LOUISIANA DEPARTMENT OF TRANSPORTATION & DEVELOPMENT

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Project Development Division
Bridge Design Section
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Bobby Jindal, Governor
Sherri H. LeBas, P.E., Secretary

MEMORANDUM

TO: ALL CONSULTANTS
ALL BRIDGE DESIGNERS

FROM: PAUL FOSSIER, P.E.
BRIDGE DESIGN ENGINEER ADMINISTRATOR

SUBJECT: BRIDGE DESIGN TECHNICAL MEMORANDUM NO. 52 (BDTM.52)
BRIDGE DESIGN AND EVALUATION MANUAL (BDEM) REVISION NO. 1

DATE: February 4, 2015

The following pages in BDEM have been revised and incorporated in the BDEM posted on Bridge Design Section Website. The revised pages are also attached for reference.

Page No.	Revision Description
Revision History-i	Updated the page to document revisions
I.Ch3-4 & 5	Updated the QC/QA Statement in Section 3.3.1 for engineering advertisements and contracts for bridge projects.
II.V1-Ch3-2	Revised γ_p to 1.0 in Table 3.4.1-1 for Extreme Event - I, to be consistent with AASHTO 2015 interim revisions.
II.V1.Ch5-11	Clarified the haunch thickness shown in the second paragraph is the minimum requirement.
II.V1-Ch9-i	Added Section 9.7.3.2 – Distribution Reinforcement
II.V1-Ch9-3	Added Section 9.7.3.2 – Distribution Reinforcement
III.Ch2-i	Added Section 2.3 - Deck Design Example
III.Ch2-1, 2 & 9	Updated references
III.Ch2-16 to 18	New pages for deck design example

In addition, the 2015 Interim Revisions to the AASHTO LRFD Bridge Design Specifications (7th Edition, 2014) shall be implemented. Refer to BDTM.50 for implementation policy on revisions to BDEM.

This technical memorandum is posted on the LA DOTD Website under *Inside La DOTD* > *Divisions - Engineering* > *Bridge Design* > *Technical Memoranda – BDTMs.*
Please contact Ms. Zhengzheng "Jenny" Fu (225-379-1321, zhengzheng.fu@la.gov) if you have questions or comments.

PF/zzf

Attachment

Cc: Janice Williams (Chief Engineer)
Chad Winchester (Chief, Project Development Division)
Vacant (Assistant Secretary of Operations)
Kirk Gallien (Deputy Assistant Secretary of Operations)
David Miller (Bridge Maintenance Administrator)
Michael Vosburg (Chief Construction Division Engineer)

Edward Wedge (Project Management Director)
Jeff Lambert (Pavement and Geotechnical Engineer Administrator)
Simone Ardoin (Road Design Engineer Administrator)
Art Aguirre (FHWA)
District Administrators (02, 03, 04, 05, 07, 08, 58, 61, 62)

BDEM REVISION HISTORY

Date	Description	Publication BDTM No.
11/17/2014	Initial Publication of Bridge Design and Evaluation Manual (BDEM)	BDTM.50
2/4/2015	Revised Pages I.Ch3-4 & 5, II.V1-Ch3-2, II.V1.Ch5-11, II.V1-Ch9-i, II.V1-Ch9-3, III.Ch2-i, III.Ch2-1, 2 & 9. Added Pages III.Ch2-16 to 18.	BDTM.52

reduce the engineering stamps on a sheet. When more than one engineering stamp is required on a sheet, the responsibilities for each engineering stamp shall be clearly defined.

- Assemble design calculations from all designers including the final geotechnical analysis report and the hydraulic report from the geotechnical engineer and the hydraulic engineer, finalize the calculation book, and seal the cover sheet of the calculation book.
- Ensure the names of the designer, design checker, detailer, detail checker, and reviewer are correctly shown on the title block of each plan sheet. Stamp all plan sheets or designate a designer, design checker, or reviewer who shall be licensed by the State of Louisiana as a professional engineer to stamp the sheets developed under their supervision. The EOR must stamp the general notes sheets.
- Ensure all special provisions are accurately shown on the construction proposal. The special provisions are typically stamped by the Specification Engineer as part of the construction proposal; however, if the Specification Engineer is not qualified or not willing to stamp the special provisions, the EOR must stamp these provisions.

Step 8: QC/QA for Design Activities after Final Plans are Signed by Chief Engineer

The same QC/QA process above shall apply to all design activities such as plan revisions, change orders, etc., occurring after the final plans are signed by Chief Engineer.

