Design Memorandum

Washington State Department of Transportation
Bridge and Structures Office

TO: All Design Section Staff
FROM: Bijan Khaleghi
DATE: April 20, 2021
SUBJECT: BDM Chapter 5 – Girder Handling Stresses and Stability

This design memorandum updates design information and requirements for girder handling stresses and stability. This memorandum modifies the Bridge Design Manual Sections 5.1.3 and 5.6 as specified herein.

Bridge Design Manual Revisions

Item 1 – Replace 5.1.3A with the following

A. General

Three types of high-tensile steel used for prestressing steel are:

1. Strands
   AASHTO M 203 Grade 270, low relaxation
2. Bars
   AASHTO M 275 Type II
3. Parallel Wires
   AASHTO M 204 Type WA

All WSDOT designs are based on low relaxation strands using either 0.5″ or 0.6″ diameter strands for girders, and ⅜″ or 7/16″ diameter strands for stay-in-place precast deck panels. Properties of uncoated and epoxy-coated prestressing stands are shown in Appendix 5.1-A8. 0.62″ and 0.7″ diameter strands may be used for top temporary strands in prestressed concrete girders when 10 - 0.6” diameter temporary top strands are not sufficient for stability.

Provide adequate concrete cover and consider use of epoxy coated prestressing reinforcement in coastal areas or where members are directly exposed to salt water.

Item 2- Replace 5.1.3C.3 with the following

3. Temporary Strands

Temporary strands in the top flanges of prestressed concrete girders may be required for stability (see Section 5.6.3). These strands shall be considered to be pretensioned for design purposes, but may be post-tensioned at the manufacturer's discretion depending on pretensioning bed capacity. If the strands are post-tensioned, calculations shall be provided by the manufacturer considering the timing of post-tensioning (before or after lifting from the form). It is more efficient to post-tension the strands after removal of the girder from the form if they are not needed for stability during stripping. The calculations shall consider the effects on camber from any revisions to the concrete strength at transfer and timing of post-tensioning. In no case shall the temporary top strands be post-tensioned more than 48 hours after transfer of permanent pretensioning. These strands can be considered in design to reduce the required transfer strength, to provide stability during handling and shipping, and to reduce the "A" dimension. These strands must be cut before the CIP intermediate diaphragms are placed.

Item 3 – Replace Table 5.6.1-1 with the following:

Table 5.6.1-1 Section Properties of WSDOT Standard Prestressed Concrete Girders

Type	Depth (in)	Area (in^2)	Y_b (in)	I_x (in4)	I_y (in^4)	J (in^4)	Wt. ($) (k/ft)	Volume-to-Surface Ratio (in)	Max. Span Capability (ft)
W42G	42	373.25	18.94	76092	5408	4670	0.428	2.77	85
W50G	50	525.5	22.81	164958	13363	8509	0.602	3.12	110
W58G	58	603.5	28.00	264609	17065	9499	0.692	3.11	120
W74G	73.5	746.7	38.08	546110	34759	10489	0.856	2.90	150
WF36G	36	690.8	17.54	124772	71291	13997	0.792	3.24	110
WF42G	42	727.5	20.36	183642	71406	14428	0.834	3.23	125
WF50G	50	776.5	24.15	282559	71559	15004	0.890	3.22	135
WF58G	58	825.5	27.97	406266	71712	15580	0.946	3.21	150
WF66G	66	874.5	31.80	556339	71865	16155	1.002	3.20	165
WF74G	74	923.5	35.66	734356	72018	16731	1.058	3.19	175
WF83G	82.625	976.4	39.83	959393	72184	17352	1.119	3.19	180
WF95G	94.5	1049.1	45.60	1328995	72411	18207	1.202	3.18	195
WF100G	100	1082.8	48.27	1524912	72516	18602	1.241	3.17	205
WF100G	100	1082.8	48.27	1524912	72516	18602	1.015 (+)	3.17	210
WF100G with Modified Top Flange (See 5.6.2.B.4)	100	1118.8	49.89	1612834	99849	18714	1.049 (+)	3.06	230
12″ x 4' Solid Slab	12	566.0	6.01	6772	-	-	0.649	4.82	30
18″ x 4' Voided Slab	18	658.6	9.01	21922	-	-	0.755	3.84	45
24″ x 4' Voided Slab	24	745.8	12.02	48331	-	-	0.855	3.91	60
26″ x 4' Voided Slab	26	840.3	13.02	63080	-	-	0.963	4.32	65

Table 5.6.1-1 Section Properties of WSDOT Standard Prestressed Concrete Girders

30″ x 4’-4” Voided Slab	30	1027.6	15.01	104791	-	-	1.177	4.72	75
U54G4	54	1038.8	20.97	292423	493926	19520	1.190	3.51	125
U54G5	54	1110.8	19.81	314382	788289	20390	1.273	3.47	130
U66G4	66	1208.5	26.45	516677	637751	22285	1.385	3.51	145
U66G5	66	1280.5	25.13	554262	997354	23153	1.467	3.47	145
U78G4	78	1378.2	32.06	827453	798969	24971	1.579	3.51	155
U78G5	78	1450.2	30.62	885451	1227303	25808	1.662	3.48	165 (157*)
UF60G4	60	1207.7	26.03	483298	639795	22376	1.384	3.48	145
UF60G5	60	1279.7	24.74	519561	999184	23246	1.466	3.45	145
UF72G4	72	1377.4	31.69	787605	800958	25127	1.578	3.48	155
UF72G5	72	1449.4	30.26	844135	1229061	26008	1.661	3.45	160 (157*)

$ Assuming normal weight concrete with a unit weight of 165 pcf, except as noted
+ Assuming lightweight concrete with a unit weight of 135 pcf.
* The span capability figure represents the length at which the section weighs approximately 262 kips.

