8.4 Materials

8.4.1 Concrete

8.4.1.2 Concrete strength

Insert after first sentence:

The specified concrete strength for Ministry standard prestressed I girders and box girders shall not exceed 55 MPa at 28 days or 37.5 MPa at release unless otherwise consented to by the Ministry.

8.4.2 Reinforcing bars and deformed wire

8.4.2.1 Reinforcing bars

Reinforcing bar layouts shall be based on standard reinforcing bar lengths of 12 m for 10M bars and 18 m for 15M bars and greater.

Commentary: *Standard reinforcing bar lengths are based on typical bar lengths which are available from reinforcing steel suppliers.*

8.4.2.1.1 Specification

Reinforcing bars shall be in accordance with SS412 and DBSS 412.

Low carbon/chromium reinforcing steel shall meet the requirements of ASTM A1035 - Types CS, CM and CL. The minimum yield strength based on the 0.2% offset method shall be equal to 690 MPa.

Other reinforcing bar types are permitted for use where consented to by the Ministry.

The designer shall consider and address the difference between metric and imperial bar sizes when specifying the use of solid stainless reinforcing bars or low carbon/chromium reinforcing steel. Design for stainless steel reinforcing shall be based on metric bars and a conversion table for allowable substitutions with imperial bars shall be provided in the Plans. Design for low carbon/chromium steel reinforcing shall be based on imperial bars and a conversion table for allowable substitutions with metric bars shall be provided in the Plans.

Commentary: *Solid stainless reinforcing bars are available in both metric and imperial sizes, while low carbon/chromium reinforcing steel meeting the requirements of ASTM A1035 is currently only available in imperial sizes. Currently, ASTM A1035 Types CS, CM and CL compliant materials are produced for and sold by MMFX Steel for North America.*

8.4.2.1.3 Yield strength

Grade 400W reinforcing bars shall be specified for flexural reinforcement in plastic hinge regions.

For bridge decks, the design yield strength shall be 420 MPa for stainless steel and low carbon/chromium reinforcing steel. There are corrosion resistant and stainless steel reinforcing grades with higher yield strengths. The Plans shall note that details such as lap lengths shall be adjusted by the construction contractor at their cost to the satisfaction of the design engineer if higher yield strength material is proposed by the construction contractor during construction.

Commentary: *Use of Grade 400W bars is intended to ensure plastic hinge regions possess expected ductility characteristics.*

For Grade 400W reinforcing bars, an upper limit for yield strength of 525 MPa is a requirement of CSA-G30.18.

Low carbon/chromium reinforcing steel may have a yield strength larger than 420 MPa and a stress-strain curve differing from Grade 400 reinforcing steel. These differences shall be taken into account in the design, in particular with respect to assumption for moment redistribution or seismic design considerations.

8.6 Design Considerations

8.6.1 General

Connection details for precast concrete abutment components shall be designed to minimize the potential for cracking in the concrete at the connections.

Commentary: *The ministry has observed concrete cracking near welded connections at precast concrete abutment components. Details should be carefully designed to address this issue.*

8.7 Prestressing requirements

8.7.4 Loss of prestress

8.7.4.1 General

Commentary: *The designer is cautioned that the losses tabulated in Table C8.2 may be unconservative for prestressed girders where the span to depth ratio pushes the capacity limit of the section.*

8.8 Flexure and axial loads

8.8.1 General

Section 4 shall apply for seismic design and detailing.

Commentary: *As per Clause 8.17 of S6-14, seismic design and detailing shall meet the requirements of Section 4 (of S6-14).*

8.8.4.5 Maximum reinforcement

The requirement of this clause may be waived by the design engineer provided it is established to the satisfaction of the Ministry that the consequences of reinforcement not yielding are acceptable.

8.9 Shear and torsion

8.9.3.8 Determination of ε_x

Commentary*: For the design and evaluation of prestressed girders the capacity-enhancing effect of negative strains (compressive) near supports may be taken into account. Acceptable approaches can be found in the latest CSA A23.3 Standard or AASHTO LRFD Bridge Design Specifications.*

8.11 Durability

8.11.2 Protective measures

8.11.2.1 Concrete Quality

Supply of concrete including methods and testing shall comply with the quality requirements of SS 211, SS 413, SS 415, and SS 933, and DBSS 211, DBSS 413, DBSS 415, and DBSS 933. Where there are any discrepancies between the SS or DBSS and CSA S6-14, the SS or DBSS will take precedence.

8.11.2.1.1 General

Delete the entire clause and replace with the following:

For the structural elements listed below, concrete mix design parameters shall be determined in consultation with the Ministry and shall comply with the requirements given in the following table unless otherwise consented to by the Ministry. The information, for each relevant classification of concrete, shall be included in the Special Provisions for the Project.

For structural concrete not covered by Table 8.4, the maximum water to cementing materials ratio shall be 0.45 unless otherwise consented to by the Ministry.

Table 8.4 is deleted and replaced with the following:

Table 8.4
Maximum water to cementing materials ratio
(See Clause 8.11.2.1.1.)

Classification	Minimum Compressive Strength at 28 days (MPa)	Nominal Maximum Size of Coarse Aggregate (mm)	Air Content (%)	Slump (mm)	Maximum W/C Ratio by Mass
Deck Concrete: Deck Slab, Approach Slab, Parapet and Median Barrier					
• Standard(1)(2)(3)	35	28(4)	5 ± 1	50 ± 20	0.38
• With Silica Fume	35	28(4)	6 ± 1	80 ± 20(5)	0.38
• With Class F or C1 Flyash(1)(6)	35	28(4)	6 ± 1	50 ± 20	0.38
Substructure Concrete: Piers, Abutments, Retaining Walls, Footings, Pipe Pile In-fills, Working Floors					
• Standard(1)(6)	30	28	5 ± 1	50 ± 20	0.45
Keyways between Box Stringers:					
• Standard(1)(2)(7)	35	14(8)	5 ± 1	20 ± 10	0.38
Concrete Slope Pavement:					
• Standard(4)	30	20	5 ± 1	30 ± 20	0.45
Deck Overlay Concrete:					
1. High Density(1)	35	20(9)	5 ± 1	30 ± 20	0.38
2. Silica Fume Modified	45	14(8)	6 ± 1	60 ± 20(5)	0.38

Notes:

(1) Superplasticizers or high range water reducers shall not be used.

(2) No supplemental cementing materials shall be used in this concrete (i.e. silica fume, fly ash, etc.).

(3) Cement shall be Type GU and total cement content shall not exceed 380 kg/m^3.

(4) The maximum proportion of aggregate passing the 5 mm screen shall be 35% of the total mass of aggregate.

(5) Silica fume application rates shall be 8% maximum by mass of Portland Cement. Slump specification is based on superplasticized concrete.

(6) The addition of fly ash shall not exceed 15% by mass of Portland Cement.

(7) Cement shall be Type GU and total cement content shall not be less than 400 kg/m^3.

(8) The maximum proportion of aggregate passing the 5 mm screen shall be 42% of the total mass of aggregate.

(9) The maximum proportion of aggregate passing the 5 mm screen shall be 38% of the total mass of aggregate.

The gradation of the 28 mm nominal size aggregate shall conform to Table 211-B in SS 211 or DBSS 211 unless noted otherwise in this clause.

Semi-lightweight concrete shall not be used in any bridge component.

Commentary: *Superplasticizers may be considered, subject to the consent of the Ministry, for substructure concrete in special circumstances such as in heavily congested elements or elements with other constraints that make it difficult for concrete placement and consolidation.*

8.11.2.1.3 Concrete placement

Delete the entire clause and replace with the following:

The deck casting sequence and the detail for construction joints shall be shown on the Plans. Typically, deck slabs shall be cast in the direction of increasing grade (uphill).

