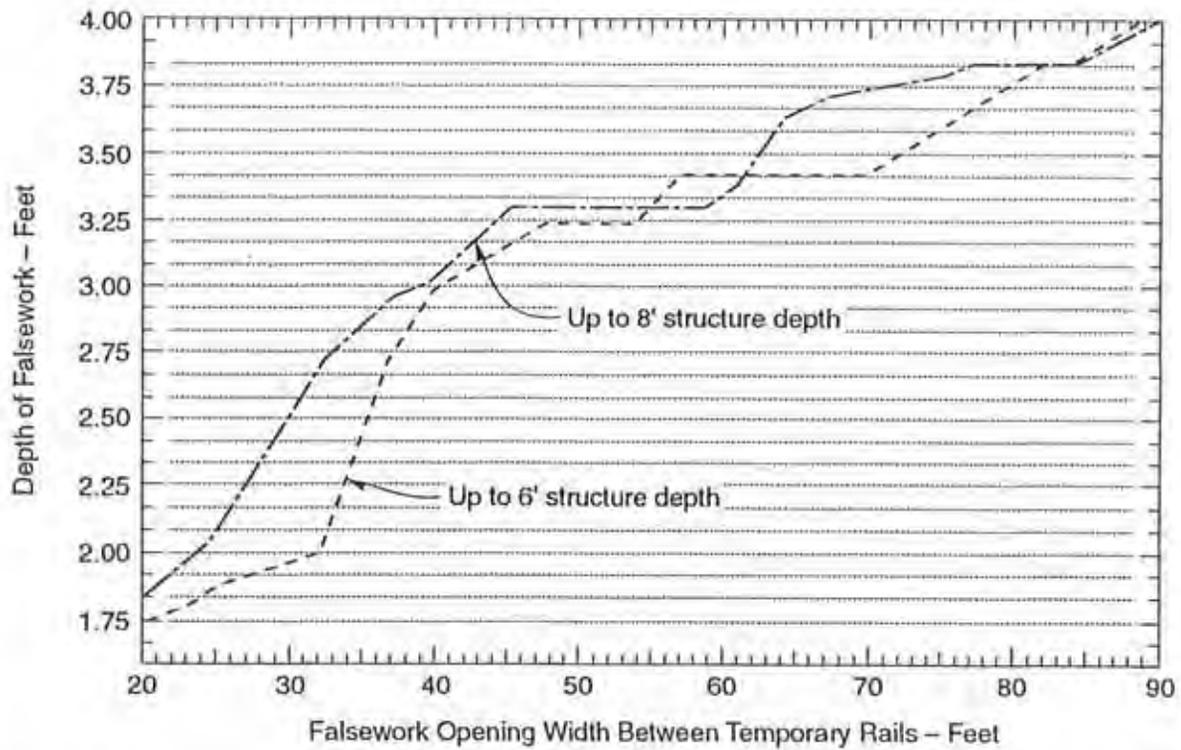
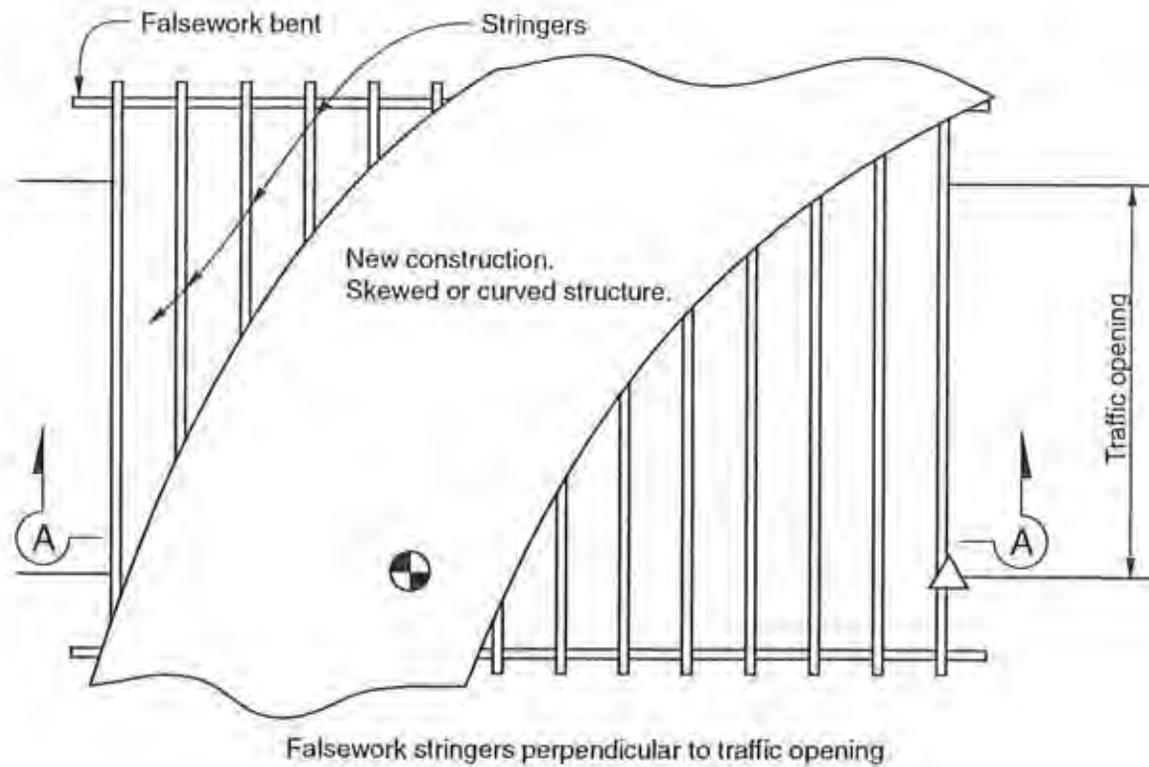
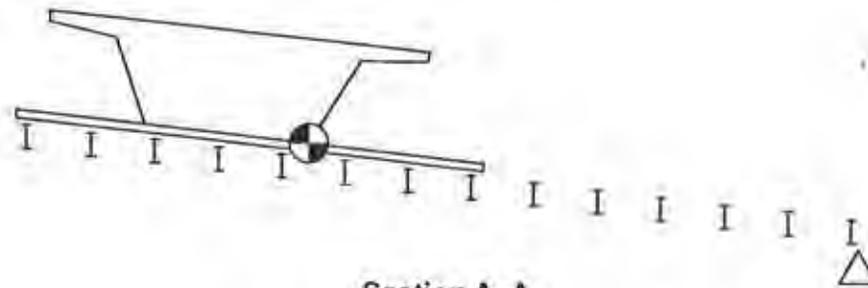


Figure 10-1



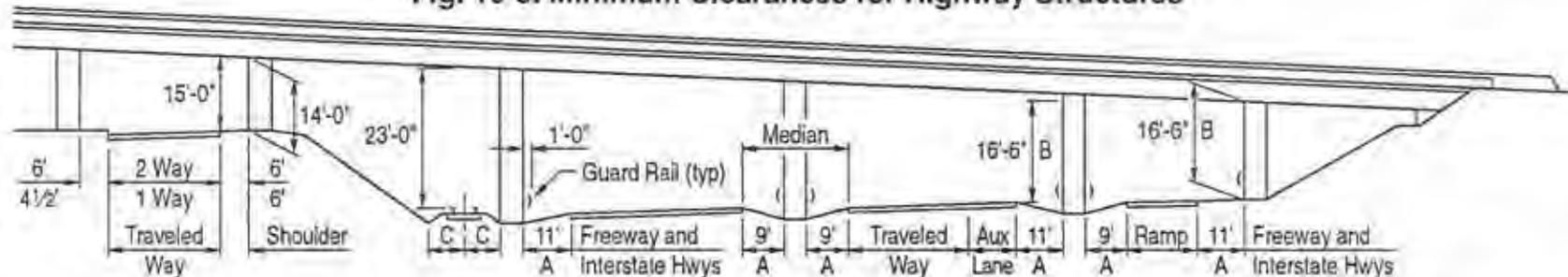
Plan



-  Location of final minimum vertical clearance
-  Location of minimum temporary vertical clearance

Figure 10-2

Fig. 10-3. Minimum Clearances for Highway Structures



Frontage Roads and
Non-Freeway Roads

Notes: A. To be used only where desired clearances of 30 feet is unreasonable.
B. Clearance at edge of shoulder.
C. For clearances, see Memo to Designers 17-105 and 17-115.

