Bridge and Structures Office
Washington State
Department of Transportation

Design Memorandum

TO: All Design Section Staff
FROM: Bijan Khaleghi
DATE: February 5, 2019
SUBJECT: Requirements for Intermediate Diaphragms

This design memorandum provides revisions to the use of intermediate diaphragms for precast prestressed girder bridges. BDM Sections 5.6.2, 5.6.4, and 15.5.4 shall be revised as follows:

Revisions to Chapter 5: Concrete Structures

5.6.2 Design Criteria

WSDOT design criteria for prestressed concrete girder superstructures are given in Table 5.6.2-1.

Table 5.6.2-1 Design Criteria for Prestressed Concrete Girders

Intermediate Diaphragms	Intermediate diaphragms shall be provided for Prestressed Concrete I Girder, Prestressed Concrete Wide Flange I Girder, Thin Flange I Girder and Prestressed Concrete Tub Girder bridges in the following situations:~~(except slabs)~~ • Water crossings with vertical clearances of 6'-0" or less from the 100-year M.R.I. • Bridge spans that are possible or likely to have vehicular traffic crossing under the span in the future. • Bridge spans crossing roadway or railway with a minimum vertical clearance of 20'-0" or less. When bridge spans require intermediate diaphragms, they shall be provided as follows: • 1/5 points of span for span length > ~~160'-0"~~ 200'-0" • ¼ points of span for ~~120'-0"~~ 150'-0" < span length ≤ ~~160'-0"~~200'-0". • ⅓ points of span for ~~80'-0"~~100'-0" < span length ≤ ~~120'-0"~~ 150'-0". • Midpoint of span for ~~40'-0"~~ 50'-0" < span length ≤ ~~80'-0"~~ 100'-0". • No diaphragm requirement for span length ≤ ~~40'-0"~~ 50'-0". Intermediate diaphragms shall be either partial or full depth as described in Section 5.6.4.C.4.

BDM 5.6.4- C. Diaphragm Requirements

1. General

Intermediate diaphragms ~~used with prestressed concrete girder bridges serve multiple purposes. During the construction stage, the diaphragms help to~~ provide girder stability for the bridge deck placement, and ~~. During the life of the bridge, intermediate diaphragms and are particularly advantageous for distribution of large overloads. Diaphragms also~~ improve the bridge resistance to over-height impact loads.

Diaphragms for prestressed concrete girder bridges shall be cast-in-place concrete. Standard diaphragms and diaphragm spacings are given in the office standards for prestressed concrete girder bridges. For large girder spacings or other unusual conditions, special diaphragm designs shall be performed.

Inserts are used to accommodate the construction of intermediate diaphragms for connections between the diaphragm and the web of prestressed concrete girders. The designer shall investigate the adequacy of the insert and the connection to develop the tensile capacity of diaphragm reinforcement, and interface shear capacity of the diaphragm-to web connections for construction and deck placement loads.

~~Open holes should be provided for interior webs so reinforcement can be placed through.~~

Vertical reinforcement for intermediate diaphragms could be terminated at the top of top flange if SIP deck panels are used for the bridge deck.

~~**Exceptions:**~~

~~Intermediate diaphragms are not required for precast deck bulb-tee girder and wide flange deck girder spans.~~

- ~~Intermediate diaphragms could be eliminated for superstructures of floating bridges.~~
- ~~Intermediate diaphragms could be eliminated for water crossing bridges with vertical clearance from of 6'-0" or more from 100-year M.R.I.~~
- ~~Intermediate diaphragms could be eliminated for bridge approach spans not likely to ever cross over traffic at the time of design or in the future.~~
- ~~Intermediate diaphragms could be eliminated for vehicle or pedestrian bridges with spans crossing roadways or railroads with a minimum vertical clearance of 20'-0" or more.~~
- ~~Intermediate diaphragms are not required for adjacent precast voided or solid slab spans.~~

2. Design

Diaphragms shall be designed as transverse beam elements carrying both dead load and live load. Wheel loads for design shall be placed in positions so as to develop maximum

moments and maximum shears. Live load need not be considered when intermediate diaphragm is not connected to deck.

3. Geometry

Diaphragms shall normally be oriented parallel to skew (as opposed to normal to girder centerlines). This procedure has the following advantages:

a. The build-up of higher stresses at the obtuse corners of a skewed span is minimized. This build-up has often been ignored in design.

b. Skewed diaphragms are connected at points of approximately equal girder deflections and thus tend to distribute load to the girders in a manner that more closely meets design assumptions.

c. The diaphragms have more capacity as tension ties and compression struts are continuous. Relatively weak inserts are only required at the exterior girder.