For simply supported span structures, each span shall be cast in one continuous operation unless otherwise consented to by the Ministry.

For continuous structures, concrete shall be cast full width in stages to limit any post-construction cracking in the deck concrete to less than 0.20 mm at the surface of the structural deck. In specifying the deck pour sequence, the designer shall pay particular attention to the adverse effects of stress reversal within freshly cast concrete deck slabs

Commentary: *A deck casting sequence is required in order to minimize the potential for deck cracking due to improper concrete placement sequencing.*

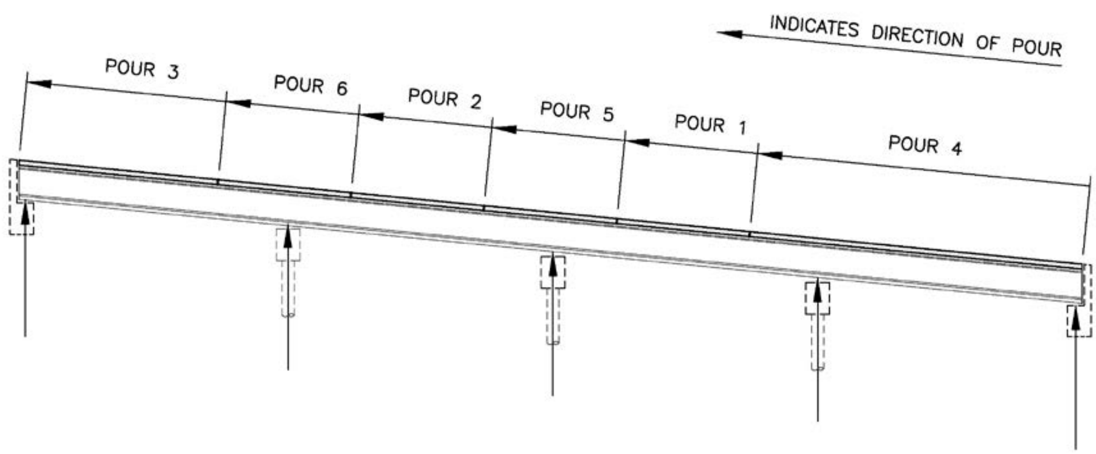
Several factors limit the quantity of concrete which can be placed in one continuous operation. Special consideration shall be given if the continuous placement exceeds a volume of 200 cubic metres or if the bridge deck exceeds four lanes in width.

Structures are to be cast full width to uniformly load the superstructure and to avoid differential deflection between stringers. The positive moment regions are to be cast first followed by the negative moment areas.

The following is the Ministry's deck casting procedure:

- ***Concrete in positive-moment zones:*** *All concrete in these zones to be cast prior to concrete in negative-moment zones.*
- ***Concrete in negative-moment zones:*** *Concrete in these zones are typically not be cast until adjacent concrete in positive- moment zones have been cast, unless cast monolithically with the positive-moment concrete as shown below in pour sequence 4.*

Figure C8.11.2.1.3
Sample schematic of deck pour sequence



Unless higher strengths are required by the designer, deck concrete shall attain a strength of 15 MPa before parapets are placed and 25 MPa before heavy loads, such as concrete trucks, are allowed on the bridge.

Concrete placement sequence for integral abutments shall be given special consideration to reduce stresses induced by deflection of the girders. Unless otherwise consented to by the Ministry, the full width and length of deck shall be cast prior to the end diaphragms being cast integral with the abutment.

Commentary: *For integral abutments, techniques for reducing stresses induced by deflection of the girders may include delaying the casting of the abutments and/or the deck in the abutment area until after all other deck concrete has been cast.*

8.11.2.1.6 Slip-form construction

Extruded concrete barriers shall not be used.

8.11.2.1.7 Finishing

Delete the entire clause and replace with the following:

The methods to be used for finishing surfaces of concrete to ensure a durable surface shall comply with the relevant SS and DBSS Clauses.

Surface finishes shall be in accordance with Table 8.11.2.1.7 and shall be specified in the Special Provisions.

Table 8.11.2.1.7
Surface finishing requirements

Surface	Finish	Relevant SS or DBSS Clause
Surfaces submerged or buried	Class 1	211.17
Top and inside (exposed) face of parapets, curbs	Class 3	211.17
Outer face of parapets, curbs; outer edges of deck	Class 2	211.17
Abutments and retaining walls	Class 2	211.17
Piers	Class 2	211.17
Bearing seats	Steel Trowel	211.14
Top of deck	Tined(1)	413.31.02.05
Approach slabs	Float Finish	211.14
Sidewalks	Transverse Coarse Broom	211.14
Underside of Deck	Class 1 (or better)	211.17
Slope Pavement	Transverse Coarse Broom(2)	211.14

Notes:

(1) Decks to receive waterproofing membranes shall be finished in accordance with SS 419.33 and DBSS 419.33.

(2) Exposed Aggregate finishes may be considered.

Consideration shall be given to surfaces exposed to close public view such as piers and abutments on underpasses where a Class 3 finish may be considered and underside of decks where a Class 2 finish may be preferred.

Exposed concrete surfaces of large abutments or retaining walls that are clearly visible to the public may require a special architectural finish. The selection of surface finishes shall also give consideration for future removal of graffiti. Such consideration may include the application of anti-graffiti coatings

8.11.2.2 Concrete cover and tolerances

The soffits of deck slabs cantilevered from the exterior girder shall be considered under Environmental exposure class, De-icing chemicals; while the soffits of deck slabs intermediate to the exterior girders may be considered under Environmental exposure class, No de-icing chemicals as detailed in Table 8.5.

All references to “minimum cover” in S6-14 shall be replaced with “minimum specified cover”.

The designer shall check the cover and tolerance in S6-14 and the cover and tolerances in SS 412 and DBSS 412 and on the Ministry standard drawings and adjust the project specifications as required to meet the minimum cover allowed in S6-14, except that the values given in Table 8.5 below shall govern. Minimum cover is hereby defined as the specified cover minus the tolerance.

Table 8.5 in S6-14 shall be amended as follows:

Table 8.5
Minimum concrete covers and tolerances
(See Clause 8.11.2.2.)

			Concrete Covers and Tolerances	
Environmental exposure	**Component**	**Reinforcement/ steel ducts**	**Cast-in-place concrete (mm)**	**Precast concrete (mm)**
All	(3) Top surfaces of Structural components Add: Bridge Decks and Approach Slabs	 Reinforcing Steel Pretensioning strands	 (1) +6 -0 –	 (1) +6 -0 100 ±5
All	(10) Precast T, I and box girders Add: Ministry Standard Precast Box Girders	 Reinforcing steel - Top surfaces - Vertical surfaces - Soffits - Inside surfaces Pretensioning strands - Top surfaces - Vertical surfaces - Soffits - Inside surfaces	 – – – – – – – –	 (1) +10 -5 40 +10 -5 30 +10 -5 30 +10 -5 200 ±5 50 ±5 40 ±5 35 ±5
	Add: Ministry Standard Precast I-Beams	 Reinforcing steel - Top surfaces - Vertical surfaces - Soffits Pretensioning strands - Top surfaces - Vertical surfaces - Soffits	 – – – – – –	 30 +10 -5 30 +10 -5 30 +10 -5 100 ±5 40 ±5 40 ±5

Notes:

(1) for specified cover and reinforcing steel type, see Table 8.11.2.3.2 in Section 8.11.2.3.2

Delete Note ‡ under Table 8.5.