Step 9: Archiving Bridge Design Files

The EOR is responsible for archiving all bridge design files including calculation books, plans, special provisions, cost estimate, and other pertinent documents in accordance with the Bridge Design Section records retention policy (see *Appendix F*). For consultant projects, the supervisor or the team leader is responsible for delivering all bridge design files to the LADOTD Bridge Task Manger no later than 30 calendar days after the stamped final plans are delivered. Any revisions made to these documents due to plan revisions and change orders must be delivered with the signed plan revisions or change order sheets.

The final calculation book and other final design documents for all projects including in-house and consultant projects shall be uploaded to the archiving location designated in the record retention policy within 30 calendar days after the stamped final plans are delivered.

3.3—CONSULTANT AND DESIGN-BUILD PROJECTS

3.3.1—Responsibilities of the Prime Consultant and Design-Build Contractor

For consultant projects and design-build projects the Prime Consultant or Design-Build Contractor is fully responsible for QC/QA of their work and the work of all subconsultants. The Prime Consultant or Design-Build Contractor is also responsible for all expenses incurred from design omissions, ignorance, or errors.

The Prime Consultant or Design-Build Contractor is required to submit a QC/QA plan document as part of the proposal (SF 24-102) evaluation. Effective Nov. 1, 2012, the following QC/QA statement is included in the advertisement and contract for all Bridge Design projects:

Quality Control and Quality Assurance (QC/QA) for Bridge Design Projects

The Prime Consultant shall submit a bridge design QC/QA plan document specifically developed for this project as part of the DOTD Form 24-102. The QC/QA plan document must comply with the minimum requirements in the LADOTD Bridge Design Section Policy for QC/QA as stated in

Part I, Chapter 3 of the LADOTD Bridge Design and Evaluation Manual (BDEM). The grading instructions, the rating matrix, and the grading sheet for the QC/QA plan document are included in Appendix G of the BDEM Part I, Chapter 3 – Policy for QC/QA. The QC/QA plan document shall be prepared to address all evaluation criteria included in the rating matrix. The QC/QA plan document must be implemented for all bridge design activities in both design phase and construction support phase of the project. The Prime Consultant is fully responsible for QC/QA of their work as well as the work of all sub-consultants. All project submittals must include a QC/QA certification that the submittals meet the requirements of the QC/QA plan document.

The bridge task manager for the project is responsible for evaluating and grading the QC/QA plan document. The grading instructions, evaluation matrix, and grading sheet are included in Appendix G.

3.3.2—Responsibilities of the LADOTD Bridge Task Manager

LADOTD Bridge Task Managers shall not perform QC/QA of consultants' work.

The responsibilities of the LADOTD bridge task manager for a consultant project are as follows:

a. Develop bridge design scope of work, man-hour estimate, minimum personnel requirements, and evaluation criteria, and obtain agreement from the direct supervisor on these items. Provide the information required for the project manager to prepare the advertisement and review the draft advertisement to ensure that all bridge design requirements are included.

b. Serve as a member of the proposal evaluation committee and select the most qualified consultant team. Evaluate SF24-102 and QC/QA plan document in accordance with the policies and procedures established by CCS and the instructions included in *Appendix G*. The final rating for SF24-102 and the QC/QA plan document shall be reviewed by the direct supervisor and the Bridge Design Engineer Administrator. SF24-102 for the selected consultant shall be retained for project duration.

c. Initiate a bridge design kick-off meeting with the consultant as soon as the project is awarded to meet key bridge design team members (supervisor or team leader, designers, design checkers, and reviewers); discuss staffing plan and implementation of QC/QA plan document; determine bridge design submittal schedules; share expectations and consultant rating criteria; discuss bridge design criteria; and discuss bridge design budget, supplemental requests, invoices, and the importance of avoiding claims. Reach an early agreement regarding bridge type, size and location (TS&L). A bridge design kick-off meeting agenda checklist is included in *Appendix H.*

d. Review and approve design criteria and TS&L and ensure the design criteria is updated as the project progresses.

e. Monitor consultant's implementation of the QC/QA plan document. Ensure each consultant submittal includes a QC/QA certification (see *Appendix I*).

f. Keep a project log sheet to record all major project activities such as project meetings, consultant submittals, DOTD review comments, major decisions made, etc. A project log sheet template is included in *Appendix J.*

g. Review consultant's submittals. Selectively check dimensions and details as a cursory review of the plans for constructability, consistency, and clarity but not as QC/QA of consultants' work.

