STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

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MEMORANDUM TO: Project Engineers
Project Design Engineers

FROM: G. R. Perfetti, P.E.
State Bridge Design Engineer

DATE: September 28, 2004

SUBJECT: DESIGN GUIDELINES FOR BOX BEAMS

To accommodate longer span length requirements on lower traffic volume roads, the Structure Design Unit shall consider the use of box beam girder bridges. This interim policy memorandum presents some general guidelines on their use.

All box beam girder units shall be constructed in a side-by-side layout, similar to the current practice with cored slab bridges. The box beam precast prestressed units shall be 36" wide and have a depth of 27", 33", or 39" (similar to AASHTO Standard types BI-36, BII-36 and BIII-36, respectively). Span length limits are based on constructibility and rideability concerns more than stresses. Designers should ensure that camber does not infringe on the ability to provide a level riding surface. The following table shows the anticipated maximum span lengths for each type of box beam:

	Max. Span Length for Type of Construction	
Depth	**Conventional**	**Top-Down**
27"	70'	60'
33"	85'	65'
39"	100'	65'

In many cases construction loads for top-down construction of spans up to 55' may be approximated with an HS-25 loading. However, when top-down construction is required for spans greater than 55', designers are reminded to consider construction loads that may result from heavy construction equipment (especially cranes and cranes with payload).

Shear keys between box beams shall be grouted. In addition, the box beams shall be post-tensioned using a pair of rods or 0.6" strands in a continuous transverse diaphragm. The number

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and location of the transverse diaphragms shall ascribe to the method and guidelines detailed in the Section 8.9 of the current PCI Precast Prestressed Concrete Bridge Design Manual, which is attached for your reference. The transverse post-tensioning shall be installed symmetrically about the mid-height of the box beam section, and shall be parallel to the bridge skew. Box beams shall not be used on skews less than 60° or more than 120°.

The box beams shall have a concrete overlay with a minimum depth of 3" at midspan. The overlay shall be class AA concrete containing glass fibers and a maximum coarse aggregate gradation of 78M. The overlay shall be placed after the barrier rails have been constructed and have cured. Longitudinal joints in the overlay shall not be permitted, except where required for staged construction. Place the following note on the plans:

"Placement of the concrete overlay shall occur after casting the concrete rail [parapet]."

Detail the transverse joints on box beam bridges with evazote joints that incorporate the standard blockout, which is filled with elastomeric concrete. In addition, detail a backwall at the end bents.

Design Manual Figure 11-3 has been revised and is attached for your use. Also attached are the Prestressed Concrete Box Beam and Concrete Wearing Surface Special Provisions.

This interim policy is effective immediately. The Design Manual, NCBDS, and project Special Provisions will be updated at a later date. Structure Standards and are currently being developed and will be available at a later date.

Attachments

PCI Bridge Design Manual, Section 8.9 - Transverse Design of Adjacent Box Beam Bridges.
Fig. 11-3, Fig. 11-3 (Metric)
Prestressed Concrete Box Beam Special Provision
Concrete Wearing Surface Special Provision

GRP/GM

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CONCRETE WEARING SURFACE 11-09-04

1.0 GENERAL

This Special Provision governs materials, forming, and all other related work in the construction of a concrete wearing surface in accordance with applicable parts of the Standard Specifications, the details shown on the plan, and as outlined in these Special Provisions.

2.0 MATERIALS

Unless otherwise noted on the plans, use class AA concrete containing glass fibers and a coarse aggregate gradation of 78M. Provide approved glass fibers at a dosage rate recommended by the Manufacturer. The Class AA concrete shall contain fly ash or ground granulated blast furnace slag at the substitution rate specified in Article 1024-1 and in accordance with Articles 1024-5 and 1024-6 of the Standard Specifications.

3.0 PREPARATION OF SURFACE

Completely clean all surfaces within the 48 hours prior to placing the overlay unless otherwise approved.

Thoroughly soak the cleaned surface for at least 12 hours prior to placing the concrete wearing surface. While soaking the surface, cover it with a layer of white opaque polyethylene film that is at least 4 mils (0.100 mm) thick. Immediately prior to placing the concrete wearing surface, remove standing water from the surface.

4.0 EQUIPMENT

Prior to beginning any work, obtain approval for all equipment to be used for deck preparation, placing, finishing, and curing the concrete wearing surface.

For surface preparation, use sandblasting or pressure washing equipment capable of removing all foreign matter. If using high pressure water blast, a minimum nozzle pressure of 3000 psi is required.

5.0 PLACING AND FINISHING

Follow the placing, finishing, and curing requirements of Article 420-15 (A) and (B). Construction Joints other than those shown on the plans are not permitted.

