Florida Department of Transportation

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March 17, 2006 (Original)
May 12, 2006 (Revised, see p.2 and Section 6.5.7)

TO: District Directors of Operations, District Directors of Production, District Design Engineers, District Structures and Facilities Engineers, District Geotechnical Engineers, District Maintenance Engineers, District Construction Engineers, District Structures Design Engineers

FROM: William Nickas, P.E., State Structures Design Engineer

COPIES: Anath Prasad, Bob Greer, Jeffrey Ger (FHWA), Brian Blanchard, John Harris, David O'Hagan , Duane Brautigam, Robert Robertson, Marcus Ansley, Larry Sessions, Larry Jones, Henry Bollmann, Steve Plotkin, Richard Kerr, Jean Ducher.

SUBJECT: Temporary Design Bulletin C06-01
Design & Load Rating Bridges

This Design Bulletin modifies the Department's policies and procedures for load rating bridges. However, the provisions stated in Section 1.7 of the Structures Design Guidelines remains the same:

> When load rating new structures, perform a LRFR load rating analysis as defined in the AASHTO Guide Manual for Condition Evaluation and Load Resistance Factor Rating (LRFR) of Highway Bridges, dated October 2003 and modified by the Department in Volume 8 of the Structures Manual.

REQUIREMENTS

1) Revise the Structures Design Guidelines (Volume 1 of the Structures Manual) dated January 2006, as follows:
   a) Delete Section 2.1.2, Design Permit Vehicles, in its entirety.
   b) Replace Section 2.10, Operational Importance, as follows:

      2.10 Redundancy and Operational Importance [1.3.4 and 1.3.5]

      A. Redundancy [1.3.4]

      Delete the redundancy factors, η_R, in ***LRFD*** 1.3.4 and use $\eta_R = 1.0$ unless a revised value is established in the tables below.

Redundancy Factors η_R for Flexural and Axial Effects

Structures Type	η_R Factors
Welded Members in Two Truss/Arch Bridges	1.20
Floor beams with Spacing > 12 feet and Non-continuous Stringers and Deck	1.20
Floor beams with Spacing > 12 feet and Non-continuous Stringers but with continuous deck	1.10
Steel Straddle Bents	1.20

Redundancy Factors η_R for Steel Girder Bridges

Number of Girders in Cross Section	Span Type	# of Hinges required for Mechanism	With Diaphragms[1]	Without Diaphragms
2	Interior	3	1.00	1.20
	End	2	1.00	1.20
	Simple	1	1.00	1.20
3 or 4	Interior	3	1.00	1.00
	End	2	1.00	1.05
	Simple	1	1.00	1.10
5 or more	Interior	3	1.00	1.00
	End	2	1.00	1.00
	Simple	1	1.00	1.05

1-With at least 3 evenly spaced intermediate diaphragms (excluding end diaphragms) in each span.

B. Operational Importance [1.3.5]
Delete the operational importance factors, η_I, in ***LRFD*** 1.3.5 and use $\eta_I = 1.0$ unless otherwise approved by the Department. Bridges considered critical to the survival of major communities, or to the security and defense of the United States, should consider using $\eta_I = 1.05$.

c) Replace Section 4.3.1.D.5), General, as follows:

When calculating the Service Limit State capacity for prestressed concrete flat slabs and girders, use the transformed section properties when calculating stresses as follows: at strand transfer; for calculation of prestress losses; for live load application. For members meeting the requirements of LRFD 5.9.5.3, use the approximate estimate of time dependant losses. For all other members, ~~U~~use the refined estimates of time-dependent losses (~~AASHTO 2005 Interim~~LRFD 5.9.5.4) with a 180 day differential between girder concrete casting and placement of the deck concrete.

d) Replace Section 7.1.1, Load Rating, as follows:

Before preparing widening plans, review the inspection report and perform a load rating in accordance with the SDG 1.7. If the *LRFR* Design Inventory load rating (Strength or Service) is less than 1.0, use *LRFR* Appendix D.6.1 to determine the *LFD* rating factors for the existing bridge. If any rating for design vehicles is below 1.0, replacement or strengthening is preferred.

If the rehabilitation/strengthening of a bridge widening does not produce a *LRFR* inventory rating greater than or equal to 1.0, calculate and report the appropriate rating factors using *LRFR* Appendix D.6 and a Variance or Exception is required for the widening. Design all bridge widening projects in accordance with SDG Section 7.3 .