Commentary: *An additional 10 mm of concrete cover shall not be provided for concrete decks.*

Cover requirements are governed by the following principles:

1. *Minimum cover, i.e. the specified cover minus the tolerance, shall not be less that the cover specified in S6-14 minus the tolerance given in S6-14.*

2. *The use of cover and tolerance requirements of Table 8.5 of S6-14 is appropriate except for the changes as shown in Table 8.5 above.*

3. *Cover and tolerances in SS 412 and DBSS 412 are acceptable where they meet the minimum cover in item 1 above even though the specified cover may be less than in S6-14.*

The term "minimum cover" should be avoided on the Plans as it creates confusion for installers. The term "specified cover" is the preferred term and the appropriate placing tolerances would apply. For vertical reinforcing in the Ministry Standard Precast Box Girders, a "specified cover" of 40 mm with placing tolerances of +10 mm and -5 mm will provide the correct installation.

Designers must be aware of, and account for, placing tolerances and specified cover requirements. As an example, consideration shall be given to the cover requirements on mechanical splices.

8.11.2.3 Corrosion protection for reinforcement, ducts and metallic components

8.11.2.3.1 General

Ends of prestressing strands shall be painted with a Ministry accepted organic zinc rich paint where the ends of stringers are incorporated into concrete diaphragms or are otherwise embedded in concrete.

Ends of prestressing strands shall be given a minimum 3 mm coat of thixotropic epoxy in 100 mm wide strips applied in accordance with the manufacturer's requirements where ends of stringers are not embedded in concrete. For prestressed box girders, the entire ends of the girder shall be covered.

If galvanized reinforcing steel is used, all reinforcing steel in the component shall be galvanized. Galvanized bars and uncoated bars shall not be permitted to be in contact with each other as specified in SS 412.11.03 and DBSS 412.11.03.

The Designer is cautioned regarding the potential for embrittlement of reinforcing steel which is cold-bent and then galvanized. (Straight reinforcing bars are not prone to embrittlement). Precautions that are to be taken for cold-bent reinforcing steel that is to be galvanized include:

- increasing the minimum bend diameter to meet the requirements for epoxy coated steel as provided in SS Table 412-B
- ensuring Grade W (weldable) reinforcing is used in accordance with SS 412.11.03 and DBSS 412.11.03.

and

- stress relieving the reinforcing steel after bending and prior to galvanizing in accordance with SS 412.11.03 and DBSS 412.11.03. (Stress relieving procedures vary with the thickness of the material. 15 M bars would typically be stress relieved for 1 hour at 620 degrees Celsius.)

Galvanized reinforcing bars are not to be bent after galvanizing.

Commentary: *Galvanized reinforcing steel and uncoated steel should not be used in combination due to the possibility of establishing a bimetallic couple between zinc and bare steel (i.e. at a break in the zinc coating or direct contact between galvanized steel and black steel bars or other dissimilar metals.*

The designer shall take into consideration the greater bend diameter for the galvanized reinforcing steel.

8.11.2.3.2 Corrosion protection for bridge decks, parapets, curbs and approach slabs

As a minimum, all reinforcing steel within the upper 50% of bridge decks and approach slabs including the top mat of deck reinforcing steel and any steel projecting into this zone and all reinforcing steel in cast-in-place parapets shall be protected against corrosion.

Corrosion protection for reinforcing steel shall be achieved by using corrosion resistant reinforcing and/or waterproofing membranes in accordance with the Table 8.11.2.3.2 below.

Table 8.11.2.3.2
Corrosion protection for top mat reinforcing steel for bridge decks, parapets, curbs and approach slabs

Top mat rebar type[1]	Minimum deck thickness (mm)	Specified Top Cover (mm)	Where used [2][3]
Stainless steel plus deck membrane	225	50	SCR – main roads
Low carbon/chromium to ASTM A1035 Type CS (or stainless steel also allowed) plus deck membrane	225	50	SCR – other roads
Stainless steel	225	60	SIR/NR – main roads
Low carbon/chromium to ASTM A1035 Type CS (or stainless steel also allowed)	225	70	SIR/NR – other roads
Black, epoxy coated, galvanized, ASTM A1035 Type CL (or other as consented to by the Ministry)	225	70	SCR/SIR/NR – gravel roads

Notes:

(1) Rebar type in accordance with Clause 8.4.2.1.1.

(2) SCR: South Coast Region, SIR: Southern Interior Region, NR: Northern Region.

(3) Main roads = includes all structures on all primary highways and also on other highways with a current AADT of 2000 or higher.
Other roads = includes all other structures.
Gravel roads = gravel roads and roads with an AADT of less than 400 vehicles.

For cable supported structures where the deck system is under compression, then stainless steel reinforcing shall be used in both the top and bottom mats of the deck.

For pedestrian bridges with a clear walkway width of less than 3 m, plain steel reinforcing bars may be used. For pedestrian bridges of 3 m and wider, corrosion protection of deck steel shall be in accordance with “SIR/NR - other roads” in Table 8.11.2.3.3.

Other corrosion protection for reinforcing steel, including stainless steel clad reinforcing and composite reinforcing steel (GFRP, CFRP etc.) may only be used with consent of the Ministry.

Commentary: *The BC numbered highway functional classification can be found at:* http://www.th.gov.bc.ca/publications/planning/Provincial%20Highways/Functional_Class_Map.pdf.

Black steel is generally used for bottom mat reinforcing.

8.11.2.3.3 Corrosion protection for components subject to spray or surface runoff containing de-icing chemicals

Except in Ministry Service Areas 1,2,3,4, 6 and 27, steel reinforcement, anchorages, and mechanical connections specified for use within 75 mm of a surface exposed to moisture containing de-icing chemicals shall use corrosion resistant material in accordance with Table 8.11.2.3.3. This shall include the following components:

- components and surfaces under expansion joints, such as bearings and girders, ballast walls, end diaphrgms, bearing seats, etc. for a horizontal distance from the joint of 1.5 x the superstructure depth.
- exposed surfaces of piers, abutments, retaining walls where buildup of snow containing de-icing chemicals in contact with the component will occur
- components on main roads adjacent to or up to 3.0 m above the pavement surface subject to spray containing de-icing chemicals.

Commentary: *Corrosion resistant material should also be considered as follows for concrete decks with or without curbs but with open railings:*

- *For the underside of the deck, past the drip groove for a minimum distance of 1.0 m.*
- *For soffits that are level or slope inward, the portion from the exterior edge to the full soffit width.*
- *For girders, the exterior surface and soffit of the girder.*

Table 8.11.2.3.3
Corrosion protection for components subject to de-icing chemicals

Corrosion resistant material type[1]	Where used [2][3]
Stainless steel	SCR /SIR/NR – main roads
Low carbon/chromium ASTM A1035 Type CS or CM (or stainless steel also allowed)	SCR /SIR/NR – other roads
Black, epoxy coated, galvanized, ASTM A1035 Type CL (or other as consented to by the Ministry)	SCR/SIR/NR – gravel roads

(1) Rebar type in accordance with Clause 8.4.2.1.1.

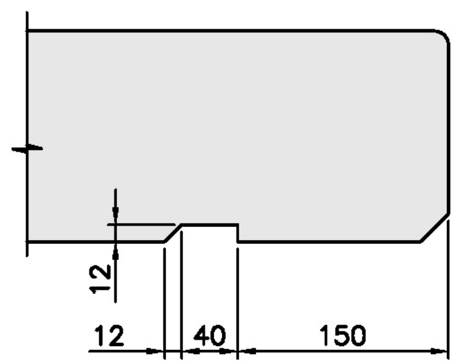
(2) SCR: South Coast Region, SIR: Southern Interior Region, NR: Northern Region.

(3) Main roads = includes all structures on all primary highways and also on other highways with a current AADT of 2000 or higher.
Other roads = includes all other structures.
Gravel roads = gravel roads and roads with an AADT of less than 400 vehicles.

8.11.2.6 Drip Grooves

Continuous drip grooves shall be formed on the underside of bridge decks and shall be detailed as shown below in Figure 8.11.2.6.

