NCHRP Project 12-71

Design Specifications and Commentary for Horizontally Curved Concrete Box-Girder Highway Bridges

Appendix D
State of Practice Summary for the United States

NCHRP 12-71 - Design Specifications and Commentary for Horizontally Curved Box Girder Highway Bridges

Results of State-of-Practice Survey of Selected State DOTs

	California	Colorado	Florida	Hawaii	Idaho	Nevada	New York	Oregon	Tennessee	Texas	Washington	Wisconsin
1 Number or Percentage of Curved Concrete Box Girder Bridges in Inventory	45% of all bridges are concrete box			Out of a total of 750 bridges, 10-20 are curved box girders, mostly ramps				~2,700 bridge inventory			~5,000 bridge inventory	
a Reinforced Concrete	35% of RC boxes are curved	53(N) Pre 1978	A few old bridges	50%	<10(N)	0	0	~1% or (~25-30)	Mostly, don't use anymore	0 (curved)	1/3 of inventory are box girders; 80% of these are curved. Of these RC/PT is 50/50. Everything over 130' is PT.	<15(N)
b Prestressed Concrete	35% to 40% of PT boxes are curved	31(N) Post 1978	Mostly balance cantilever	50%	<10(N)	4 segmental and 4 CIP curved, one with tight curve, 20 yrs old	5 Segmental	~1% or (~25-30)	Don't use	< 1%		0
2 Method of Construction Used												
a CIP on Falsework	Majority	Yes		Most	100%	4 bridges	0	50%	Avoid, contractors don't like	Yes	65%	100%
b Segmental Construction	Some, perhaps more in future	Cantilever and span-by-span, both Precast and CIP	Yes, number increasing. Use tendons in top and bottom flanges	Windward Viaduct	0	4 bridges	5	50%	Don't use	Both balanced and span-by-span	5%	0
c Precast Girders with CIP Deck	None built, but OK for future	Girders are chords	Yes, use straight girders, CIP deck is curved	No	0	0	0	0	Girders are straight	"U" sections	30%	0
d Other Method		Using spiced precast tubs with CIP deck				0		0			State is using precast box girder segments more and more; many new bridges around Olympia use this.	0
3 Percentage of Bridges with Geometric Attributes												
a Single Span	15%	79%	Few (maybe only one)	No	No	0	No	25-30%		5%	20%	0
b Constant Width Multi-span on Single Column Bents	50%	50%	Majority are constant depth. Many with integral bent caps but most have 2 bearings	Yes	Yes	100%	Yes	50-60%		86% (ramps)	50% (all single columns with width 38' or less)	Most
c Skewed Abutments	30%	15%	1% - try to avoid skew abutments	No	No	1 bridge	Yes	30%		17%	80%	50%
d Skewed Interior Multi-column Bents or Piers	20%, Recently one PS&E'd in Fresno (3-span)	10%	Avoided	No, maybe	No	0	No	<5%		7%	80%	0
e Spans Greater than 50 meters	30%, most multi-span ramps	38%	~ 1%	No	<5(N)		Yes	15-20%		2%	20% - Note, have some long spans like Columbia River crossing, 660'	0
4 How Will the Answers to Questions 1 to 3 Change in the Future	Precast and segmental may increase	Trend to longer spans, more precast tubs, and precast segments	More curved bridges due to urban environment	No more RC Box, maybe more segmental	More curved, expecially ramps	More segmental	More segmental	Going to longer spans and more skews as more routes/bridges are placed in urban areas	Don't expect change	More precast, less CIP, more curved bridges	Going to longer spans	Most segmental, no more CIP
5 Identify and Describe Your Problems with Curved Concrete Box Girder Bridge												
a Surface Crack along Tendon Path	Yes	Not much - 1% at anchorage	Don't use tendons in webs	No	One case, cracked, injected	No	No	Only 1 bridge	No prestress	No	None	Minor
b Tendon Breakout	405/55, maybe others	Not due to web curvature	None	One case, missed bursting reinforcement	One case of bottom slab crack, but was not curved	No	No	3 or 4 bridges	No prestress	No	None	No
c Bearing Uplift or Overload	Shasta County	No - try to avoid - use tie-downs with PC tub	Yes, but mostly due to poor bearing quality or improper installation	No	No, use only spherical in curved	No	No	3 bridges	No, use continuous bridges with integral abutments	Yes	None, but they place extra stirrups to prevent this	No, conservative cesign
d Shear/Torsion Cracking	No	Some in RC, not in PS	Not as a result of curvature	No more for curved	No, except in RC straight	No	Yes, shear crack in 1960, I-80 over Onida lake, spliced	1 bridge	No problems	No	None	No