2) Delete Volume 8 of the January 2006 Structures Manual, FDOT Supplement to Load and Resistance Factor Rating (LRFR), and replace it with revised Volume 8 attached to this Bulletin.

COMMENTARY

Replace the commentary in SDG 7.1.1 as follows:

The State Maintenance Office should be contacted by the District regarding any calculated operating ratings for existing bridges, Service or Strength, less than 1.0 for the FL120 permit vehicle on any state road to assure appropriate permitting operations.

Commentary is provided in Volume 8, FDOT Supplement to Load and Resistance Rating LRFR.

BACKGROUND

Changes to the Structures Design Guidelines (Volume 1 of the Structures Manual) are required to make a bridge design and bridge load rating compatible. Calculation of losses for prestressed flat slabs and "I" girders has been revised to assure more precise stress calculations for prestressed bridges (see NCHRP 496). In addition, system factors used to calculate factored resistance in LRFR methods have been introduced as redundancy factors used as a load modifier in LRFD methods. The redundancy factor (η_R) is approximately the inverse of the system factor ($Ø_S$) with the $\eta_R \geq 1.0$.

FDOT Supplement to Load and Resistance Factor Rating (Volume 8 of the Structures Manual) issued with this Design Bulletin supersedes all previous load rating instructions including those issued in January of 2005. Volume 8 is now consistent with the revised "Bridge Load Ratings, Permitting and Posting Manual" being issued by the State Maintenance and includes new load rating reporting requirements.

Professor Dennis Mertz has worked with the Department to refine the load rating process and develop the Department's new policies and procedures. LRFR design load factors specified in FDOT Table 6-1 are compatible with LRFD while Legal and Permit load factors deliver a similar capacity to LFD but with a more consistent reliability between structure types. Service Limit checks for prestress concrete bridges have been added at a reduced reliability consistent with expected traffic loadings.

New load rating tables are also included to summarize the results of newly rated bridges and bridges rated during design. Load rating of existing bridges may continue using Load Factor Design method (LRFR Appendix D.6). However, LRFR rating methods are strongly encouraged.

A workshop titled "Load Rating Summit" was held on December 7 and 8, 2005. During the "Summit" an "ask the professor" series of questions and answers was documented. These questions and answers are attached along with this document.

IMPLEMENTATION

This Design Bulletin is effective immediately. The new policies clarify previously issued directives and reduce the number of load cases previously required by the Department.

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WNN/LMS

REVISIONS TO "MANUAL FOR CONDITION EVALUATION AND LOAD AND RESISTANCE FACTOR RATING (LRFR) WITH 2005 INTERIM"

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1 – INTRODUCTION

1.1 PURPOSE

Add the following:

Florida Department of Transportation revisions and additions to LRFR address requirements to load rate bridges in Florida.

1.2 SCOPE

Add the following:

Additional Sections and procedures have been added to address Florida's unique bridges.

1.3 APPLICABILITY

Add the following:

Florida Administrative Code 14-15.002, Manual of Uniform Standards for Design, Construction, and Maintenance for Streets and Highways (Commonly known as the "Florida Greenbook") requires load rating for all bridges in Florida.

1.5 DEFINITIONS AND TERMINOLOGIES

Add the following:

Posting Avoidance Techniques – Applying engineering judgment to a load rating by modifying the specification defined procedures through use of Variances and Exceptions (as defined in the FDOT Plan Preparation Manual). See Appendix F.6 for Posting Avoidance details and requirements.

2 – BRIDGE FILE (RECORDS)

2.2 COMPONENTS OF BRIDGE RECORDS

2.2.15 Structure Inventory and Appraisal Sheets

Add the following:

In addition to the requirements of the State Maintenance Office, report the LRFR ratings on the load capacity information form as follows:

1. Longitudinal design load ratings (inventory and operating) as rating factors.
2. FL120 permit vehicle (Table 6-1, Permit load) longitudinal permit ratings in tons.
3. For transversely prestressed concrete bridge decks provide the transverse capacity of the deck at the design load operating level. Load rate both the design truck single axle and the design tandem axles.
4. If the design load rating at operating, for either longitudinal or transverse capacity expressed as rating factor, is less than 1.0, calculate the legal load ratings for the SU4, C5 and ST5 Florida legal trucks in tons.

For both the longitudinal and transverse ratings, provide a sketch indicating the location of the controlling components for both the transverse and longitudinal analysis.