On curved bridges, diaphragms shall normally be placed on radial lines.

4. Full or Partial Depth Intermediate Diaphragms

~~Full depth intermediate diaphragms as shown in the office standard plans shall be used for all deck bulb tee and wide flange deck girder superstructures.~~

Based on research done by Washington State University (WSU) on damage by over-height loads[24], the use of intermediate diaphragms for Prestressed Concrete I Girder, Prestressed Concrete Wide Flange I Girder, Thin Flange I Girder and Prestressed Concrete Tub Girder bridges shall be as follows:

a. Full depth intermediate diaphragms as shown in the office standard plans shall be used for bridges crossing over roads of ADT > 50000.
b. Partial depth intermediate diaphragms as shown in the office standard plans may be used for all bridges not included in item 1.

Intermediate diaphragms in bridge widenings shall meet the requirements a and b.

5. Tub Girder Intermediate Diaphragms

Intermediate diaphragms shall be provided ~~both inside and~~ between prestressed concrete tub girders. The need for intermediate diaphragms inside the precast tub girders may be considered for bridges with large deck overhang.

The diaphragms inside the tub, if required, may be cast in the field or at the fabrication plant. The bottom of the diaphragm inside the tub shall be at least 3 inches above the top of the bottom flange.

The diaphragms between the tubs shall be cast in the field. For diaphragms between the tubs, the roughened surface or shear keys on the sloped web faces may not be effective in resisting interface shear. All diaphragm and construction loads on the diaphragm before the deck cures and gains strength will then be resisted by the reinforcement or inserts alone.

Revisions to Chapter 15: Structural Design Requirements for Design-Build Contracts

15.5.4 Superstructures

5. Diaphragms

Diaphragms for prestressed concrete girder superstructures shall be cast-in-place concrete.

Diaphragms shall be oriented parallel to girder support skew. On curved bridges, diaphragms shall be placed on radial lines. Intermediate and end diaphragms shall be in accordance with Bridge Standard Drawings.

Intermediate diaphragms shall be provided for Prestressed Concrete I Girder, Prestressed Concrete Wide Flange I Girder, Thin Flange I Girder and Prestressed Concrete Tub Girder bridges in the following situations:

- Water crossings with vertical clearances of 6'-0" or less from the 100-year M.R.I.
- Bridge spans that are possible or likely to have vehicular traffic crossing under the span in the future.
- Bridge spans crossing roadway or railway with a minimum vertical clearance of 20'-0" or less.

When bridge spans require intermediate diaphragms, they shall be provided as follows:

- 1/5 points of span for span length > 200'-0"
- ¼ points of span for 150′-0″ < span length ≤ 200′-0″.
- ⅓ points of span for 100′-0″ < span length ≤ 150′-0″.
- Midpoint of span for 50′-0″ < span length ≤ 100′-0″.
- No diaphragm requirement for span length ≤ 50′-0″.

Intermediate diaphragms shall be full depth for structures crossing over roads with average daily traffic (ADT) greater than 50,000, in accordance with Section 5.6.4.C.4.

~~**Exceptions:**~~

- ~~Intermediate diaphragms could be eliminated for superstructures of floating bridges.~~
- ~~Intermediate diaphragms could be eliminated for water crossing bridges with vertical clearance from of 6'-0" or more from 100-year M.R.I.~~
- ~~Intermediate diaphragms could be eliminated for bridge approach spans not likely to ever cross over traffic at the time of design or in the future.~~
- ~~Intermediate diaphragms could be eliminated for vehicle or pedestrian bridges with spans crossing roadways or railroads with a minimum vertical clearance of 20'-0" or more.~~
- ~~Intermediate diaphragms are not required for adjacent precast voided or solid slab spans.~~

Background:

This policy memorandum provides some moderation in the use of intermediate diaphragms for prestressed girder bridges. However, intermediate diaphragms are beneficial for during construction, and providing girder stability for the bridge deck placement. Intermediate diaphragms and are advantageous for distribution of large overloads, and improve the bridge resistance to over-height impact loads. Softened

If you have any questions regarding this policy memorandum, please contact Anthony.Mizumori@wsdot.wa.gov or (360) 705-7228, Bijan.Khaleghi@wsdot.wa.gov at 705-7181.

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