6.0 LIMITATIONS OF OPERATIONS

Vehicles and construction equipment are not permitted on the finished concrete wearing surface until the seven day curing time is completed and the concrete reaches the minimum specified compressive strength.

Use insulation that meets the requirements of Article 420-9(c), and if required, place it on the concrete wearing surface as soon as the initial set permits.

7.0 METHOD OF MEASUREMENT

The quantity of concrete wearing surface to be paid for is the actual number of square feet (square meters) of concrete wearing surface as provided on the plans.

8.0 BASIS OF PAYMENT

The quantity for which payment is made will be that quantity shown in square feet (square meters) on the plans. Where the plans have been revised, the quantity to be paid for will be the quantity shown on the revised plans.

The unit bid per square foot (square meter) will be full compensation for all work covered by this Special Provision and applicable parts of the Standard Specifications, but not limited to furnishing and placing concrete, joint filler and sealer, deck drains, bridge scuppers, and any other material; erecting and removing all forms, curing concrete, protecting concrete in wind, rain, low humidity, high temperatures or other unfavorable weather.

Payment will be made under:

Concrete Wearing Surface ..... Square Foot (Square Meter)

SPAN TYPE		SPAN LENGTH	DIM. B	DIM. A	DIM. C
PRESTRESSED	18'' CORED SLAB	< 42'	2'-9''	+ 0.4'	- 3.2'
	21'' CORED SLAB	< 49'	↑	+ 0.0'	- 3.6'
	27'' BOX BEAM	≤ 70'		- 1.2'	- 4.8'
	33'' BOX BEAM	≤ 85'		- 1.9'	- 5.5'
	39'' BOX BEAM	≤ 100'		- 2.7'	- 6.3'
	36'' GIRDER	≤ 45'		- 3.4'	- 7.0'
	45'' GIRDER	≤ 65'	↓	- 4.4'	- 8.0'
	54'' GIRDER	< 90'	2'-9''	- 5.6'	- 9.2'
	63'' MBT	< 105'	4'-0''	- 5.8'	- 9.4'
	72'' MBT	≤ 118'	↑	- 6.9'	- 10.5'
	63'' GIRDER	< 125'	↓	- 5.8'	- 9.4'
	72'' GIRDER	≤ 141'	4'-0''	- 6.9'	- 10.5'
I-BEAM		40'	2'-9''	- 2.5'	- 6.1'
		45'	↑	- 2.9'	- 6.5'
		50'		- 3.1'	- 6.7'
		55'		- 3.2'	- 6.8'
		60'		- 3.4'	- 7.0'
		65'		- 3.6'	- 7.2'
		70'		- 3.7'	- 7.3'
		75'		- 3.9'	- 7.5'
		80'	↓	- 3.9'	- 7.5'
		85'	2'-9''	- 4.0'	- 7.6'
PLATE GIRDER		90'	4'-0''	- 4.3'	- 7.9'
		100'	↑	- 4.8'	- 8.4'
		110'		- 5.4'	- 9.0'
		120'		- 5.8'	- 9.4'
		130'		- 6.4'	- 10.0'
		140'		- 6.9'	- 10.5'
		150'	↓	- 7.5'	- 11.1'
		160'	4'-0''	- 8.0'	- 11.6'

+VALUES INCREASE BRIDGE LENGTH
- VALUES DECREASE BRIDGE LENGTH
DIM.A- FOR HYDRAULICS UNIT'S USE IN SETTING BRIDGE LENGTH

STREAM CROSSING DETAILS FOR 1'-0'' MIN. BERM

FIGURE 11 – 3

SPAN TYPE		SPAN LENGTH	DIM. B	DIM. A	DIM. C
PRESTRESSED	457mm CORED SLAB	< 13m	840mm	+ 160mm	- 980mm
	533mm CORED SLAB	< 15m	↑	+ 0.0mm	- 1080mm
	686mm BOX BEAM	≤ 21m		- 370mm	- 1470mm
	838mm BOX BEAM	≤ 26m		- 580mm	- 1680mm
	991mm BOX BEAM	≤ 30m		- 820mm	- 1920mm
	914mm GIRDER	≤ 14m		- 1040mm	- 2120mm
	1143mm GIRDER	≤ 20m	↓	- 1400mm	- 2480mm
	1372mm GIRDER	< 30m	840mm	- 1730mm	- 2810mm
	1600mm MBT	< 32m	1220mm	- 1760mm	- 2860mm
	1829mm MBT	≤ 36m	1220mm	- 2100mm	- 3200mm
	1600mm GIRDER	< 38m	1220mm	- 1760mm	- 2860mm
	1829mm GIRDER	≤ 43m	1220mm	- 2100mm	- 3200mm
I-BEAM		12.2m	840mm	- 790mm	- 1870mm
		13.7m	↑	- 930mm	- 2010mm
		15.2m		- 990mm	- 2070mm
		16.8m		- 1020mm	- 2100mm
		18.3m		- 1060mm	- 2140mm
		19.8m		- 1110mm	- 2190mm
		21.3m		- 1170mm	- 2250mm
		22.9m		- 1200mm	- 2280mm
		24.4m	↓	- 1200mm	- 2280mm
		25.9m	840mm	- 1240mm	- 2320mm
PLATE GIRDER		27.4m	1220mm	- 1330mm	- 2410mm
		30.5m	↑	- 1480mm	- 2560mm
		33.5m		- 1660mm	- 2740mm
		36.6m		- 1800mm	- 2880mm
		39.6m		- 1980mm	- 3060mm
		42.7m		- 2110mm	- 3190mm
		45.7m	↓	- 2300mm	- 3380mm
		48.8m	1220mm	- 2440mm	- 3520mm