ELEVATION

When additional vertical clearance will add to the project costs, the above minimum vertical clearances may be extended up to 0.5 foot. When vertical clearance exceeds this tolerance, Federal participation will be based on the minimum given.

Standards for Bridge Shoulder Width ⁽⁷⁾

Freeways and Expressways	Shoulder Width (Feet)	
	Left	Right
a. 4 Lanes	5	10
b. 6 Lanes or more	10 ⁽¹⁾	10
c. Separate Roadways	⁽²⁾	10
d. Auxilliary Lanes		10
e. Fwy to Fwy Connections	5	10 ⁽³⁾
f. Ramps	4 ⁽⁴⁾	8 ⁽⁵⁾

Conventional Highways	Shoulder Width (Feet)	
	Left	Right
a. Multi-lane Divided	⁽⁶⁾	8
b. Multi-lane Undivided		8
c. Two Lane		
Design Yr Traffic		
ADT under 400		4 ⁽⁴⁾
ADT 400 – 1,500		6
ADT over 1,500		8
d. Climbing Lanes		4

Notes:

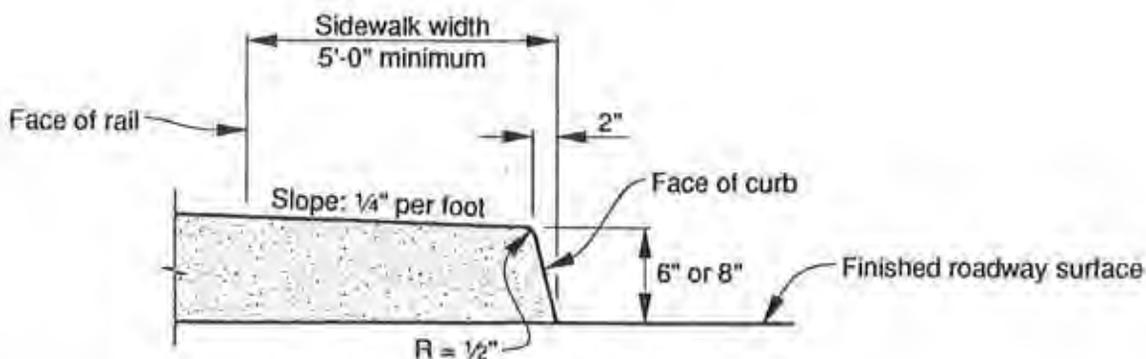
- ⁽¹⁾ On I-3R projects, 5 feet on 6-lanes and 8 feet on 8-lanes are acceptable. (See Highway Design Manual, Topic 302.1)
- ⁽²⁾ Use a and b above.
- ⁽³⁾ A single lane connection over 1,500 feet in length shall be widened to 2-lanes with 5 foot shoulders.
- ⁽⁴⁾ Minimum width on structure.
- ⁽⁵⁾ A single lane ramp widened to 2-lanes shall have (in the 2-lane section) 2-foot shoulder in rural areas or 4-foot permissible in urban areas.
- ⁽⁶⁾ Use 5 feet for 4-lanes and 8 feet for 6 or more lanes.
- ⁽⁷⁾ Lane references are for total number in both directions.



Curbs

1. Type H Curb

To be used for matching approach roadway curb.



2. Match Existing Curbs

Curbs or sidewalks may be made to match those on existing adjacent streets, or to conform to city or other standards, if local authorities so request.

3. Omit Curbs

Curbs shall be omitted from structures unless required for sidewalks or drainage.

4. Highway Design Manual

Topic 209 – Curbs and Gutters, covers policy and procedures for curbs on highway facilities.

CONCRETE BARRIERS & BARRIER RAILINGS
(STRUCTURES)

General Policy

The purpose of structure barriers is to retain and redirect errant vehicles. Special attention shall be given to barrier railing design on structures having heavy pedestrian traffic or located near schools.

In general, there are four classes of barrier or railings:

- (a) Vehicular barriers.
- (b) Combination vehicular barriers and pedestrian railings.
- (c) Pedestrian railings.
- (d) Bicycle railings.

Listed below are the approved types of barriers and railings for use on bridge structures including overcrossings.

Concrete Barrier Types 25 and 26 are vehicular barriers designated for general use on structures. The Bridge Approach Railing type and length is usually recommended by the Districts.

The type of pedestrian railing and/or combination thereof, shall be selected by the District and a recommendation included with the bridge site data forwarded to the Office of Structures Design.

On structures which are to be transferred to local jurisdictions and which do not cross over a State highway, consideration may be given to use of local standards where such a request is made by local authorities.

Vehicular Barriers or Railings

CONCRETE BARRIER TYPE 25

This barrier is designated for general use. It has functional vehicle redirection characteristics similar to the Concrete Barrier Type 50.

BARRIER RAILING TYPE 18 (metal tube)

This railing may be used in those situations where a self-cleaning deck is required. It should not be used where drainage off the sides of the structure is a hindrance to anything beneath it.

Combination Railings (Vehicular and Pedestrian)

CONCRETE BARRIER TYPE 26

This is the barrier for general use when sidewalks are provided on a bridge which also carries vehicles. It must be accompanied with a tubular handrailing or a fence-type railing.

The standard sidewalk width is 5'; however, this width may be varied as circumstances require.

CHAIN LINK RAILING TYPE 7

This is the fence-type railing for general use with Concrete Barrier Type 26 to prevent objects from being thrown to the roadway below. When a sidewalk (Type 26 barrier) is provided on one side of a bridge and Type 25 barrier on the other side, Type 7 railing may be placed on the top of the Type 25 as additional protection from thrown objects. Consideration should be given to the effect of the Type 7 railing on sight distance at the bridge ends and view over the side of the bridge.

CHAIN LINK RAILING TYPE 6

This railing may be used in lieu of Type 7 when special architectural treatment is required.

TUBULAR HAND RAILING

This railing is used with Type 26 (or Type 25) to increase the combined rail height for the safety of pedestrians. It should be used in lieu of Type 7 where object throwing will not be a problem or at ends of bridges to increase sight distance if fence-type railing would restrict sight distance.

Pedestrian Railings

CHAIN LINK RAILING TYPE 3

This railing is used on pedestrian structures to prevent objects from being thrown to the roadway below.

CHAIN LINK RAILING TYPE 7 (Modified)

This railing is similar to Type 7 except that it is mounted on the structure at the sidewalk level.