Figure 8.11.2.6
Drip groove detail



8.11.2.7 Waterproofing

Delete the first paragraph and replace with:

Unless otherwise consented to by the Ministry, all bridges in the South Coast Region shall have a hot rubberized asphalt membrane system for waterproofing and 100 mm thick asphalt overlay on top of the bridge deck.

Buried concrete structures with a soil cover of 1000 mm or less shall receive a hot rubberized asphalt membrane system for waterproofing. Positive drainage shall be provided on the top surfaces of buried structures to avoid ponding of water.

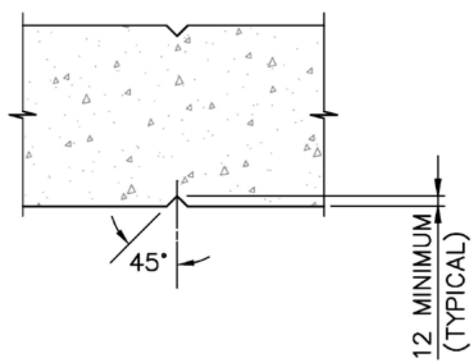
Bridges located in the Southern Interior Region and the Northern Region shall be protected with an application of linseed oil or as otherwise directed by the Ministry.

8.12 Control of Cracking

8.12.1 General

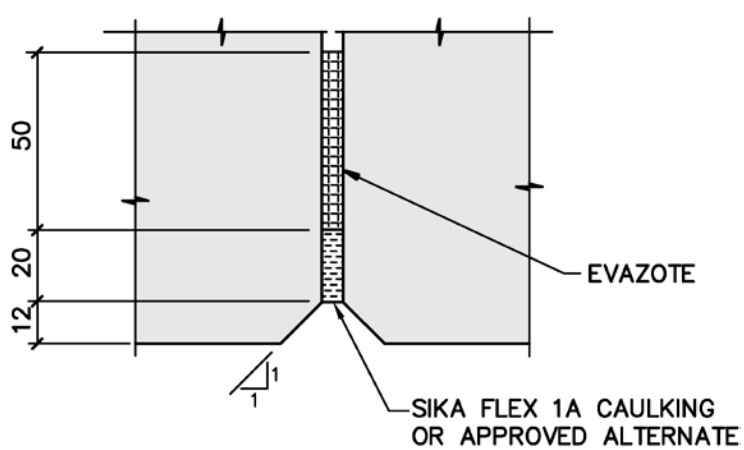
Control joints shall extend around the entire perimeter of the traffic barrier and be evenly spaced throughout the full length of the barrier with spacing not exceeding 3 m as shown below.

Figure 8.12.1(a)
Control joint detail



Concrete traffic barriers shall have a minimum 6 mm wide rotation joint over the supports on continuous spans as shown below.

Figure 8.12.1(b)
Rotation joint detail



8.13 Deformation

8.13.3 Deflections and rotations

8.13.3.3 Total deflection and rotation

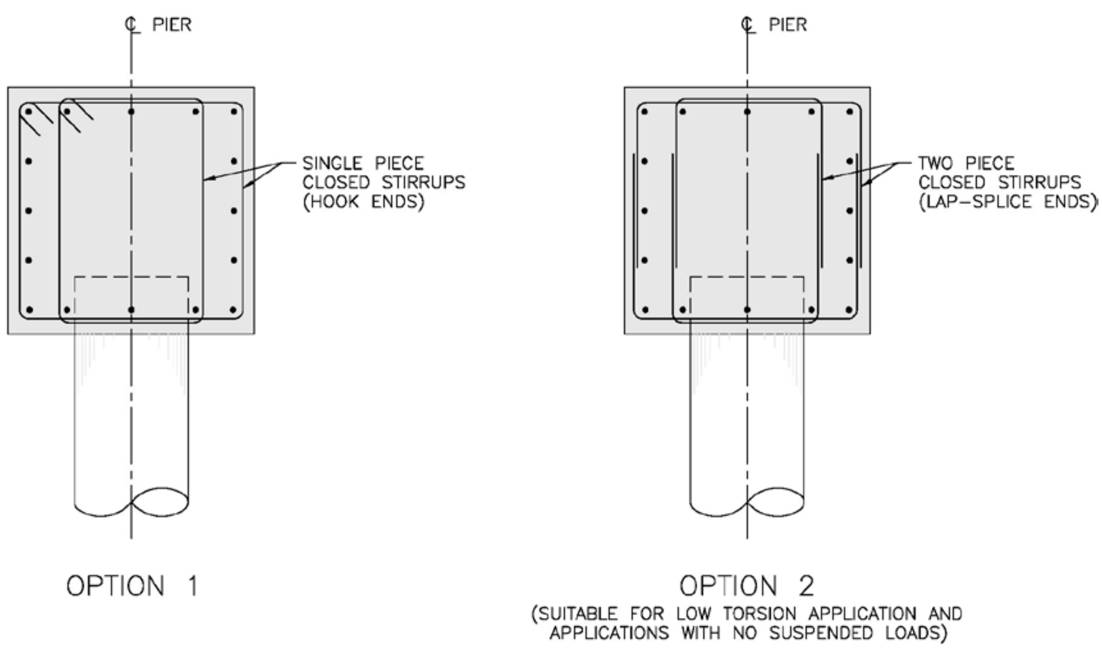
Commentary: *The Commentary to S6 (S6.1-14) states that long time deflection and rotation may be calculated by using the empirical multipliers given in Table C8.8 which is taken from CPCI (1996). However, Table C8.8 is not an exact copy of the table included in CPCI (1996). The original table or the table in the current edition of the CPCI Handbook (CPCI (2008)) may be used in place of the commentary.*

8.14 Details of reinforcement and special detailing requirements

8.14.3 Transverse reinforcement for flexural components

Typical arrangements for transverse reinforcement of pier caps are shown in Figure 8.14.3.

Figure 8.14.3
Typical transverse reinforcement of pier caps (drip grooves and top surface slope not shown)



Commentary: *The typical transverse reinforcement arrangements shown in Figure 8.14.3 alleviate problems encountered with installation of longitudinal reinforcing in situations where piles are installed slightly off alignment. These preferred arrangements facilitate placement of two longitudinal bars in close proximity to the piles. Identical-size pairs of closed stirrups which lap one another horizontally do not provide as much tolerance for placement of the two longitudinal bars adjacent to the piles.*

For diaphragms and other varying depth members, closed stirrups formed from two piece lap-spliced U-stirrups or U-stirrups with lapped L splice bars as shown in Supplement Figure 8.20.7.1 shall be used (low torsion applications and applications with no suspended loads).

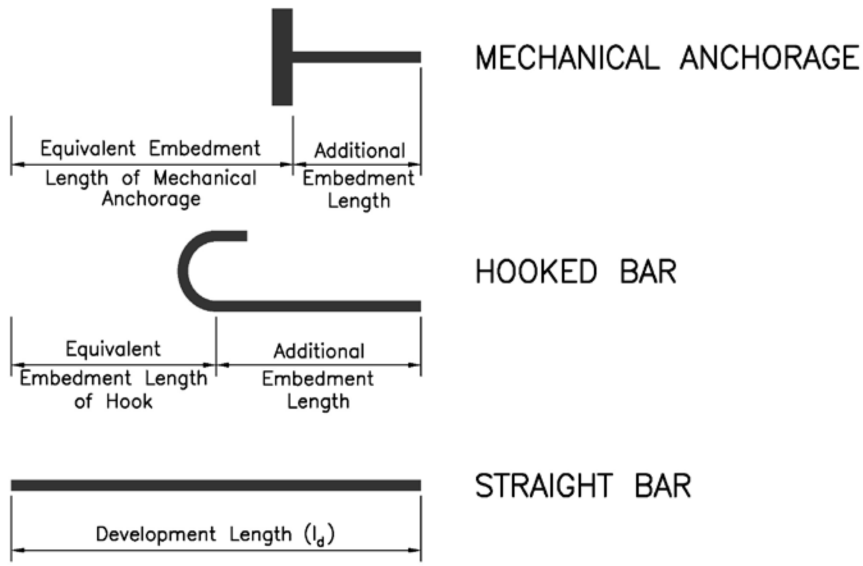
Commentary: *Problems are encountered with stirrup sizes in diaphragms when stirrups are either too long or too short depending on the final depth of the haunches. The method of using two piece U-stirrups of suitable depth allows for minor adjustments and alleviates problems of proper field fit-up when accommodating variable depth of diaphragms.*

8.15 Development and splices

8.15.6 Combination development length

Commentary: *Figure 8.15.6 below illustrates how the development length,* l_d*, may consist of a combination of the equivalent embedment length of a hook or mechanical anchorage plus additional embedment length of the reinforcement measured from the point of tangency of the hook.*

Figure 8.15.6
Combination development length



8.15.9 Splicing of reinforcement

8.15.9.1 Lap splices

All splices that are critical to the structure shall be indicated on the Plans.