+VALUES INCREASE BRIDGE LENGTH
- VALUES DECREASE BRIDGE LENGTH
DIM.A- FOR HYDRAULICS UNIT'S USE IN SETTING BRIDGE LENGTH
DIM.A OR C- FOR STRUCTURE DESIGN UNIT'S USE IN SETTING STATION OF FRONT SLOPE

STREAM CROSSING DETAILS FOR 300mm MIN. BERM

FIGURE 11 – 3

PRESTRESSED CONCRETE BOX BEAM 11-09-04

The prestressed box beam members shall meet the requirements for prestressed concrete members as specified in the Standard Specifications with the following exceptions and additions.

1.0 FABRICATION

Place concrete for box beams in 2 or more horizontal layers. Place and compact each layer before the preceding layer takes initial set so that there is no surface or separation between layers. Should shrinkage or settlement cracks occur, the Engineer reserves the right to require additional layers and/or vibration.

The requirements of the above paragraph may be waived if self-consolidating concrete is used.

When box beams are cast, a positive hold-down system shall be employed to prevent voids from moving. Design the system to be left in place until the concrete has reached the release strength. At least six weeks prior to casting box beams, the Contractor shall submit to the Engineer for review and comment, detailed drawings of the proposed void material and hold-down system. In addition to structural details, location and spacing of the hold-downs shall be indicated. The Contractor shall also submit his proposed method of concrete placement and of consolidating the concrete under the void. Cutting or drilling holes in the void material for the purposes of providing access for consolidating equipment will not be permitted.

Rake the top surface of the box beam section to a depth of 3/8" (10 mm). No surface finish is required for sides and bottom of the box beam sections except the exposed side of the exterior beam section as noted below. Provide a resulting surface finish essentially the same color and surface finish as the surrounding concrete. Fill all voids in the outside face of exterior box beams with a sand-cement or other approved grout. Repair voids greater than ¼" (6 mm) in diameter or depth in other faces of the box beams in a like manner. Where an excessive number of smaller voids exist in any member, the Engineer requires a similar repair.

Provide a ¾" (19 mm) chamfer along the bottom edges on ends and sides of all beam sections, top outside edges of exterior beam sections and acute corners of beam sections. Round the top edges on ends of all sections with a ¼" (6 mm) finishing tool. Provide square corners along top edges on all slab sections along shear keys. Do not chamfer vertical edges at ends of beam sections.

2.0 ALIGNMENT AND DIRECTIONAL TOLERANCES

In order to ensure a good, neat field fit, assemble box beam spans in the yard and have pieces match-marked. Ensure that pieces fit together neatly and in a workman-like manner.

Manufacture the box beams within the tolerances listed in the “Box Beam Tolerances” table and sketches.

3.0 ERECTION

The post tensioning system shall use 0.6" (15mm) diameter strands or 1¼" (32mm) diameter steel bars. Steel bars shall have a minimum yield strength of 150,000 psi (1034.2 MPa), meeting the requirements of ASTM A722. Strands shall be tensioned to 43,950 pounds (195.5 kN) and bars shall be tensioned to 150,000 pounds (667 kN). Strands shall be placed in a non-corrosive 0.6" (15mm) diameter, 1/16" (1.6mm) minimum wall thickness black polyethylene pipe meeting the requirements of ASTM D2239. Similarly, bars shall be placed in a black polyethylene pipe.