CHAIN LINK RAILING (Six-foot)

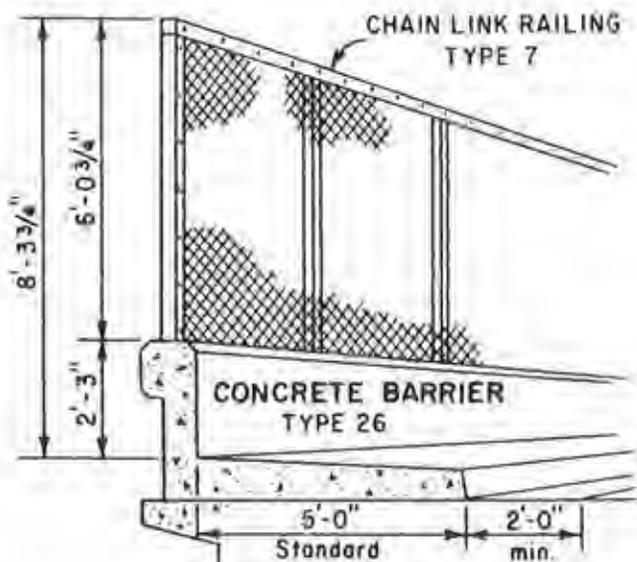
This railing is not as high as Type 3 or 7 (Modified) and therefore, its use is restricted to those locations where object

throwing will not be a problem (i.e., the ramp portion of pedestrian overcrossing when the ramp is not parallel to any roadway below).

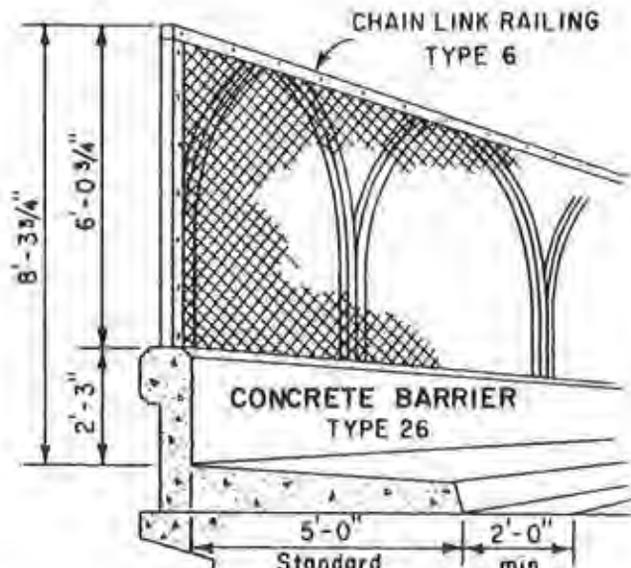
Bicycle Railings

The minimum height of bicycle rail is 4' 6" above the deck surface. Therefore, any of the combination railings or the chain link railings are satisfactory for bicycle rails. Bicycles are not considered to operate on the walking surface of a sidewalk.

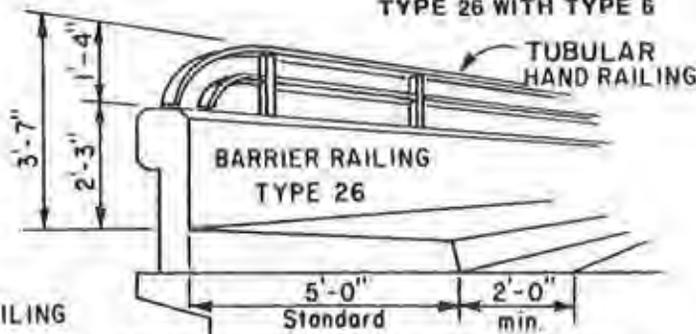
COMBINATION RAILINGS FOR BRIDGE STRUCTURES (VEHICLE & PEDESTRIAN)



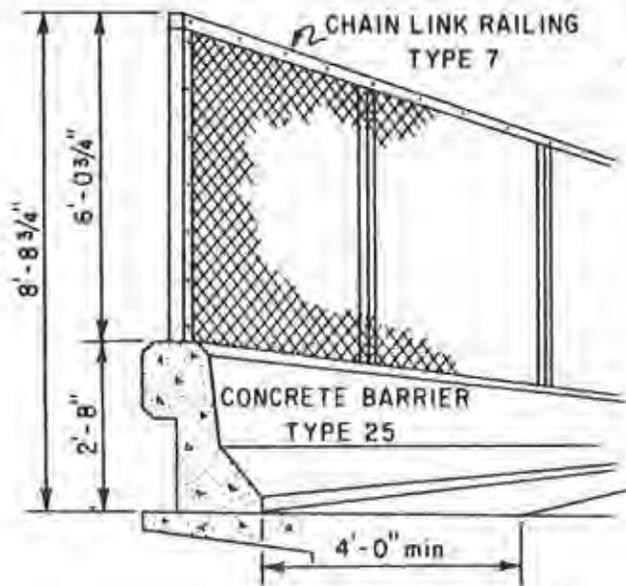
TYPE 26 WITH TYPE 7



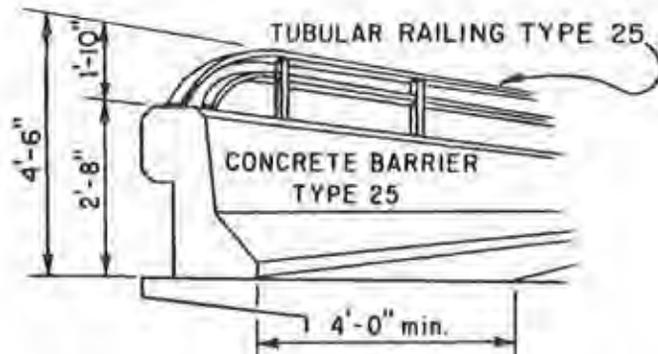
TYPE 26 WITH TYPE 6



TYPE 26 WITH TUBULAR HAND RAILING

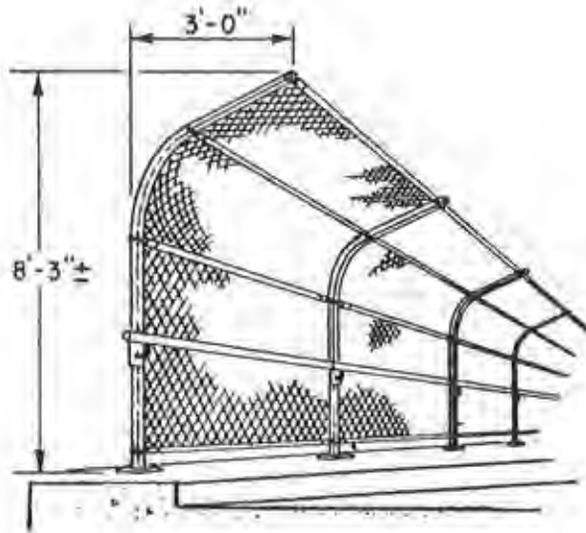


TYPE 25 WITH TYPE 7

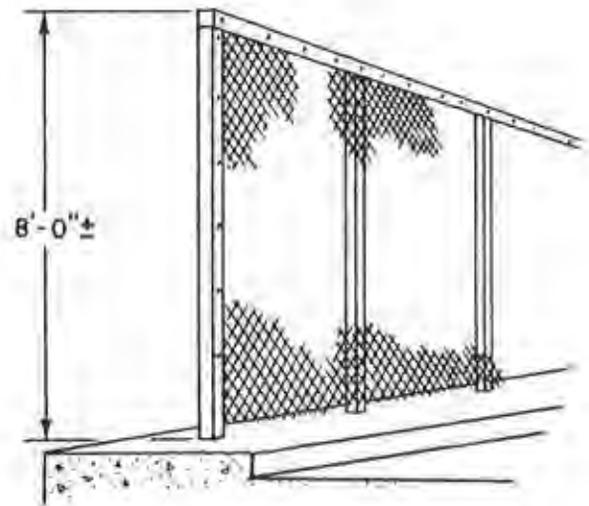
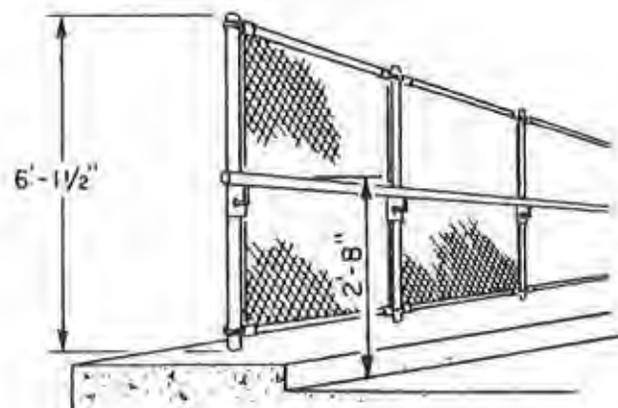


TYPE 25 WITH TUBULAR RAILING TYPE 25

PEDESTRIAN RAILINGS FOR BRIDGE STRUCTURES



CHAIN LINK RAILING TYPE 3

CHAIN LINK RAILING
TYPE 7 (MODIFIED)

CHAIN LINK RAILING (6 FT.)