Splicing of transverse reinforcing bars in bridge decks shall be avoided if possible. If such splices are necessary, their location shall be indicated on the Plans.

8.15.9.2 Welded slices

Delete clause and replace with the following:

The use of welding to splice reinforcement is not permitted unless consented to by the Ministry.

8.16 Anchorage zone reinforcement

8.16.7 Anchorage of attachments

Dowel holes for Ministry standard prestressed concrete box stringers shall be detailed as shown in the Ministry Standards and Procedures Manual Volume 3, Ministry Standard Drawings 2978-1 to 2978-24 (latest revision) standard reference details for Standard Twin Cell Box Stringers. Similar details may be used, as appropriate, for Ministry Standard Single Cell Box Stringers, Drawing D205.

8.18 Special provisions for deck slabs

Bridge deck heating systems are not permitted.

Commentary: *Heating of bridge decks in British Columbia has been problematic. Its use has therefore been discontinued.*

8.18.2 Minimum slab thickness

Delete the last sentence and replace with the following:

The slab thickness shall not be less than 225 mm.

8.18.3 Allowance for wear

Delete this clause.

8.18.4 Empirical design method

8.18.4.4 Full-depth precast panels

Full-depth precast panels may only be used on numbered highways when consented to by the Ministry.

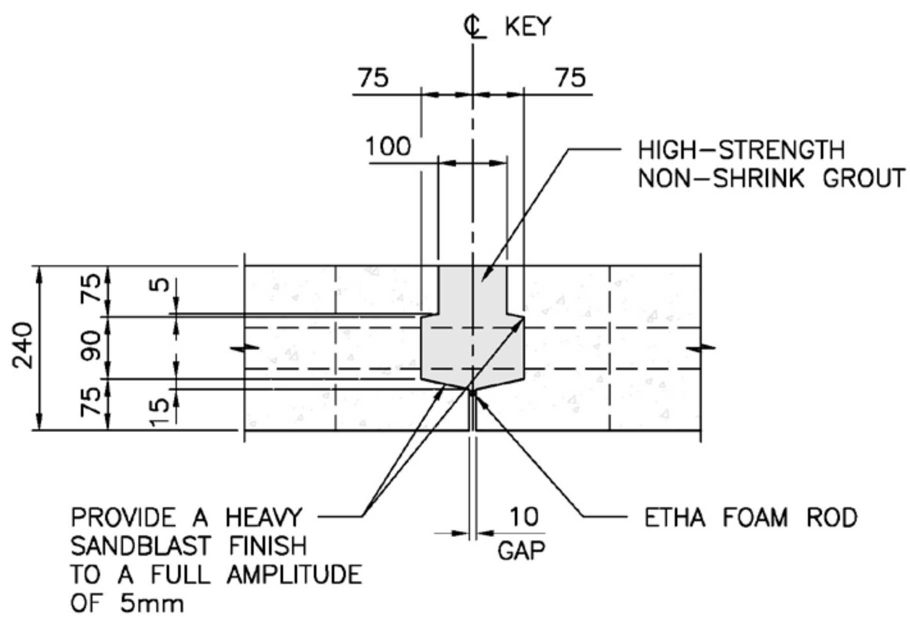
Delete the first sentence and replace with the following:

Regardless if the empirical design method or flexural design method is chosen by the engineer, design of full-depth precast panels shall satisfy the following conditions in addition to those of Clause 8.18.4.1 and, as applicable, Clause 8.18.4.2:

Delete Item (c) and replace with the following:

(c) at their transverse joints, the panels are joined together by grouted reinforced shear keys and are longitudinally post-tensioned with a minimum effective prestress of 1.7 MPa. The post-tensioning system shall be fully grouted. The transverse joints shall be of a female to female type. Tongue and groove type shear keys and butt joints shall not be used. The shear key shall be detailed to allow for the panel reinforcing to be lapped with hooked ends with reinforcing placed parallel to the shear key. Figure 8.18.4.4(a) details the requirements for minimum shear key size.

Figure 8.18.4.4(a)
Full depth precast panel shear key



Alternatively, reinforced concrete shear keys may be used without post-tensioning where consented to by the Ministry. The shear key design shall account for all force transfer effects through the shear keys. Figures 8.18.4.4(b) and 8.18.4.4(c) give examples for reinforced shear keys.

Figure 8.18.4.4(b)
Full depth precast panel with reinforced shear key over deck support member

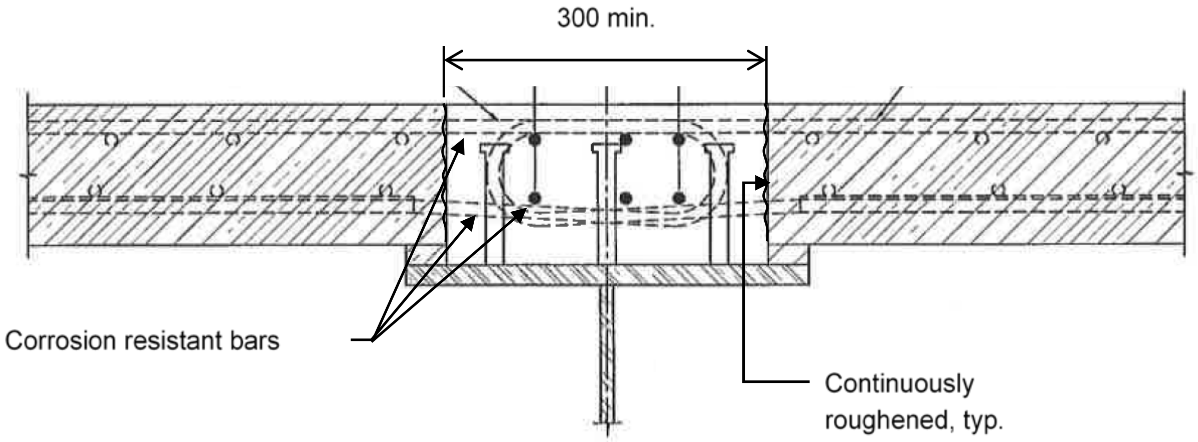
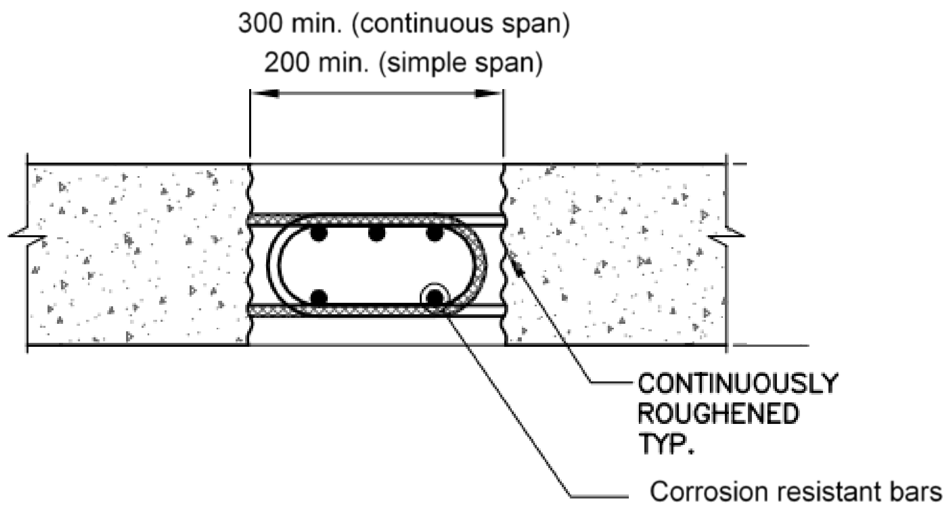


Figure 8.18.4.4(c)
Full depth precast panel with reinforced suspended shear key



Add the following additional items:

(h) a minimum specified gap of 25 mm shall be provided under the panels above the supporting beams, including any splice plates.