Item 4 – Add new Section 5.6.2.B.4 and Figure 5.6.2-2

4. Slenderness Ratio

The lateral slenderness ratio of WF girders, $\frac{l}{r}$ where l is the girder length and r is the radius of gyration about the weak axis $\left(r = \sqrt{\frac{I_y}{A}}\right)$ shall not exceed 310. WF100G girders reach this limit at a length of 210 ft. Modify the WF100G top flange by increasing its width to 5’-1” for spans greater than 210 ft. The modified top flange is shown in Figure 5.6.2-2.

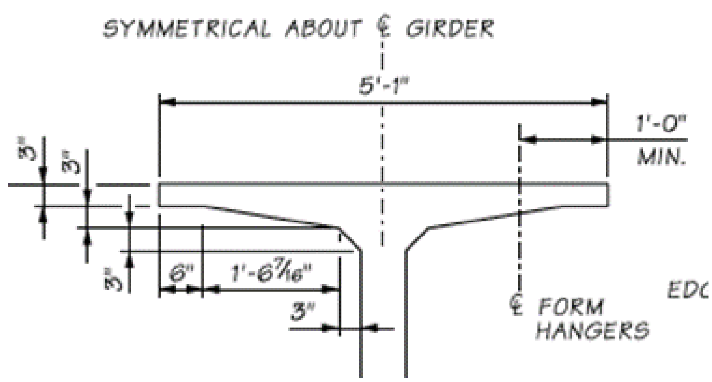

Figure 5.6.2-2 – WF100G modified top flange.

Item 5 – Renumber figures in 5.6.2

Item 4 adds a new figure 5.6.2-2. Renumber existing figures and figure references for figures 5.6.2-2 through 5.6.2-7 to 5.6.2-3 through 5.6.2-8

Item 6 – Replace 5.6.3.C.1 with the following:

1. In-Plant Handling

The maximum weight that can be handled by precasting plants in the Pacific Northwest is 262 kips. It is possible that products heavier than 262 kips can be manufactured if they will be shipped directly to the jobsite by barge, but special plant lifting arrangements must be investigated. Headroom is also not generally a concern for the deeper sections.

Item 7 – Replace 5.6.3.D.3 with the following:

3. Weight Limitations

The net weight limitation with trucking equipment currently available in Washington State is approximately 180 kips, if a reasonable delivery rate (number of pieces per day) is to be maintained. Product weights of up to 262 kips can be hauled with currently available equipment at a limited rate. The hauling of heavier girders may be possible with coordination with hauling subcontractors. Hauling subcontractors should be consulted on the feasibility of shipping large or heavy girders on specific projects

Item 8 – Replace 5.6.3.E with the following:

E. Erection and Bridge Deck Construction

A variety of methods are used to erect prestressed concrete girders, depending on the weight, length, available crane capacity, and site access. Generally, lifting girders during erection is not as critical as when they are stripped from the forms, particularly when the same lifting devices are used for both. However, if appurtenances such as deck overhang formwork brackets are attached to the girder, the lifting slings are at an angle other than 90° ± 10° from the top surface of the girder, wind loads are present, the girder is erected in such a manner that one end is supported at the top by a lifting device while the other end is seated on a girder transport vehicle or bearing, or a separate set of erection devices are used, the girder shall be checked for stresses and lateral stability as part of the contractor's erection plan. In addition, once the girder is set in place, the free span between supports is usually increased. Wind can also pose a problem. Consequently, when girders are erected, they shall immediately be braced. The temporary bracing of the girders is the contractor's responsibility.

For tub girders, designers should consider web out-of-plane bending forces that will develop during construction. Examples of these loads include forces developed by lift rigging and loading due to the deck finishing machine. These cases may require temporary struts and govern the design of web stirrups.

Background

AASHTO LRFD 2.5.3 requires constructability issues are addressed as part of design. One way this is accomplished for pretensioned girders is designing for the handling conditions of initial lifting and girder shipment from the fabricator to the bridge site.

Recent experience with long span pretensioned girder prompted a review of pretensioned girder design practices. Field observations suggest limiting the lateral slenderness ratio of pretensioned girders is warranted. This memorandum defines a new lateral slenderness ratio limitation and provides guidance that is generally applicable to girders that are more than 210 ft in length.

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

cc: Patrick Glassford, Construction Office – 47354

Craig Boone, Bridge and Structures – 47340