When erecting prestressed box beams, place the transverse post tensioning system in the diaphragms, place grout in the grout pockets located at the areas of the post tensioning strands, if provided, and tension to the required force. Grease the bars or strands and place in the polyethylene pipe. Do not apply grease or extend the pipe in the area of the recesses at the ends of the tensioning strands where grout is applied. Tension the bars or strands in the diaphragm nearest mid-span first. Proceed to tension bars or strands in the adjacent diaphragms. Continue the tensioning operation in a symmetric manner along the length of the span. At each diaphragm location, maintain a symmetric tension force between each pair of bars or strands in the diaphragm. After all tensioning in a span is completed and before placing any equipment, material or barrier rail on the span, fill the shear key, dowel holes, and recesses at the ends of the diaphragm with an approved non-metallic, non-shrink grout. Cure for 3 days minimum and until the grout reaches a compressive strength of 3000 psi (20.7 MPa).

After tensioning and curing, obtain approval prior to placing material and equipment on the box beam spans. Support cranes or other equipment exceeding the legal load limit on mats. Submit for review a detailed drawing for the mats that are intended for use on the box beams. Provide a complete description of the equipment that is intended for placement on the mats. Supply and construct mats at no additional cost to the Department.

4.0 PAYMENT

The quantity of prestressed concrete box beams shown on the plans will be paid for at the contract unit price per linear foot for "_____ x _____ Prestressed Concrete Box Beams." This price and payment shall be full compensation for furnishing and placing the prestressed concrete box beams and includes all materials, tools, equipment, labor and incidentals necessary to complete this work.

BOX BEAM TOLERANCES:

a = Length: ± 1 in.

b = Width (overall): ± ¼ in.

c = Depth (overall): ± ¼ in.

d = Variation from specified plan end squareness or skew:

± $^1/_8$ in. per 12 in. width, ± ½ in. max.

e = Variation from specified elevation end squareness or skew:

± $^1/_8$ in. per 12 in., ± ½ in. max.

f = Sweep, for member length:

up to 40 ft. ± ¼ in.

40 to 60 ft. ± $^3/_8$ in.

greater than 60 ft. ± ½ in.

g = Differential camber between adjacent members:

¼ in. per 10 ft., ¾ in. max.

h = Local smoothness of any surface: ¼ in. in 10 ft.

k = Position of strands: ± ¼ in.

n = Longitudinal Position of blockout: ± 1 in.

o_1 = Position of dowel holes: ± ¼"

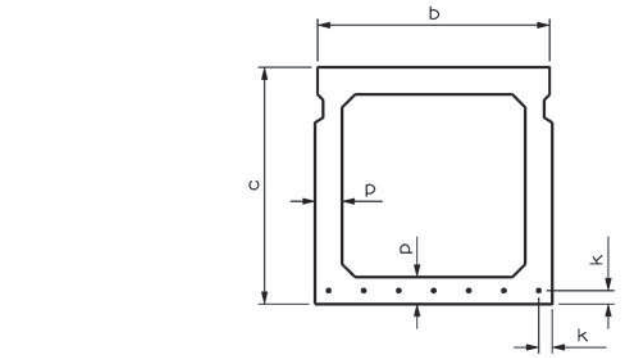
o_2 = Position of sleeves cast in beams, in both horizontal and vertical plane: ± ½ in.

p = Position of void: ± $^3/_8$"

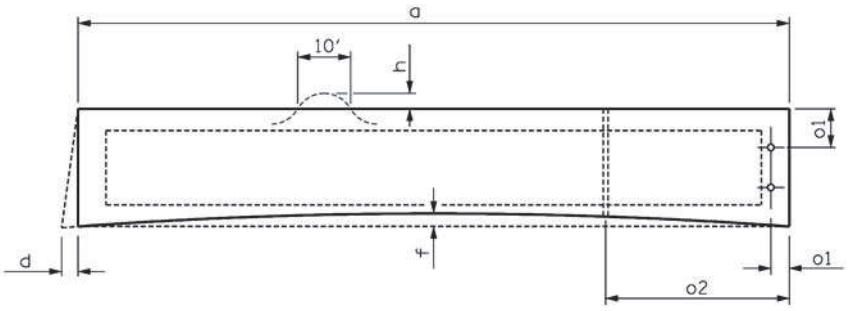
Bearing area – deviation from plane surface: ± $^1/_{16}$"

Width of any one span = Plan width + $^1/_8$" per joint

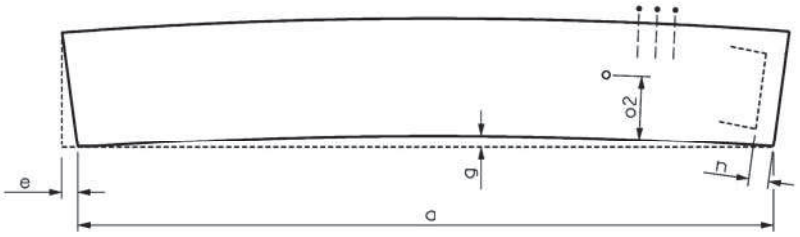
Box Beam Tolerances:



CROSS SECTION



PLAN



ELEVATION