(i) the deck slab comprised of full-depth precast panels shall be fully composite with the supporting beams.

(j) cast-in-place concrete parapets shall be used for the bridge barriers on numbered routes unless consented to by the Ministry. The parapets shall be continuous across the transverse joints except in the negative moment regions of the supporting beams. The parapets shall be placed after the longitudinal post-tensioning is complete and fully grouted.

(k) the deck shall have a waterproofing membrane with a 100 mm thick asphalt wearing surface unless otherwise consented to by the Ministry. Bare precast concrete decks may be used on low volume road bridges.

(l) Stud connectors shall be in accordance with Section 10.11.8.3.3.

Commentary: *Shear keys between precast deck panels may also consist of reinforced concrete joints or, when consented to by the Ministry, of ultra-high performance fibre-reinforced concrete (UHPFRC, also abbreviated UHPC). In these cases adequate force transfer through the joints and reinforcing bar overlap need to be assured.*

Further information on UHPFRC shear keys and joints as well as guidance to splice and development lengths can be found in:

> *Graybeal, B., (2014) Design and Construction of Field-Cast UHPC Connections, FHWA Publication No. FHWA-HRT-14-084, Turner-Fairbank Research Center, McLean, VA, October.*
>
> *Graybeal, B., Yuan J. (2014). Bond Behavior of Reinforcing Steel in Ultra-High Performance Concrete [TechBrief], FHWA Publication No. FHWA-HRT-14-089, Turner-Fairbank Research Center, McLean, VA, November.*

Confinement of stud clusters may be required to obtain the required shear connector strength.

8.18.5 Diaphragms

Add the following sentence to the end of the first paragraph:

Steel diaphragms for concrete girders shall be hot-dipped galvanized and detailed similar to Supplement Figure 8.20.7.3. For monolithic cast-in-place concrete end diaphragms and intermediate diaphragms, consideration shall be given to additional deck reinforcing over the diaphragms to withstand negative moment demands. Refer to Clause 8.20.7 for specific guidance regarding design of concrete diaphragms for concrete girders.

8.19 Composite construction

8.19.1 General

Ministry standard prestressed concrete box girders with a concrete overlay wearing surface shall be designed as non-composite. For non-composite design, the placement of a concrete overlay wearing surface on top of box girders shall be considered as an additional dead load and shall not be assumed to contribute to any composite properties under live loads.

Non-standard composite prestressed concrete box girders shall achieve composite action through the use of mechanical anchorage between the box girder and the composite topping.

8.19.3 Shear

Shear reinforcement in prestressed I-beams shall extend 125 mm above the top of the beam. When the haunch height exceeds 75 mm, additional shear reinforcement (e.g. shear ties matching the spacing of stirrups in the I-beams) and additional longitudinal reinforcing at the haunch corners shall be provided as shown in Supplement Figure 8.19.3 (a).

Additional shear reinforcement and longitudinal reinforcing at the haunch corners shall also be provided above steel girders, as shown in Figure 8.19.3 (b), where haunch heights exceed 75 mm.

Figure 8.19.3 (a)
Additional reinforcement for haunches over 75 mm high (conceptual)

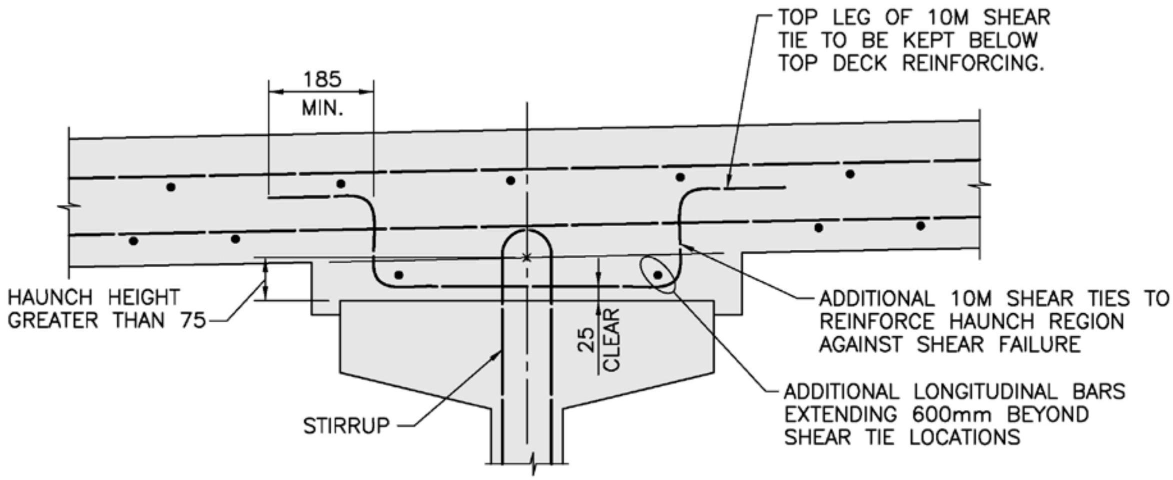
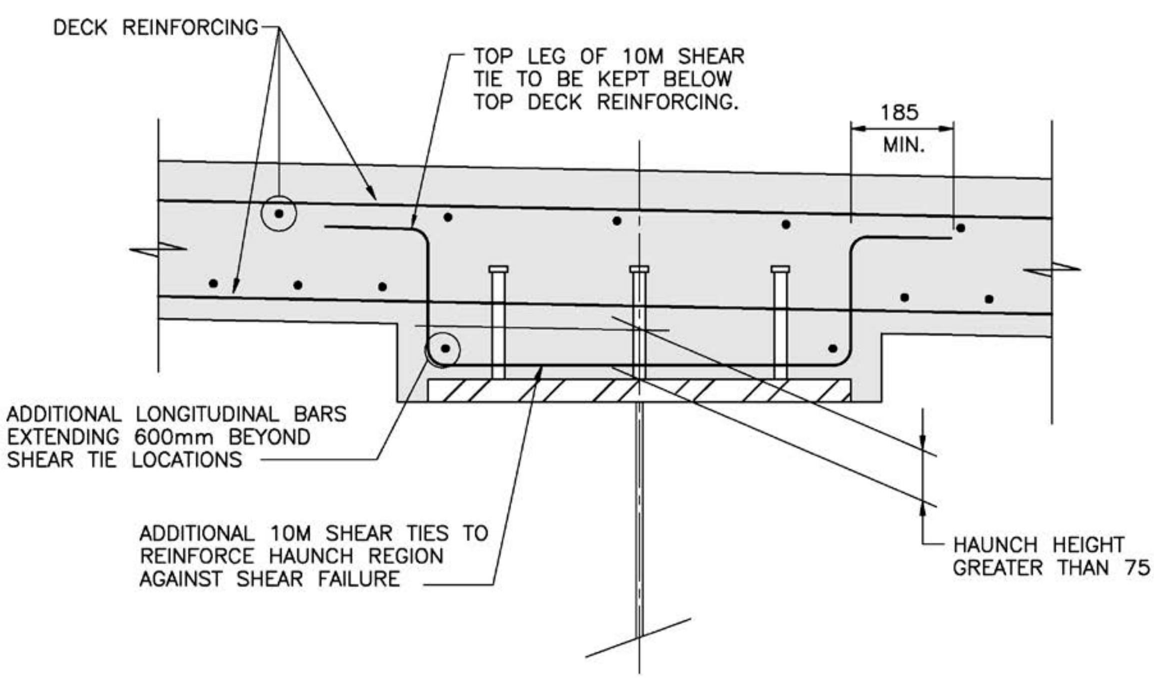