ROADWAY DRAINAGE

The transverse drainage of roadways shall be secured by means of a suitable crown in the roadway surface and longitudinal drainage by camber or gradient. If necessary, longitudinal drainage shall be secured by means of scuppers, inlets or other suitable means, which shall be of sufficient size and number to drain the gutters adequately. If drainage fixtures and downspouts are required, the downspouts shall be of rigid corrosion-resistant material not less than six inches in least dimension, provided with suitable cleanout fixtures. The details of floor drains shall be such as to prevent the discharge of drainage water against any portion of the structure. Overhanging portions of concrete decks preferably shall be provided with drip grooves.

1. Roadway Drainage Details

Cross drainage of bridge decks is provided by crown or cross slope of the surface. The crown is normally centered on the bridge except for one-way bridges where a cross slope in one direction is used. The cross slope shall be the same as the approach pavement.

Bridge deck drains shall not discharge on approach embankments or on other areas where harmful erosion may occur. On railroad overheads and on highway separation structures of sufficient length to require deck drains it is usually necessary to install a system of longitudinal pipes below the deck slab to convey storm water to points where it may be discharged without damage to property below the structure. Drainage facilities should be designed in such a manner that they will be as inconspicuous as practicable. Drainage of bridge decks requires adequate grade. Vertical curves on bridge decks should provide a minimum fall of 0.05 foot per station. This fall shall not extend over a length greater than 100 feet. The flattest allowable tangent grade shall be 0.12 percent. The flattest allowable tangent grade on long bridges where drainage is confined to the bridge deck shall be 0.25 percent.

SUPERELEVATION

The superelevation of bridge decks shall be the same as that for highways. The Highway Design Manual contains complete information on superelevation and superelevation transitions.

Superelevation diagrams or grid sheets are incorporated in the Preliminary Report. If this information is lacking or incomplete, it will be supplied by the district on request.

Transitions which fall on a structure sometimes cause an unsightly warp in the bridge railing. If this happens it should be called to the attention of the district. It may be possible to shift or alter the transition.

SURFACING ON BRIDGES

It is the policy of the Office of Structures Design to provide a concrete deck as the final riding surface on all new bridges. Some requests have been received from Districts to provide asphaltic surfacing across an isolated short bridge. A critical review should be made of all such requests. Asphaltic surfacing is often required to match existing bridge surfacing material, or to modify the bridge cross slope on bridge widenings. Modification of railing, deck drains and expansion joint details should be considered with asphaltic surfacing.

District requests to match the coloring of approach roadways may be accomplished with the application of a slurry seal.

Special surfacing and seals may be required in areas where salts are used to prevent icing.

Contrast Treatment

See Topic 7-706 of the Highway Design Manual.

UTILITIES

Where required, provisions shall be made for trolley wire supports and poles, pillars for lights, electric conduits, telephone conduits, water pipes, gas pipes and sanitary sewers.

ENCROACHMENTS ON BRIDGES

When required, or when permitted, provisions shall be made for the encroachment of public utility facilities on or near bridges.

The District makes the fundamental decision to permit an encroachment in accordance with the Department of Transportation's "Policy on Encroachments in Highway Rights of Way."

The District submits the information on proposed encroachments on or near bridges to the Office of Structures Design.

During the design stage, the bridge designer reviews the proposal for the following:

1. Structural adequacy of the bridge for the weight and location of the facility.
2. Compliance with the "Encroachments on Bridges" section of the policy on encroachments.
3. Conflicts in construction sequence.

The District and bridge designer should work in close conjunction with their Permit Engineers to avoid commitments that conflict with the encroachment policy. The bridge PS&E should clearly show the utility work to be performed by the State's contractor.

The minimum information necessary on the plans consists of the name of the owner, general description, and the location of the facility, openings and access openings (if required). In addition, all hardware and material to be furnished and/or installed by the State's contractor must be shown.

The District prepares the encroachment permits at the completion of the PS&E. Those involving bridges are submitted to the Office of Structures Maintenance for approval. Upon approval the District issues the permits.

During construction, inspection of the work is performed from the plans, specifications and the details of the permits.

SPECIAL REQUIREMENTS FOR RAILROAD STRUCTURES

In almost all cases the agreement between the State and the railroad company for the construction of a railroad underpass (a structure carrying railroad tracks over a highway) provides that upon completion of construction the State will maintain the substructure (piers and abutments up to the bridge seats) and the railroad company will maintain the superstructure. In view of their responsibility in connection with such maintenance the railroad companies have certain special requirements and preferences which must be observed in connection with the design and construction of underpass superstructures carrying their tracks. These requirements are shown in Section 17 Memo to Designers.

SELECTION OF TYPE

GENERAL

Structures designed by the Division of Structures can be described by the principal type of construction such as slab, T-beam, box girder, steel girder, etc. Selection of the proper type for any given location is the responsibility of the Design Engineer, subject to approval of the Design Supervisor. The Project Designer prepares studies and makes recommendations for structure type under the direction of the Design Engineer. Economy, safety and aesthetics are generally the controlling factors. Selection may be based on other considerations as well, such as:

- Deflection
- Maintenance cost
- Traffic convenience during construction
- Time for construction
- Construction worker safety
- Similarity to adjacent structures
- Superstructure depth and other preferences
- Substructure details
- Suitability for widening for ultimate construction
- Feasibility of falsework
- Passage of flood debris
- Seismicity at the site
- Commitments made to officials and individuals of the community.

The structure selected for the site should be the type which best satisfies the traffic conditions and the environment in which it is located. The importance of considering how traffic will be handled at a particular bridge site during the general plan stage of plan preparation cannot be overemphasized. Failure to give adequate thought to traffic handling early in project development can lead to situations in which safety is compromised to avoid major changes in completed plans. Finding the least costly method of handling traffic safely through construction projects requires close cooperation and good communication between the Districts and the Division of Structures. The depth to span ratio shown for each structure type has proven to be workable and satisfactory for most ranges of variables in structure configurations with constant structure depth. Variations from those ratios should be considered only for special cases at the advanced planning study stage.

REPORT

After fully considering the above factors to determine the proper structure type, the Project Engineer and Design Engineer are to discuss the architectural features with the Structures Aesthetics and Model Section. For large or controversial projects, discussions should also be held with District Design and Landscape personnel. These may be individual or joint discussions as dictated by the size, complexity and sociological, economical, ecological and environmental demands of the project.

Through these discussions a structure with architectural features that are compatible with structural, safety and site requirements can be developed. These discussions and resulting mutual agreements take place before the general plan is prepared.