Table 3.4.1-1—Load Combinations and Load Factors

Load Combination Limit State	DC DD DW EH EV ES EL PS CR SH	LL IM CE BR PL LS	WA	WS	WL	FR	TU	TG	SE	Use One of These at a Time				SC[1]
										EQ	IC	CT	CV	
Strength-I	γ_p	1.75	1.00	-	-	1.00	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-	-
Strength-II	γ_p	1.35	1.00	-	-	1.00	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-	-
Strength-III	γ_p	-	1.00	1.40	-	1.00	0.50/1.20	γ_{TG}	γ_{SE}		-	-	-	-
Strength-IV	γ_p	-	1.00	-	-	1.00	0.50/1.20	-	-	-	-	-	-	-
Strength-V	γ_p	1.35	1.00	0.40	1.00	1.00	0.50/1.20	γ_{TG}	γ_{SE}	-	-	-	-	-
Extreme Event-I	1.00	**0.25**[2]	1.00	-	-	1.00		-	-	1.00	-	-	-	
Extreme Event-II	γ_p	0.50	1.00	-	-	1.00	-	-	-	-	1.00	1.00	1.00	-
Extreme Event-III[1]	γ_p	**1.75**	**1.00**	**0.30**	**-**	**1.00**	**-**	γ_{TG}	γ_{SE}	**-**	**-**	**-**	**-**	**1.00**
Extreme Event-IV[1]	γ_p	**-**	**1.00**	**1.40**	**-**	**1.00**	**-**	γ_{TG}	γ_{SE}	**-**	**-**	**-**	**-**	**0.70**
Extreme Event-V[1]	γ_p	**-**	**1.00**	**-**	**-**	**1.00**	**-**	**-**	**-**	**-**	**1.00**	**1.00**	**1.00**	**0.60**
Extreme Event-VI[1]	γ_p	**-**	**1.00**	**-**	**-**	**1.00**	**-**	**-**	**-**	**1.00**	**-**	**-**	**-**	**0.25**
Service-I	1.00	1.00	1.00	0.30	1.00	1.00	1.00/1.20	γ_{TG}	γ_{SE}	-	-	-		-
Service-II	1.00	1.30	1.00	-	-	1.00	1.00/1.20	-	-	-	-	-		-
Service-III	1.00	**1.00**[3]	1.00	-	-	1.00	1.00/1.20	γ_{TG}	γ_{SE}	-	-	-		-
Service-IV	1.00	-	1.00	0.70	-	1.00	1.00/1.20	-	1.00	-	-	-		-
Fatigue- I LL, IM & CE only	-	1.50	-	-	-	-	-	-	-	-	-	-	-	-
Fatigue- II LL, IM & CE only	-	0.75	-	-	-	-	-	-	-	-	-	-	-	-

1. SC (Scour) is the total scour depth determined by Bridge Hydraulic Engineer in accordance with *HEC-18.* Scour is not a load, but an extreme event that alters geometry of the foundation, possibly causing structural collapse or amplification of applied load effects. Adopted factors for SC are based on NCHRP Report 489*, Design of Highway Bridges for Extreme Events*, and modified for Louisiana practice.

2. NCHRP Report 489 has shown that the commonly used live load factor of 0.50 in combination with earthquake effects is conservative and a reduced live load factor of 0.25 will provide an adequate safety level. Since probability of a major earthquake occurring in Louisiana is generally very low, it is reasonable to use a live load factor of 0.25.

(*continued on next page)*

capacity.

Strand pattern details showing strand layouts, number and spacing of strands, concrete cover and edge clearances, and layout of all mild reinforcing steel shall be shown in contract plans. The girder spacing shall not exceed 12.0 feet center-to-center.

The haunch thickness at girder bearing centerline shall be minimum 2 inches for spans less than 90 feet, 3 inches for spans from 90 to 120 feet, and 4 inches for spans greater than 120 feet. Haunch thickness shall be included in weight calculation, but shall be omitted in the calculation of composite section properties used in determining live load effect.

Designers shall pay special attention to the haunch thickness of prestressed girders when they are used in conjunction with a high degree of vertical and horizontal curvature which could present challenges to meeting haunch dimension requirements.

The haunch thickness along the girder due to camber at time of erection and non-composite dead load shall not be less than zero (the top flange of the girders shall not intrude into the deck). Reinforcement shall be provided in haunches exceeding 4 inches in thickness. Girder haunch shall not exceed 6 inches at any location.