Figure 8.19.3 (b)
Additional reinforcement for haunches over 75 mm high (conceptual)



Commentary: *The examples in Figure 8.19.3 (a) and (b) show haunch reinforcement on a conceptual level. The reinforcing requirements for these haunches should be checked during design and the reinforcement in the haunches adjusted as required. Particular attention should be given to situations with deep haunches where the stirrups or shear studs may not protrude into the deck beyond the bottom deck slab reinforcement.*

8.20 Concrete girders

8.20.1 General

Prestressed concrete I-girder and box girder skews over 30° shall be avoided where possible. Where skews over 30° are used, sharp corners at ends of girders shall be chamfered as a precaution against breakage.

Box girders shall be skewed in increments of 5°.

8.20.3 Flange Thickness for T and Box Girders

8.20.3.2 Bottom Flange

The cross section dimensions of the Ministry Standard Twin Cell Box Stringers shown on Drawings 2978-1 to 2978-24 (latest revision) shall be considered acceptable for use on Ministry projects.

Commentary: *The bottom flange thickness of Ministry standard prestressed concrete box stringers does not comply with the minimum code requirement of 100 mm. No rationale is given in the Code or the Commentary for this minimum requirement.*

The current series of standard twin cell boxes have been in use since the late 1970's and have performed extremely well over the years. The increase in cost of fabrication and transportation necessary to update to the cover requirements of S6-14 is not considered to be warranted.

8.20.6 Post-Tensioning Tendons

Unbonded post-tensioning tendons shall not be used.

Commentary: *Unbonded tendons have experienced numerous corrosion incidents due to inadequacies in corrosion protection systems, improper installation, or environmental exposure before, during and after construction.*

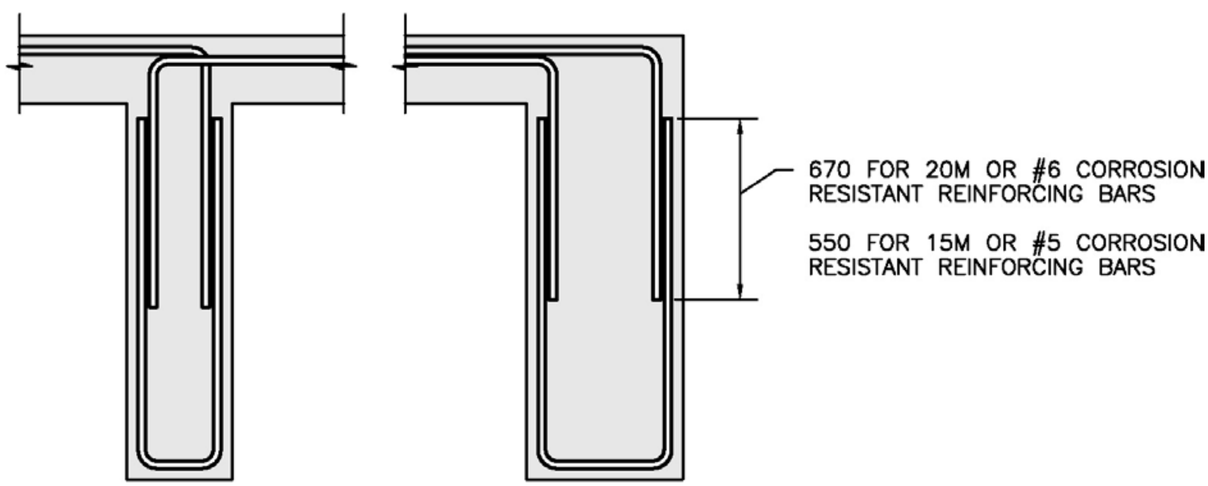
8.20.7 Diaphragms

Delete clause and replace with the following:

Concrete diaphragms shall be provided at abutments and piers to support the deck and transfer loads to the supports. Abutment, pier and intermediate diaphragms shall be oriented parallel to the bridge skew and shall have a minimum thickness of 350 mm. Additional reinforcing shall be placed between longitudinal temperature reinforcement to account for negative moment effects. The minimum added reinforcing shall be 15M bars and shall extend for a distance S/2 into the deck slab from the edge of the diaphragm where 'S' is the c/c of stringers. The bars shall have a standard hook at the diaphragm end. Where intermediate concrete diaphragms support the slab, bars shall be added between the longitudinal reinforcing. The bars shall be 15M and be the same bar type as the reinforcing steel in the top mat of the deck and the length shall equal to 'S.'

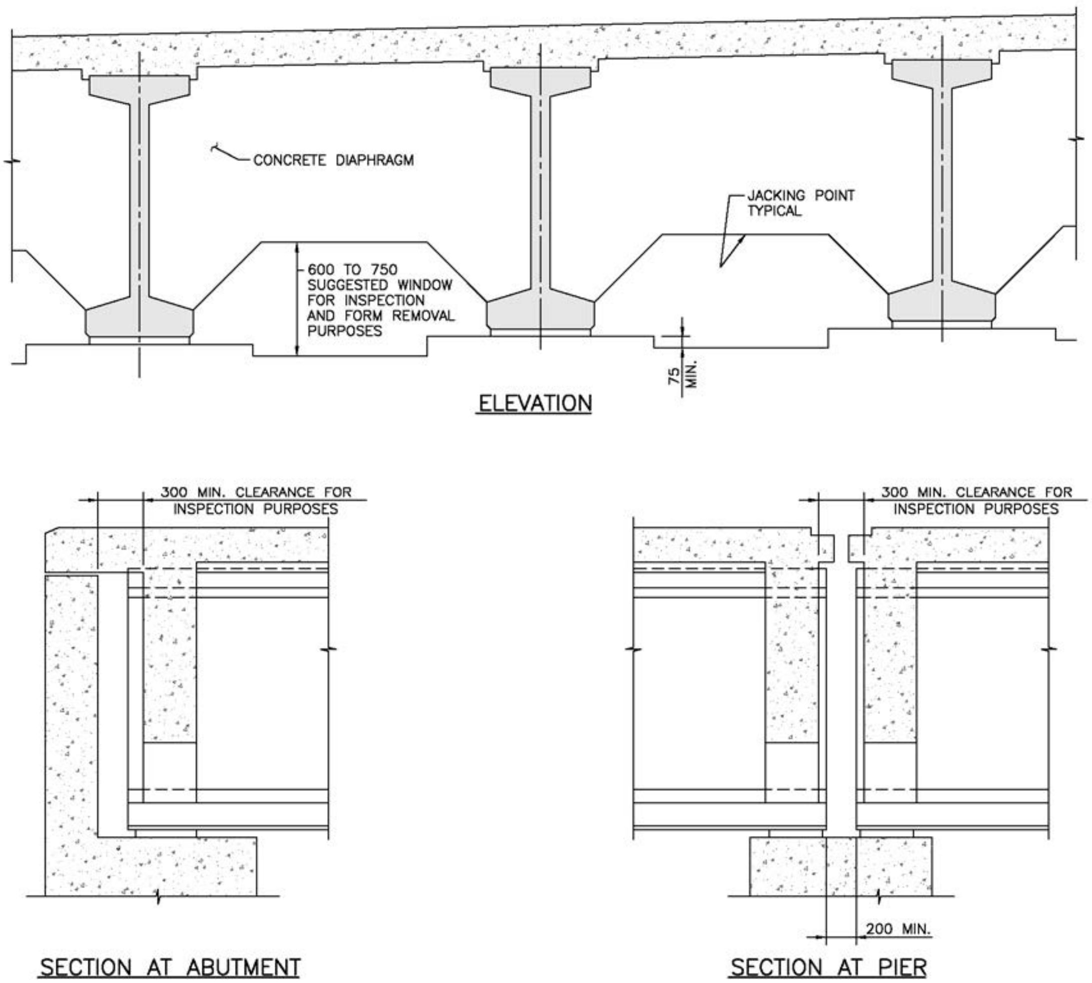
A typical tie arrangement for intermediate and end diaphragms is shown in Figure 8.20.7.1 below.