Form DSD 0045, "Structure Type Selection" shall be completed to document the decisions made through this planning process. A copy of Form DSD 0045 is on page 10-23. Under the "Engineering and Architectural Summary" heading, enter a brief discussion or outline of factors which were considered in making the determination of structure type and related architectural features. The color for steel bridges should also be entered under this heading. The color selection should also be mutually satisfactory to the District and the Division of Structures. In the transmittal letter which accompanies the reduced prints to the Districts, concurrence or comments should be requested for the recommended color. Dates of meetings with other than Division of Structures personnel and of visits to the sites should be noted along with the participants' names. Visits to structure sites where the terrain is not changed is required by policy to ensure that the structure fits the site. Bridge Design, Construction and District personnel should coordinate this effort. The completed "Structure Type Selection" shall accompany two (2) reduced prints of the General Plan and should be routed as listed on the form.

Under "Types Considered," a complete discussion of the cost and feasibility of alternative designs must be included. This is especially important for unusual and major structures (see page 10-24, Alternative Designs).

DEPARTMENT OF TRANSPORTATION
STRUCTURE TYPE SELECTION

DSD 0045 (Rev. 2/90)

PROJECT IDENTIFICATION

DATE

DIST	CO	RTE	PM	CU	EA	DESIGN GROUP
------	----	-----	----	----	----	--------------

BRIDGE NAME(S)	BR NO(S)	PM	CONSTRUCTION COST - \$	DESIGN HRS REQ'D

TYPES CONSIDERED:

PREVIOUS COMMUNITY AESTHETIC OR ECOLOGICAL COMMITMENTS:

ARCHITECTURAL RECOMMENDATIONS: (SKETCH ELEV & X-SECT; GIVE STD. COL. NO.)

ENGINEERING AND ARCHITECTURAL SUMMARY:

- (1) DESIGN ENGR _____
- (2) BR DES SUPV _____
- (3) BR ARCH PLNR _____
- (4) CHIEF STRUOT DES _____
- (5) FILE _____

PROJECT ENGINEER
PROJECT ARCHITECT

ALTERNATIVE DESIGNS

In order to maximize competition among bidders and thus achieve the lowest possible total project cost, alternative designs are occasionally necessary. Alternative designs include plans which provide for a choice of structure types or materials, span arrangements or construction methods.

Such alternative designs may be appropriate for structures of any size. However, when federal funds are used, the FHWA requires that an analysis of alternatives be made and documented during the planning stage for all unusual or major (Cost > \$10 million) structures.

Complete alternative designs should be prepared whenever:

1. Preliminary studies indicate costs for two or more alternative designs are nearly equal and,
 - a. The competing alternatives are aesthetically acceptable. This generally eliminates the use of alternative types for individual components of large interchanges.
 - b. The construction of all competing alternatives can be accomplished without unacceptable effects on the environment and within an acceptable time limit.
2. A proprietary system appears to be competitive. In order to provide for open competition, a nonproprietary alternative design is then provided so that any qualified contractor may bid.

The decision as to which projects warrant alternative designs will generally be made at the General Plan development (type selection) stage.

If the decision is made not to develop alternative designs for a major structure, sufficient justification should be included in the Structure Type Selection memo. Such justification can be based on relative costs, serviceability, aesthetics or geometric constraints. This information is required by the FHWA if they are to waive their requirement that alternative designs be prepared for major bridges. The Project Engineer will provide this information to the Planning Section for inclusion in the letter transmitting the General Plan to the FHWA.

CHARACTERISTICS OF TYPES OF STRUCTURES

Regardless of structure type, the following factors are to be considered in any recommendation:

1. Bearings, hinges, drainage, expansion details and excessive skew create maintenance problems. Consideration should be given to minimizing the number of these details on a structure.
2. Steel structures require maintenance painting which varies in frequency throughout the State. Cost and hazard of this painting should be considered in type selection studies.

3. Generally, concrete structures require less maintenance than steel structures. Structures with articulated details will present more maintenance problems than monolithic structures.
4. Cast-in-place structures constructed over traffic will require falsework openings and guard railing. Often the openings will entail impaired vertical clearance. Grade lines may be determined by falsework requirements where large horizontal openings are required. The falsework requirement should be based on ultimate construction conditions if it is planned to widen the structure at some future date.

Following is a list of the general characteristics of the common types of bridge structures which will help in determining structure type for a specific site. The comments made in regard to each structure type are general in nature. In special situations such as large projects, a large number of repetitive spans, long spans, clearance problems, etc., the types considered should be expanded and the use of alternatives given serious consideration.

The Project Designer should be ever aware of new and innovative structure types and construction methods that could be used to advantage in any given situation and condition. Included in the "innovative" types or details should be segmental (cast-in-place or precast) partial length P/S tendons, stayed girders and launched girders.

As span lengths increase the types considered should include trusses, suspension bridges and arches (steel and/or concrete).

In general the larger the structure the more comparative studies should be made.

Slab

Cost: Most economical type of bridge for spans up to approximately 40± feet.

Construction: Details and form work simplest of any type.

Appearance: Neat and simple. Desirable for low short spans. Pile bents may be aesthetically undesirable for bridges 10 feet or higher.

Structural: Standard designs on hand. No stress analysis necessary except for nonstandard span layouts.

T-Beam

Cost: Generally economical for spans 40 to 60 feet.

Construction: Form work complicated, particularly for skewed structures.

Appearance: Not as desirable from below. Elevation same as Box Girder.

Structural: Requires detailed stress analysis. Depth span ratio: 0.070 simple span, 0.065 continuous span.

Other: Greatest use is for stream crossings. Do not use for streams which carry drift and the grade line provides less than 6 feet of clearance over high water.

Box Girder (Cast-In-Place Reinforced)

Cost: Slightly higher costs than T-Beam except for spans of 60 feet or more. Used for spans 50 to 120 feet. Should not be used on simple spans over 100 feet due to excessive dead load deflections. Usually more economical than steel girders and precast concrete girders.

Construction: Rough finish satisfactory on inside surfaces. Form work simpler than T-Beam for skewed structures but still complicated.

Appearance: Good from all directions. Conceals utilities, pipes and conduits.

Structural: Requires detailed stress analysis. Depth span ratio: 0.060 simple spans, 0.055 continuous spans. High torsional resistance makes it desirable on curved alignments.

Other: Excellent in metropolitan areas.

Box Girder (Cast-In-Place Prestressed)

Cost: About the same as conventionally reinforced box girder. Used for spans up to 600 feet.

Construction: Same as conventional box girder.

Appearance: Better than conventional box girder because of shallow depth. Has all other qualities of conventional box girder.

Structural: Requires detailed stress analysis. Depth span ratio: 0.045 simple spans, 0.040 continuous spans. High torsional resistance makes it desirable on curved alignment. Dead load deflections minimized. Desirable for simple spans over 100 feet. Long-term shortening of structure must be provided for.

Other: Excellent in metropolitan areas. Can be used in combination with conventional box girders in long structures with varying span lengths to maintain constant structure depth. Excellent for widenings to control deflections.

Prestressed Concrete Slabs

1. Cast-In-Place

Cost: More expensive than reinforced concrete slabs.

Construction: More difficult than reinforced concrete slabs.

Appearance: Same as reinforced concrete slabs.

Structural: Used for spans up to 65 feet. Recommended for conditions where very low depth span ratio is required. Can be used for either simple or continuous spans. Depth span ratio: 0.030 for simple and continuous spans.

2. Precast

Cost: Is economical where many spans are involved or in desert areas.

Construction: Details and form work very simple. Shop fabrication methods employed.

Appearance: Same as reinforced concrete slab.

Structural: Standard plans for cored slabs of spans 20 to 50 feet are available. Not recommended for long multispan structures because of difficulties in camber control resulting in undesirable riding qualities.