PPC girders shall not be used in a curved bridge where the offset between an arc and its chord exceeds 1 foot. Refer to *PCI Bridge Design Manual* for additional design considerations for skewed and curved bridges.

The notes below shall be included in PPC girder detail sheets or general notes sheets for all projects.

"The contractor is responsible for stability of precast prestressed concrete girders during fabrication, storage transportation, erection, and deck placement. Supporting analysis and calculations stamped, signed, and dated by a Louisiana licensed professional engineer and shop drawings showing the method of lifting the girder, lifting locations and details, support (dunnage) locations for storage and transportation details, and erection bracing details shall be submitted to the EOR for review.

Any inherent stability provided by cast-in-place diaphragms shall not be considered by the contractor in designing the required construction bracing. The diaphragms are provided to restrain lateral movement of girders when the bridge is in-service and are not intended or allowed for use as construction stability bracing."

Girder stability during each phase of construction is dependent on the type of lifting equipment and pick up methods and therefore, is the responsibility of the contractor.

For extremely long girders (typically > 160 feet), the contractor may consider using lifting brackets instead of using lifting loops; so that the girder would be lifted from below its center of gravity. The brackets may eliminate the chance of an "off center" lifting which may occur when using lifting loop on the top flange.

During the design process, the EOR shall ensure that all girders, while within the allowable stress

CHAPTER 9 – DECKS AND DECK SYSTEMS

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Minimum reinforcement bar size shall be No. 4. Reinforcement spacing in both transverse and longitudinal directions in the deck shall not exceed seven inches on centers to minimize cracking width.

LADOTD Deck design tables presented in Part III, Ch 2 may be used to determine the deck reinforcement requirements in the interior regions of the deck, provided that the stated limitations are met.

Deck overhang and the adjacent region to the overhang shall be designed for vehicle collision provisions in accordance with *A13* in addition to wheel load. Refer to *D9.5.5* for deck overhang reinforcement requirement when approved crash tested railings are used.

For bridges composed of simple span precast girders made continuous, additional longitudinal continuity reinforcement shall be provided at the top of deck over continuity diaphragm locations in accordance with *D5.14.1.4*. Refer to *A6.10.1.7* for additional deck reinforcement requirements in negative flexure moment region of continuous steel girder bridges.

A deck placement sequence shall be provided on the bridge plans for all continuous multiple span bridges with a cast in place concrete deck. Refer to *Bridge Design Special Details - Miscellaneous Span Details* and *D6.7.2* for requirements on deck placement sequences for continuous multi-span prestressed girder and steel girder bridges.

9.7.3.2—Distribution Reinforcement

The following shall supplement *A9.7.3.2*.

Steel reinforcement shall also be placed in the secondary direction in the top of slabs as a percentage of the primary reinforcement for negative moment using the same equations as for the bottom distribution reinforcement.

C9.7.3.2

The following shall supplement *AC9.7.3.2*.

It has been observed that many new bridges with increased girder spacing exhibited deck cracking due to the decrease of deck mass and hence high vibration. In addition the thermal effects, which are generally ignored in the design, could be significant and lead to excessive cracking. Increasing the top longitudinal reinforcement will help limit the potential for cracking and reduce crack width which in turn should improve long-term durability.

CHAPTER 2 – LADOTD DECK DESIGN TABLES

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2.1—LADOTD DECK DESIGN TABLES, GIRDER TOP FLANGE ≥ 48 INCHES

The tables in this section are developed for concrete cast-in-place deck supported by concrete girders with flange width ≥ 48 inches.

These tables may be used in lieu of detailed analysis. The following assumptions and limitations are used in developing this table and must be considered when using the listed values.