2.2.17 Rating Records

Add the following:

Perform load ratings in accordance with the FDOT Bridge Load Rating, Permitting, and Posting Manual. Report the date of the Bridge Load Rating, Permitting, and Posting Manual used in the rating calculations. Complete the Bridge Load Capacity Summary form found in the manual. For new bridges and bridges receiving a new rating, include the appropriate structures load rating summary sheets in the plans or load rating documents. See Appendix G.6 for Load Rating Summary Sheets.

C1.1

Add the following:

Unless there is a change in condition of the bridge, an existing load rating using allowable stress method or load factor design is not required to be load rated with LRFR.

C1.3

Add the following:

Do not use previous editions of the AASHTO Manual for Condition Evaluation of Bridges. The load rating methods from these earlier publications are incorporated in LRFR Appendix D.6.

6 – LOAD RATING ANALYSIS (REVISED TITLE)

Was previously titled Section 6 - Load and Resistance Factor Rating

6.0 (NEW) OVERVIEW OF LOAD RATING METHODS AND PROCEDURES

The load rating of existing structures shall be in accordance with Table 2-1. The order of preference in rating methodologies is: (1) load and resistance factor rating (LRFR), (2) load factor rating (LFR) and (3) allowable stress rating.

Table 2-1 Acceptable Load Rating Methodologies

	LOAD-RATING METHODOLOGY		
DESIGN METHODOLOGY	Allowable Stress Rating - ASR (Appendix D.6)	Load Factor Rating – LFR (Appendix D.6)	Load & Resistance Factor Rating - LRFR (Section 6)
Allowable Stress Design (ASD)	√[1]	√	√
Load Factor Design (LFD)		√	√
Load & Resistance Factor Design (LRFD)			√[2]

1 – Allowable stress rating is not permitted for bridges on the National Highway System if the bridge is either structurally deficient or functionally obsolete.
2 – Bridges designed using the LRFD methodology before January 7, 2005 may be load rated using either the LFR or LRFR methodologies. For new designs (January 7, 2005 and after), the Department will not allow the use of an alternative load rating methodology (Appendix D.6) or posting avoidance techniques, with the exception of curved steel bridges (see 6.6.1).

The analysis shall include reference to the dated Structures Manual.

C6.0

Add the following:

In 1993 an agreement was reached between the FHWA and the FDOT concerning the use of allowable stress method for load rating bridges. In summary, the agreement states allowable stress rating is not permitted for bridges on the National Highway System if the bridge is either structurally deficient or functionally obsolete.

6.1 INTRODUCTION

6.1.7 Load Rating (revised title)

Delete the last two sentences and add the following:

The routine FDOT rating process is shown in FDOT Figure 6-1.

Rate bridges designed January 2005 and after using LRFR. For bridges designed before January 2005, use Appendix D.6 for rating. For bridges designed using the LFD methodology before January 2005, LRFR may be used as an alternative.

Replace Figure 6-1, Flow Chart for Load Rating, with FDOT Figure 6-1.

C6.1.7

Add the following:

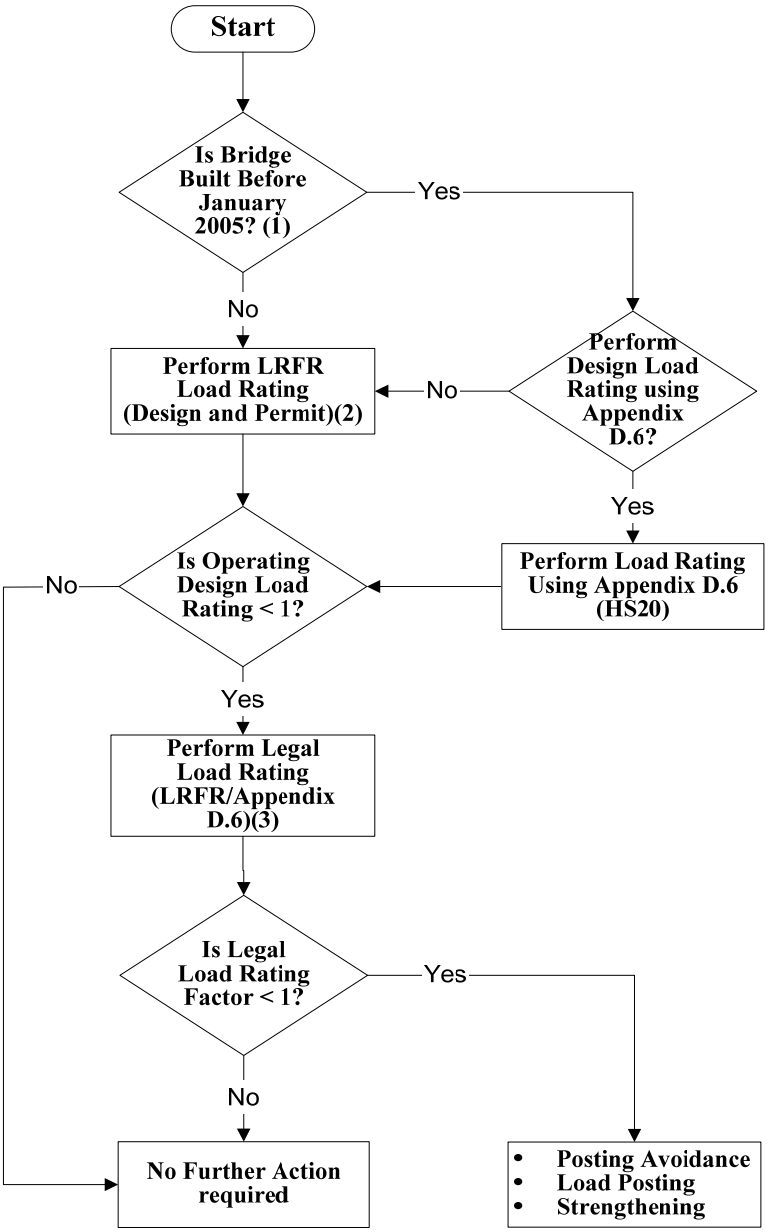
The rating process of AASHTO LRFR suggests that each permit vehicle be evaluated individually. Such is not the case with FDOT or with most other States. Traditionally, annual blanket permits were issued based upon a comparison of force effects of the permit vehicle in question to that of the HS20 operating rating. To continue the practice of having information available to easily judge permit applications, FDOT's rating process includes an FL120 permit-load rating as part of the routine rating of bridges. Single-trip permit vehicles will be evaluated outside of the routine FDOT rating process.

6.1.7.1 Design Load Rating

Replace the 3rd sentence of the 1st paragraph with the following:

Under this check, bridges are screened for both the strength and service limit states.

Delete the 4th and 5th sentences of the 1st paragraph.



(1) References 6.0 and 6.17
(2) References 6.1.7.1, 6.1.7.2, 6.4.3 and 6.4.5
(3) References 6.1.7.2, 6.2.3.1, 6.4.4 or Appendix D.6

FDOT Figure 6-1, Flowchart for Load Rating

6.1.7.2 Legal Load Rating

Replace the 3rd sentence of the 1st paragraph with the following:

Using this check, bridges are screened for both the strength and service limit states as noted in Table 6-1.

Delete the 4th and 5th sentences of the 1st paragraph.

6.1.8 Component-Specific Evaluation

Add the following:

Bridges may contain local details that must be appropriately designed to carry local loads or distribute forces to the main bridge components (beams). Although forces in these details can vary as a function of the applied live loads (with the exception of in-span beam splices), it is recommended that they not be included in the load rating. Rather, the capacities of such details should be checked only for critical loads or ratings and then only if there is evidence of distress (e.g. cracks).

6.1.8.3 (new) Diaphragms

The main purpose of transverse diaphragms is to provide lateral stability to girders during construction and wind loading.

Transverse diaphragms themselves need not be analyzed as part of a routine load rating. Only if there is evidence of distress (e.g. efflorescence, rust stains or buckling), or at the discretion of the engineer, should it be necessary to more closely consider the forces and stresses in a diaphragm.

The stiffness of any transverse diaphragms should be included, if significant and appropriate, in any finite element analysis program used to establish Live Load Distribution Factors.

6.1.8.4 (new) Support for Expansion Joint Devices

Expansion joint devices are usually contained in a recess formed in the top of the end of the top slab and transverse diaphragm. Occasionally, depending upon the need to accommodate other details, such as drainage systems, this may involve a corbel - usually as a contiguous part of the expansion joint diaphragm. It is not necessary to analyze such a detail for routine load rating. Only if there is evidence of distress (e.g. cracks, efflorescence or rust stains), or at the discretion of the engineer, should it be necessary to more closely consider the forces and stresses in such a detail.