Prestressed Concrete Girders (Precast)

Cost: Competitive with steel girders. Generally costs more than reinforced concrete of same depth to span ratio.

Construction: Fabrication plants in Long Beach, Visalia, Napa, Santa Fe Springs, Antioch and other areas. Requires careful handling after fabrication.

Appearance: Similar in appearance to T-Beam. Straight girders on curved alignment look awkward.

Structural: Applicable to spans 30 to 150 feet. Standard detail plans are available for "Double T" and "I" girders to cover complete range of spans. Requires design analysis to determine prestress force, concrete strength and camber. Structure depth is girder depth plus necessary slab thickness. Girders longer than 120 feet cannot be hauled over State highways.

- "Double T"
Girder: Suitable for spans 30 to 60 feet. Maximum girder depth for standard forms is 2'-8". Design must give serious consideration for camber control to minimize changes in camber with time.
- "I" Girder: Suitable for spans 50 to 120 feet. Maximum girder depth for standard forms is 5'-6". Depth and span ratio: 0.055 simple, 0.050 continuous.
- "Δ" Girder: Suitable for spans 120 to 150 feet. This type of girder may be fabricated in segments, hauled to the job site and post-tensioned either on the ground or on falsework.

Composite Welded Girder

- Cost: Suitable for spans 60 to 300 feet. May be competitive when erected type of superstructure is required. Competitive with precast concrete girders.
- Construction: Details and form work simple. Transportation of prefabricated girders may be a problem.
- Appearance: Can be made to look attractive. Girders can be curved to follow alignment.
- Structural: This structure type has low dead load, which may be of value when foundation conditions are poor. Depth span ratio: 0.060 simple spans, 0.045 continuous spans. Can be adapted to curved alignment.

Structural Steel Box

- NOTE: Because of the many opportunities for welding and detail errors that can give rise to fatigue failures, the steel box should only be used in very special circumstances.
- Cost: Usable for spans 60 to 500 feet. More expensive than steel "I" girder. More economical in the upper range of usable span and where depth may be limited.
- Construction: Very complicated welding and welding details.
- Appearance: Generally pleasing. Better than steel or precast concrete girders.
- Structural: Generally would use multiple boxes for spans up to 200 feet and single box for longer spans. Depth span ratio: 0.045 for continuous spans, 0.06 for simple spans.

Railroad Structures (Steel)

- Cost:** Deck type structures are more economical than through girder structures.
- Construction:** Details and form work simple. Shop fabricated.
- Structural:** Reinforced concrete deck preferred. Steel plate deck may be used. Deck type preferred. SP Transportation Company policy is to require deck type except under unusual conditions. Depth span ratio: 0.10 for deck type (not including the 2'-0" from top of rail to bottom of ballast). Through girder structures require deck thickness of about 4.2 feet for single track; 4.8 feet for double track. (Includes 2'-0" from top of rail to bottom of ballast.) Depth span ratio of through girders 0.13.

Railroad Structures (Prestressed Concrete)

- Cost:** Generally more economical than structural steel underpasses. Preferred for aesthetics, economy and maintenance.
- Construction:** Form work complicated. About the same as prestressed box girder.
- Structural:** Through girders for single track only. Requires 5.0 feet from top of track to soffit. Depth to span ratio 0.07 for through girders. Deck girder or box type for any number of tracks. Depth to span ratio: 0.08 simple span, 0.07 continuous. This ratio does not allow for the 2.0' required for ballast and rail height.
- Other:** Not acceptable to Union Pacific RR. Deck type preferred by SPT Co.

Pedestrian Structures

Tunnel type pedestrian undercrossings are not desirable from the standpoint of personal safety and psychological effects. Also excessive vandalism of walls and lighting adds to the maintenance costs.

Pedestrian overcrossings are the preferable type of pedestrian structure. They shall be of the deck type of superstructure rather than through type to minimize defacement and provide an open view for personal safety. Profile of the structure should have a rising symmetrical vertical curve over the traffic lanes to enhance the appearance of the structure. Curved changes in horizontal alignment are more preferable than angular changes.

Minimum desirable structure depth to span ratios are 0.04 for steel and 0.033 for reinforced concrete and prestressed concrete. Smaller depth to span ratios should be avoided because of possible excessive live load deflection.

ABUTMENTS

TYPES — SEE PAGE 10-31

Abutments are placed in two basic categories: Open End and Closed End. Within these two categories are several types of abutments as follows:

1. Open End
 - a. Diaphragm
 - b. Seat type abutment

2. Close End
 - a. Backfilled
 - (1) Cantilever Abutment
 - (2) Struted Abutment
 - (3) Rigid Frame
 - b. Cellular
 - (1) Bin
 - (2) Closure Wall

TYPE SELECTION

Open end structures are usually more economical, adaptable and attractive than closed abutments. Since they have lower height abutment walls, there is less settlement of road approaches than for the higher backfilled closed abutment. They also permit more economical widening than the closed abutment type.

SLOPE PAVING

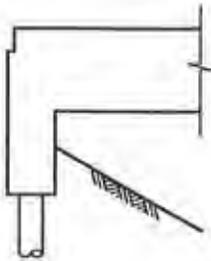
General policy of the Office of Structures Design relative to slope paving is outlined in Memo to Designers 5-10 and *Highway Design Manual*, 872.3.

It is the District's responsibility to determine where slope paving is to be done and the type to be used. The Structures Aesthetics and Model Group will assist when requested.

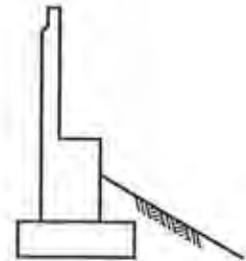
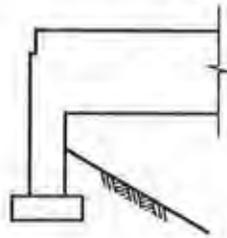
SLOPES AT ABUTMENTS

Figures 1 and 2, page 10-33, indicate various common types of slopes at abutments. It is not intended that they should preclude the use of other acceptable treatments.