- The equivalent strip method is used and all limit states are satisfied.
- Reinforcements shown are for interior regions of the deck only and cannot be applied to deck overhang and its adjacent regions of the deck that need to be designed for vehicle collision provisions in accordance with *AASHTO LRFD Bridge Design Specifications* (hereinafter referred to as "LRFD" in this chapter) *Section 13,* in addition to the wheel load.
- This table is applicable to decks supported on at least three girders. The maximum total overhang length from the center of exterior girder to the edge of deck shall equal to the smaller of 0.625 times the girder spacing and 6'-0". The minimum overhang length shall equal to 5 times deck thickness.
- Maximum live load moment from *LRFD Appendix A4 Table A4-1* is used. Design section for the negative moment is determined in accordance with *LRFD Section 4.6.2.1.6* assuming a 48 inch top flange width for the girder.
- Flexural moments due to dead load effects are assumed to be $M=c*w*L^2$, where w is the uniformly distributed load in kip/ft and L is the girder spacing. For positive flexural moment c=0.08; for negative flexural moment c=0.10.
- The compressive strength of concrete, f'_c=4000 psi. The yield strength of the reinforcing bars, f_y=60 ksi.
- The deck thickness shown includes ½" sacrificial thickness that was not included in the structural calculation, but considered in the dead load calculations.
- For overall deck thickness ≥ 8 inches, the clear concrete cover at top and bottom of the slab equals to 2 ½" inches (including ½" sacrificial thickness) and 1 ½" inches, respectively. For overall deck thickness of 7 and 7 ½ inch, the clear concrete cover equals to 2" (including 1/2" sacrificial thickness) and 1 ½", respectively. Overall deck thickness less than 8 inches can only be used for movable bridge spans.
- The weight of the railing equals to 520.5 lb/ft (TL-5). The bottom width of the railing from the edge of the deck to the gutter line equals to 1'-8". The weight of railing is evenly distributed along the deck in transverse direction (perpendicular to traffic).
- Concrete density is 150 pcf.
- Stay-in-Place (SIP) steel form (foam filled) weight of 10 psf is included.
- Future wearing surface of 25 psf is included.
- The girder spacing is the distance between the centers of the girders.
- Minimum and maximum bar spacings are limited to 5 inches and 7 inches, respectively, with increments of 0.5 inch. This limitation applies to both transverse and longitudinal directions.
- Reinforcing bars are limited to #4, #5, and #6.

- Exposure factor for crack control calculations is assumed to be 1.0.
- Effective span length "S" for the distribution reinforcement calculation is in accordance with *LRFD Section 9.7.2.3,* assuming 48 inch top flange width and 7 inch web thickness for the girder.

2.2—LADOTD DECK DESIGN TABLES, GIRDER TOP FLANGE < 48 INCHES

The tables in this section are developed for concrete cast-in-place deck supported by concrete or steel girders with flange width < 48 inches.

These tables may be used in lieu of detailed analysis. Refer to Section 2.1 for assumptions and limitations used. In addition, the following assumptions were used as exceptions to those cases listed in Section 2.1 in order to develop these tables and must be considered when using the listed values.

- Maximum live load moment from *LRFD Appendix A4 Table A4-1* is used. Design section for the negative moment is determined in accordance with *LRFD Section 4.6.2.1*.6, assuming a 12 inch top flange width for the girder.
- Effective span length "S" for the distribution reinforcement calculation is in accordance with *LRFD Section 9.7.2.3*, assuming a 12'' top flange and 5/8'' web for the girder.

2.3—DECK DESIGN EXAMPLE (GIRDER TOP FLANGE = 48", OVERALL DECK THICKNESS = 8.5", GIRDER SPACING = 10'-6")

This example is to demonstrate the development of deck design tables in the previous sections. The design is in accordance with the *AASHTO LRFD Bridge Design Specifications (7th Edition)*, *BDEM*, and assumptions and limitations listed in 2.1 and 2.2.

1. Design Information:

f'_c =	4,000	psi	*Concrete compressive strength, β_1 = 0.85*
f_y =	60,000	psi	*Steel yield strength*
w_c=	0.15	kcf	*Weight of concrete*
S =	10.50	ft	*Beam spacing*
t_{slab}=	8.50	in	*Total thickness of deck*
$t_{Structural}$=	8.00	in	*Structural thickness of deck*
Top clear cover=	2.0	in	*Does not include the 0.5" sacrificial surface*
Bottom clear cover=	1.5	in	
Min. bridge width =	28.08	ft	*2 girder spacing + min. overhang (5×deck thickness)*
Barrier unit weight, w_b=	0.037	klf	*2×0.520 k/ft /Min. bridge width*
Slab unit weight, w_s=$w_c t_{slab}$=	0.106	klf	*Per unit width*
SIP form unit weight, w_{SIP}=	0.010	klf	*Per unit width*
Wearing surface unit weight, w_{ws}=	0.025	klf	*Per unit width*

2. Design Moment

	(Positive)		(Negative)		
M_{DC}=$c(w_s+w_b+w_{SIP})S^2$	1.35	k-ft/ft	-1.69	k-ft/ft	*c = 0.08 for positive moment and 1.0 for negative moment*
M_{DW}=$c(w_{ws})S^2$	0.22	k-ft/ft	-0.28	k-ft/ft	
M_{LL}=	7.17	k-ft/ft	-4.75	k-ft/ft	*LRFD Appendix A4 Table A4-1. Distance from center of girder to design section for negative moment is 15 in*
M_u=	14.57	k-ft/ft	-10.84	k-ft/ft	*$1.25M_{DC}$+$1.5M_{DW}$+$1.75M_{LL}$*