	California	Colorado	Florida	Hawaii	Idaho	Nevada	New York	Oregon	Tennessee	Texas	Washington	Wisconsin
e Unexpected Displacements	Yes, mainly on skewed supports where movement about CG of column group causes the shear key to engage	More due to skew	Because balanced cantilever construction, displacements are well controlled	No	Yes in steel box, but not in concrete	No	No			No	None	No
f Other Problems	Lateral displacement of columns		Problems have occurred because expansion joints must accommodate multi-directional displacements						Deck replacement an issue - difficult to do	No		No
6 Describe Design and Construction Procedures												
a Type of Global Analysis	BDS, CT-Bridge may do a better job for curved	Usually 2D with adjustments. 3D at designers discression fo R< 800 ft. 3D more common with multiple webs	Not prescribed - Most designs use 2D analysis with supplementation by 3D analysis	3D analysis, SAP like, FEM	3D FEM for R<800'	FEM, case by case	No guide	Always 2D plane frame (usually STRUDL)			Typically 2D plane frame; but designers decide on a case-by-case basis	Use web by web design
b Wheel Load Distribution	Nothing special	V load method. Use program for spread box beams	AASHTO and influence surfaces	None	AASHTO, unless FEM is used	AASHTO	No guide	AASHTO, but for curved bridges, depends on the designer - sometimes added loads for exterior girders			Strictly AASHTO LRFD	AASHTO
c Distribution and Sequence of Longitudinal Prestressing	Nothing special, Allowing contractor to distribute the PT with variation may be a problem	Usually the same. Designer's descretion if girder lengths materially different	Established by designer and included in the construction documents	Nothing specific	None	Yes, but no guidelines	?	Nothing special			Nothing special	No, PT slab, straight
d Prevention of Tendon Breakout	Nothing special, except tendon ties	Memos for addressing breakouts. 1:24 maximum flare. Construction quality an issue.	Have had no problems	No	Caltrans details	Caltrans Details	?	std details (attached)			Nothing special	No
e Design of Bearings	Nothing special	Designed for vertical and torsion	Typically use pot bearings and SBI 1008 Specification for Structural Bearings (USDOT)	No guide	None	Use all kinds, but like spherical best	No guide	Have not done extra, but sometimes do have problems			Nothing special	Multi-directional, sliding, uni-directional
f Torsion Design	Nothing special	Consider vertical and torsion for outside and inside web	Torsion demands obtained from 3D frame analysis and results	No	Code	No guide	?	Nothing add'l	Don't design for torsion		Nothing additional	No
g Design of Web Reinforcing for Combined Shear and Transverse Bending	Memo to Designers Chapter 11	LRFD(2000) - Use modified compression field theory with interaction with web	?	Designer's choice	No, case by case	Conventional, Caltrans	?	Nothing add'l			Nothing additional	No
h Standard Details	Nothing special		Extensive website plus PTI Post-Tensioning Manual	No	No, Caltrans	Caltrans/Tendon ties	No guide	Including minimum rules for duct ties and duct arrangement (attached)				No
I Number and Spacing of Diaphragms	Nothing special, do not believe interior	Use as few as possible at designer descretion	Diaphragms placed at support locations	No	No guide, but usually use at 40' OC	Midspan for curved or straight with L>100'	No guide	Follow AASHTO			Follow AASHTO	Same as straight, use 8" diaphragms, 25' oc
j Other		Quality control - designer, checker, leader						None			None	No
Other Comments												