ABUTMENTS TYPES

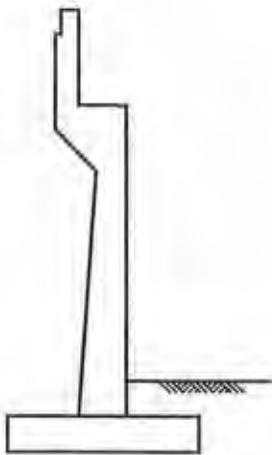


Diaphragm

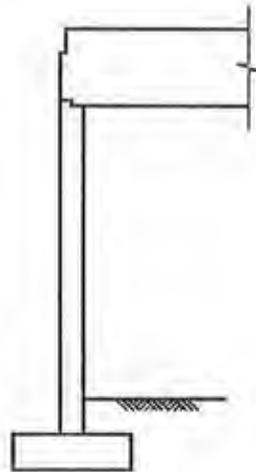


Seat

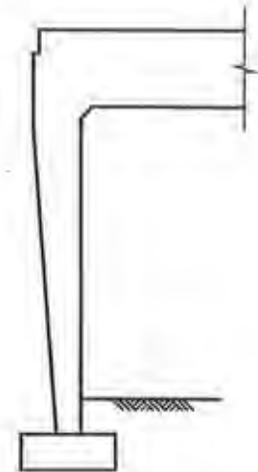
OPEN END



Cantilever

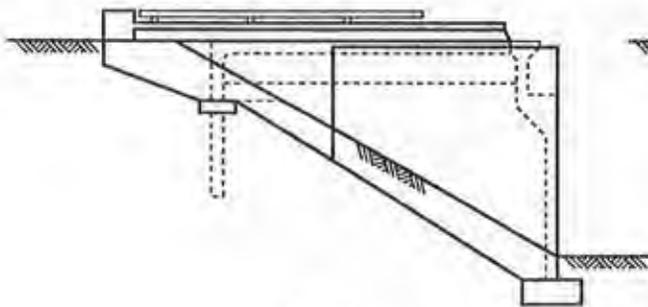


Strutted

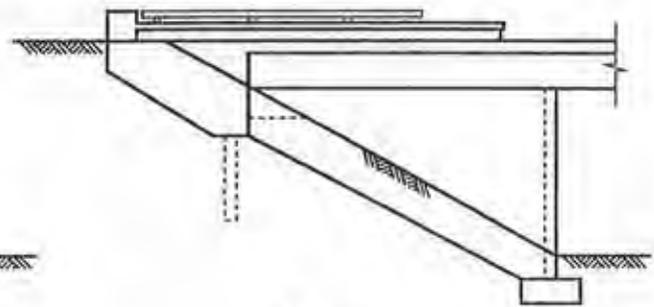


Rigid Frame

CLOSED END-BACKFILLED

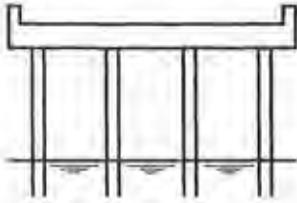


Bin



Closure

CLOSED END-CELLULAR

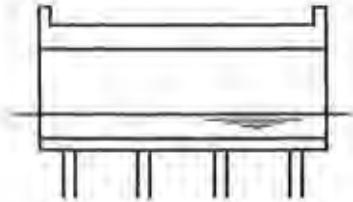


Pile Bents

PIERS OR BENTS

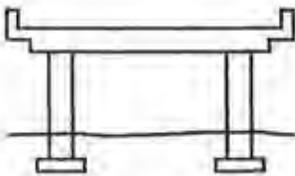
Usually most economical. Use for slab spans and T-Beams. Usable for stream crossings when debris is not a problem.

Pile extensions should be limited to about 20 feet. Use special pile extensions when design load is 70T or higher.



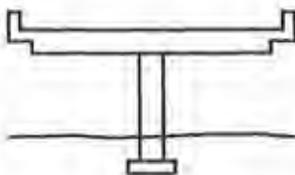
Solid Pier

Use in streams where debris or fast current is present. Desirable for long spans. May be supported on spread footings or pile foundations. Consult special studies for special nose design.



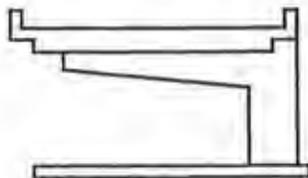
Column Bent

Generally used under dry land structures. Use in lieu of pile bent when spread footings are recommended. May be supported on spread footings or pile foundations.



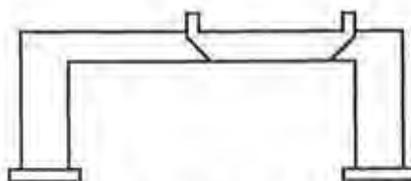
"T" Bent

Can sometimes be used to avoid skewed bents. Helpful on viaducts over city streets where location of column is restricted.



"C" Bent

Modification of T-Bent. Used where location of columns is very restricted and alignment change is impossible.

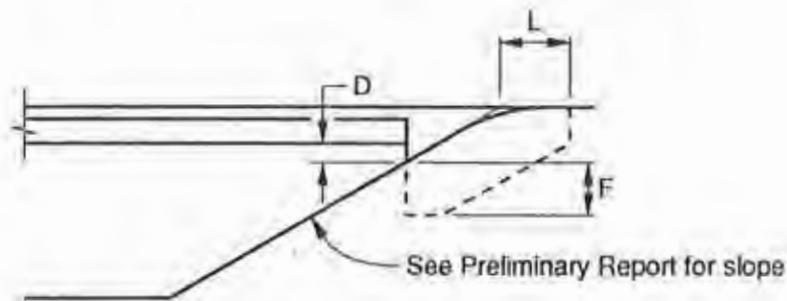


Outrigger Bent

Modification of Column Bent. Used where understructure facilities require it.

SLOPES AT ABUTMENTS

Superelevation and skew will materially affect the appearance of a structure. The designer should make certain that the plans clearly indicate the finished ground lines around the ends of structures. The bridge architect should be consulted on any question of aesthetics.

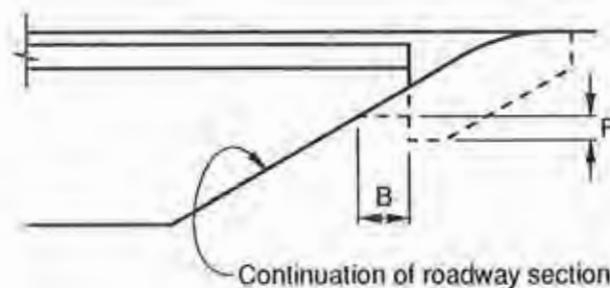


L = Normally about 8 feet, may be reduced to 5 feet for minor structures; should be increased for major structures.

D = Normally 2 feet for all bridge types. Parallel to deck when cross slope is constant and level for crown slopes.

F = Normally 3 feet.

Figure 1. Open End Abutment



B = Normally 5 feet.

F = Normally 2 feet.

Figure 2. Open End Abutment with Berm

BRIDGE NUMBERS

For the purpose of having a definite and concise designation for each structure and railroad crossing on the State Highway System, an official number for identification, hereinafter referred to as the bridge number, is assigned to every structure and to each railroad crossing of which periodic inspections are considered to be advisable. The bridge number is hyphenated, the first portion being the county designation numeral (counties are numbered in a general way running from north to south throughout the state), and the last portion being an arbitrary number assigned to the structure, e.g., "49-105."

Bridge numbers do not therefore necessarily run consecutively along a route. Where the highway is divided and two distinct structures exist, the letter (R) or (L) is placed after the number to indicate the right or left structure when facing along the route in the direction in which the "Bridge Log" is taken.

For purposes of record, each city or county bridge (sometimes called "feeder road bridge") examined by the Department is numbered in a manner similar to the state bridge numbering system, except that a letter "C" follows the county designation number, e.g., "49C-105."

The Office of Structures Maintenance is responsible for the assignment of bridge numbers.

They are generally assigned to the following structures and to all other structures which, in the judgment of the engineer, require periodic attention.

CONCRETE AND STEEL STRUCTURES

Bridge numbers are assigned to all concrete and steel structures of 10 foot span or over, except to those of less than 20 foot span having a depth of fill over them greater than their span length.

TIMBER STRUCTURES

Bridge numbers are assigned to all timber structures of 3 feet or greater total span and 2 feet or greater height, except those of span less than 20 feet having fills over them greater than 1.5 times their span.

STRUCTURES OVER 20 FEET LONG

To conform with the records of the FHWA, all structures which, measured parallel to the roadway centerline, have a length of more than 20 feet between the inside faces of the end abutments shall be carried as bridges regardless of the length of the spans making up this total.

STRUCTURES LESS THAN 20 FEET LONG

Short structures of less than 20 foot length measured parallel to the roadway centerline, which come within the limits of the bridge classification only because of their skew, shall not be carried as bridges.

KINDS OF STRUCTURES

Structures are named in accordance with the kind of facility they provide. To determine these names place yourself on the major facility and describe the structure from that position. Major facilities rank in the following order: (1) railroads, (2) highways, (3) county roads or city streets, (4) pedestrian walkways, cattle trails, etc.