3. Select Deck Reinforcement

	Bottom	Top	
Transverse reinforcement	#5@6.5in	#4@5in	
$A_{s,\ provided}$ (transverse)=	0.572 in^2/ft	0.480 in^2/ft	
Longitudinal reinforcement	#4@6in	#4@7in	*Both the top and bottom longitudinal reinforcements are taken as a percentage of the primary reinforcement. See D9.7.3.2 for details.*
$A_{s,\ provided}$ (longitudinal)=	0.400 in^2/ft	0.343 in^2/ft	

4. Check Transverse Reinforcement

	Positive Moment (Bottom Reinf.)		Negative Moment (Top Reinf.)		
$A_{s\_provided}$=	0.572	in^2/ft	0.480	in^2/ft	*Area of provided reinforcement per ft*
b=	12.00	in	12.00	in	*Analysis is based on a one-foot strip*
a=	0.84	in	0.71	in	$a=A_s f_y/(0.85 f'_c b)$
d=	6.19	in	5.75	in	*Deck structural thickness minus cover to centerline of rebar*
ε_s=	0.016		0.018		$\varepsilon_s=0.003(d-a/0.85)/(a/0.85)$
ϕ =	0.9		0.9		$\phi=0.9$ *if* $\varepsilon_s>0.005$
M_n=	16.50	k-ft/ft	12.95	k-ft/ft	$M_n=A_s f_y(d-a/2)$
$\phi\ M_n$=	14.85	k-ft/ft	11.66	k-ft/ft	*Check for positive moment:* $\phi M_n=14.85$ *k-ft* $>M_u=14.57$ *k-ft, OK* *Check for negative moment:* $\phi M_n=11.66$ *k-ft* $>M_u=10.84$ *k-ft, OK*

5. Check Longitudinal (Distribution) Reinforcement (*LRFD Section 9.7.3.2* and *D9.7.3.2*)

$S_{effective}$=	9.92	ft	*Girder spacing - Girder web thickness 7"*
220/sqrt.($S_{effective}$)=	69.86	%	
Percentage=	67.00	%	*Lesser of* $220/\sqrt{S}$ *or 67%*
$A_{s,dist.}$ (bottom)=	0.38	in^2/ft	*Percentage× transverse bottom reinforcement* $<A_{s,\ provided}=0.400\ in^2/ft$ *at bottom, OK*
$A_{s,dist.}$ (top)=	0.32	in^2/ft	*Percentage× transverse top reinforcement* $<A_{s,\ provided}=0.343\ in^2/ft$ *at top, OK*

6. Check Crack Control (*LRFD Section 5.7.3.4*)

	Positive Moment (Bottom Reinf.)		Negative Moment (Top Reinf.)		
b=	12.00	in	12.00	in	*Analysis is based on a one-foot strip*
ρ=	0.008		0.007		*Reinforcement ratio=*$A_s/(bd)$
n=	8		8		E_s/E_c
k=	0.29		0.28		$k=-\rho n+\sqrt{(\rho n)^2+2\rho n}$
j=	0.90		0.91		$j=1-k/3$
$M_{service}$=	8.74	k-ft/ft	-6.72	k-ft/ft	$1.0M_{DC}+1.0M_{DW}+1.0M_{LL}$
f_s=	32.86	ksi	32.24	ksi	$f_s=M_s/A_s(jd)$
β_s=	1.42		1.56		*LRFD Eq. 5.7.3.4-1*
γ_e=	1.00		1.00		*LRFD Eq. 5.7.3.4-1*
s_{max}=	11.39	in	9.43	in	*Check for positive moment:* s_{max} *=11.39 in.>6.5 in., OK* *Check for negative moment:* s_{max} *=9.43 in.>5.0 in., OK*

7. Check for Temperature and Shrinkage (*LRFD Section 5.10.8*)

$A_s\geq$	0.052	in^2/ft	*LRFD Eq. 5.10.8-1*
$A_s\geq$	0.11	in^2/ft	*LRFD Eq. 5.10.8-2*
$A_s\leq$	0.60	in^2/ft	*LRFD Eq. 5.10.8-2*
Controlling A_s=	0.11	in^2/ft	*Less than provided reinforcement at each direction and each face, OK*