Figure 8.20.7.1
Typical diaphragm tie arrangement



Abutment and pier diaphragms shall be designed to transfer loads to the supports and to facilitate future jacking. Diaphragms shall be detailed to provide access for maintenance inspection, as generally outlined in Figure 8.20.7.2 below.

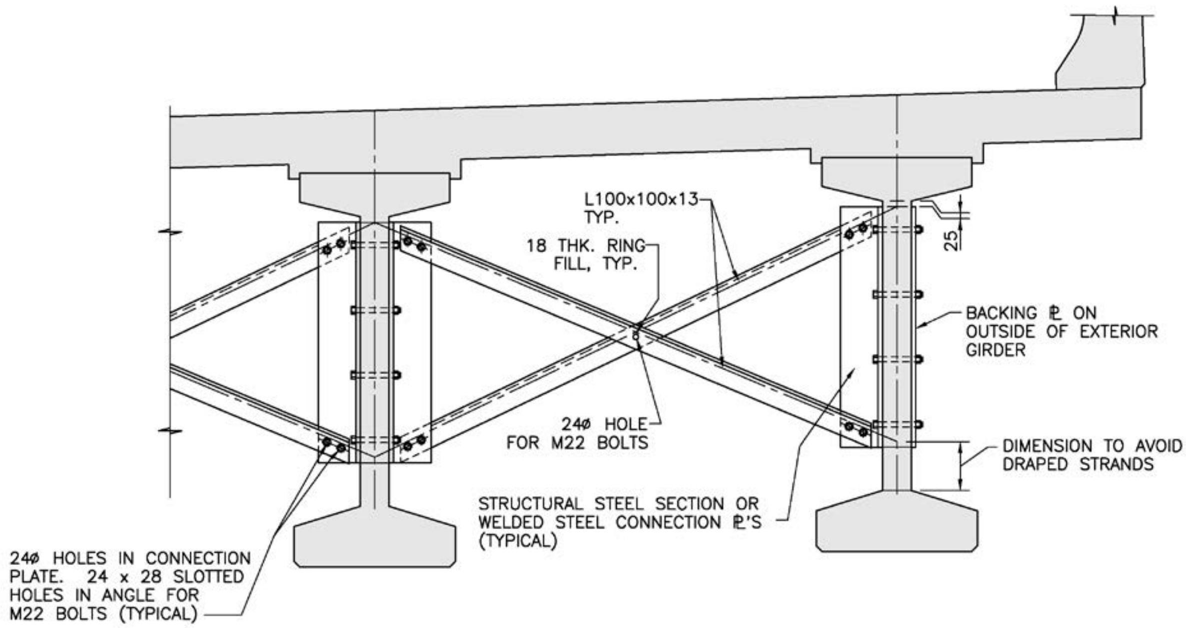
Figure 8.20.7.2
Typical concrete diaphragm arrangement



The hole size for abutment and pier diaphragm reinforcing which passes through the ends of prestressed girders shall be 2.5 times the bar diameter.

Unless specifically consented to by the Ministry, the designer shall provide intermediate diaphragms to improve load distribution and for stability during construction and future rehabilitation. The diaphragms shall be galvanized steel framing with details similar to those in Figure 8.20.7.3 unless analysis dictates the use of a concrete intermediate diaphragm.

Figure 8.20.7.3
Typical steel diaphragm arrangement



8.21 Multi-beam decks

The shear key and reinforcement details shown on Ministry Standard Twin Cell Concrete Box Stringer, Standard Drawings 2978-1 to 2978-24 (latest revision) shall be considered as an approved means for live load shear transfer between multi-beam units in accordance with Clause 8.21(c) of S6-14.

Commentary: *Ministry standard box stringers less than 20 m in length without lateral post-tensioning have performed well (no longitudinal cracks or leaks) since they were first introduced in the late 1970's. According to site investigations completed by the Ministry on multi-beam decks with asphalt overlay where transverse post-tensioning was not used, no longitudinal cracking of the asphalt overlay was observed over the shear key areas. The majority of the non-composite box spans investigated were less than 20 m spans.*

Standard box stringer bridges up to 30 m may also be used without lateral post-tensioning, provided explicit analysis indicates that the shear key has sufficient live load shear transfer capacity.

In most cases, a reinforced concrete overlay is applied as a wearing course topping on twin or single cell box beams. Where specified as an alternative to a concrete overlay, or as otherwise consented to by the Ministry, the top surfaces may be protected with a waterproofing membrane selected from the Ministry's Recognized Products List, and applied in accordance with the manufacturer's instructions with an asphalt overlay of 100 mm placed in two lifts of 50 mm.

Mechanical anchorage is required between precast beams and a composite reinforced concrete deck slab to achieve composite action.

Commentary: *Figures 8.21 (a) and 8.21 (b) are suggested means of achieving composite action between the structural beam and the composite reinforced concrete deck slab.*

Figure 8.21 (a)
Double cell box beam composite deck slab connection detail

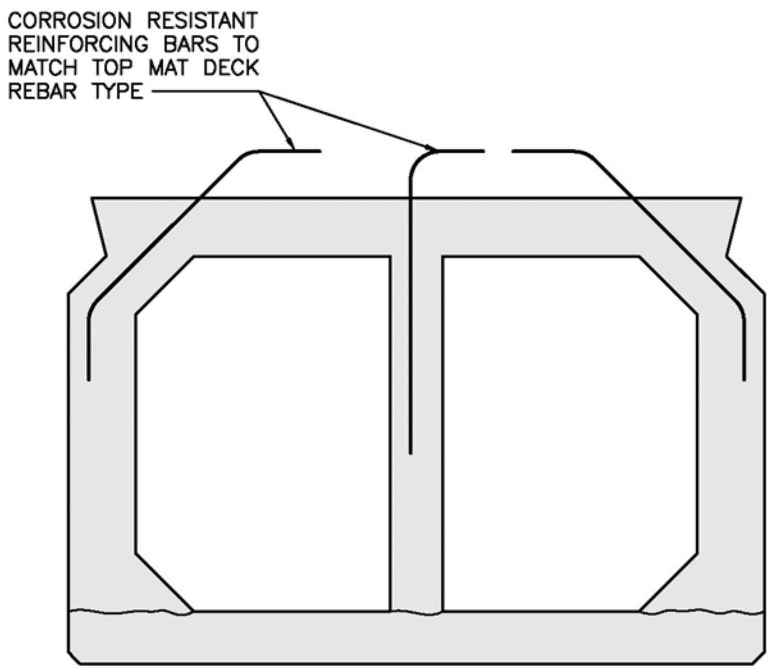


Figure 8.21 (b)
Single cell box beam/overlay connection detail