<i>Bridge</i>	The term "bridge" is usually reserved for structures over water courses.
<i>Overhead</i>	A structure carrying a highway over a railroad is called an overhead.
<i>Underpass</i>	A structure which provides for passage of a highway under a railroad is an underpass.
<i>Overcrossing</i>	A structure carrying a county road or a city street over a state highway is an overcrossing.
<i>Undercrossing</i>	A structure which provides for passage of a county road or city street under a state highway is an undercrossing.
<i>Separation</i>	A grade separation of two state highways is called a separation.
<i>Interchange</i>	The group of ramps and structures required to provide connections for traffic between intersecting roadways is called an interchange.
<i>Viaduct</i>	A structure of some length carrying a state highway over streets, railroads, or other various features is called a viaduct.
<i>Tunnel</i>	A structure carrying a state highway through a hill or mountain is called a tunnel.
<i>Pedestrian Overcrossing</i>	A structure carrying a pedestrian walkway over a highway is a pedestrian overcrossing.
<i>Pedestrian Undercrossing</i>	A structure which provides for passage of a pedestrian walkway under a highway is a pedestrian undercrossing.
<i>Miscellaneous Structures</i>	Structures other than those described above are given a descriptive title such as Equestrian Overcrossing, Equestrian Tunnel, Cattlepass, Pipeline Overcrossing and Conveyor Belt Overcrossing.

STRUCTURE TYPES

Structures of all kinds are further described by the major building material used, such as steel, concrete, or timber. The type of design also enters into the description of all or part of a structure, such as a truss, girder, T-beam, box girder, prestressed girder, or slab.

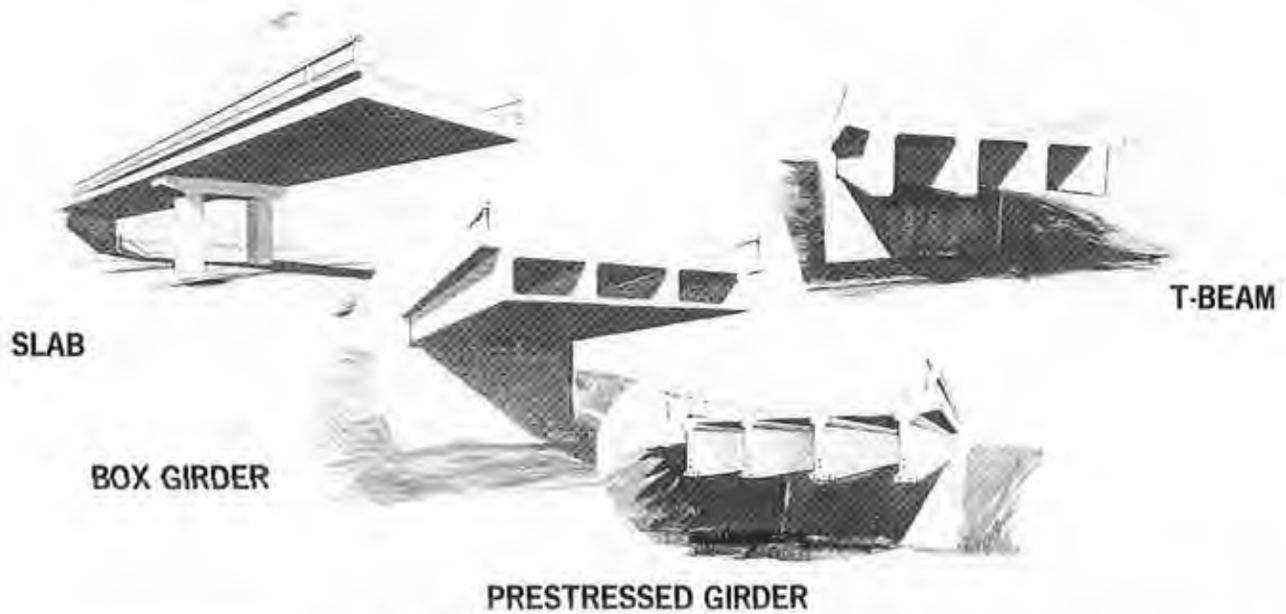
CONCRETE BRIDGES



SLAB BRIDGE



T-BEAM OVERCROSSING



SLAB

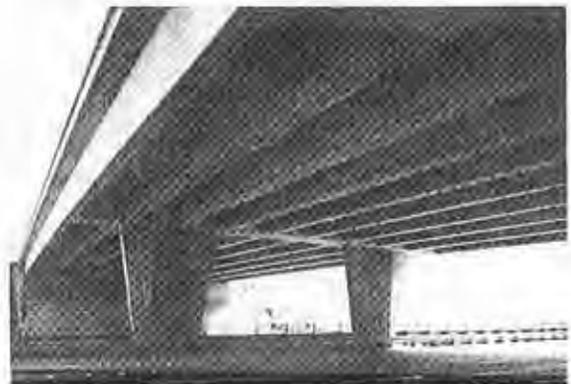
BOX GIRDER

T-BEAM

PRESTRESSED GIRDER



OVERCROSSING



PRESTRESSED GIRDER OVERCROSSING

CONCRETE BRIDGES



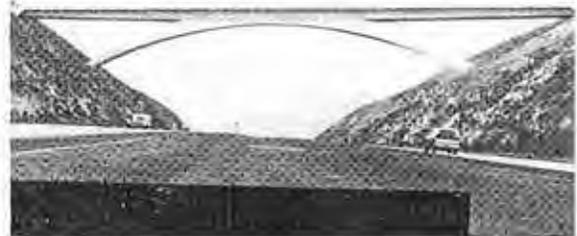
PRESTRESSED DELTA GIRDER
OVERCROSSING



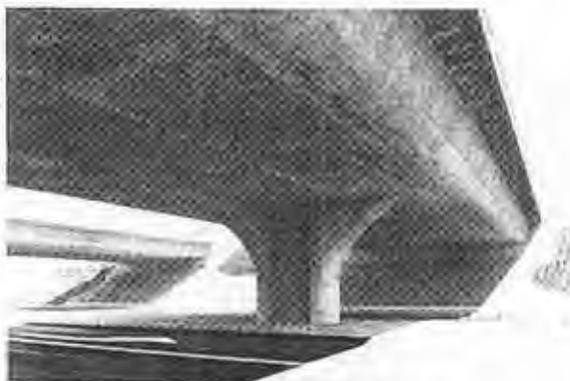
BOX GIRDER UNDERCROSSING



VIADUCT



CONCRETE ARCH



UNDERCROSSING



OVERCROSSING AND OVERHEAD

BRIDGES



BRIDGE



BRIDGE



STEEL GIRDER



CABLE STAYED SWING



DECK TRUSS



VERTICAL LIFT

SEPARATIONS AND INTERCHANGES



DOUBLE DECK



INTERCHANGE



SEPARATION



4-LEVEL



PRESTRESSED GIRDER



STEEL GIRDER

OVERHEADS AND UNDERPASSES



THRU GIRDER - U.P.



CONCRETE BOX - U.P.



PRESTRESSED GIRDER - O.H.



DECK GIRDER - U.P.



CONCRETE BOX - O.H.



STEEL GIRDER - O.H.

PEDESTRIAN TRAFFIC



PEDESTRIAN OVERCROSSING



PEDESTRIAN UNDERCROSSING



PEDESTRIAN OVERCROSSING



PEDESTRIAN OVERCROSSING



TIMBER BRIDGE



PEDESTRIAN OVERCROSSING

MISCELLANEOUS STRUCTURES



DIVIDED HIGHWAY TUNNELS



TUNNEL



PUMP HOUSE



METAL SOUNDWALL



OUTRIGGER BENT



CONCRETE BLOCK SOUNDWALL