6.1.8.5 (new) Anchorages for Post-Tensioning Tendons

Anchorages are normally contained in a widened portion of the web at the ends of a beam. It is not necessary to analyze anchorage details for routine load rating. Only if there is evidence of distress (e.g. cracks, efflorescence or rust stains) should it be necessary to more closely consider the forces and stresses in such a detail itself.

Changes in the gross section properties at anchor block zones should be properly accounted for in any finite element analysis program used to establish principal tension/bursting.

6.1.8.6 (new) Post Tensioned Concrete Beam Splices within a Span

Beam splices within a span are frequently used to connect portions of continuous girders. Such splices usually require reinforcing bars projecting from the ends of the precast beams and into a reinforced, cast-in-place transverse diaphragm. Longitudinal post-tensioning ducts are connected and tendons pass through the splice.

Beam splices are typically near inflection points; consequently, live load effects may induce longitudinal tensile stress in the top or bottom. Therefore, the longitudinal tendons are approximately concentric, i.e. at mid-depth of the

C6.1.8

Add the following:

Important local details in concrete bridges include diaphragms and details, such as corbels, that support expansion joint devices and anchorages for post-tensioning tendons. The behavior of these details and the forces to which they are subjected may be determined by appropriate models or hand calculations. Analysis methods and design procedures are available in LRFD (e.g. strut and tie analysis).

composite section. It is necessary to check longitudinal flexure and shear effects at in-span beam splices.

6.1.8.7 (new) Post Tensioned Concrete Beam Dapped Hinges within a Span

Dapped hinges are rarely used in beam bridges in Florida. Forces acting through dapped hinges within a span should be calculated for statically determinate structures or be determined as a part of the time-dependent construction analysis for indeterminate structures. Maximum live load reactions should also be calculated. Once all reaction forces are known, local analyses should be performed to develop the hinge forces into the main beam components using suitable strut-and-tie techniques. An alternate approach would be to develop three-dimensional finite element models to analyze the flow of forces.

6.2 LOADS FOR EVALUATION

6.2.3 Transient Loads

6.2.3.1 Vehicular Live Loads (Gravity Loads): *LL*

Replace the vehicles given after Legal Loads: *with the following:*

Florida Legal Loads (SU4, C5, and ST5, see 6.4.4.2.1 for vehicle configurations).

Replace the vehicle given after Permit Loads: *with the following:*

Florida Permit Load (FL120, see 6.4.5.4.2.1 for vehicle configurations). For new bridges the minimum rating factor for the FL120 is 1.0.

C6.2.3.1

Add the following:

For simple span bridges, see figure C6-4 for a comparison of legal loads and HL-93.

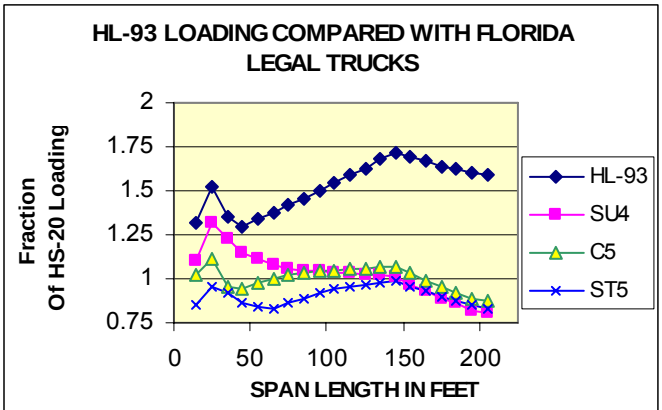


Figure C6-4

6.3 STRUCTURAL ANALYSIS

Add the following:

Transverse and longitudinal ratings shall be reported for post-tensioned concrete segmental bridges. All bridge decks designed with transverse prestressing require transverse ratings. For all other bridges, only longitudinal ratings are typically required.

6.3.2 Approximate Methods of Structural Analysis

Add the following:

Approximate methods include one-dimensional line-girder analysis using LRFD distribution factors.

6.3.3 Refined Methods of Analysis

Add the following:

Refined methods of analysis include two or three dimensional models using grid or finite-element analysis.

All analyses will be performed assuming no benefit from the stiffening effects of any traffic railing barrier or other appurtenances.

C6.3.3

Delete the second paragraph of the commentary in its entirety

.

6.4 LOADS RATING PROCEDURES

6.4.2 General Load Rating Equation

Add the following:

When calculating the Service Limit State capacity for prestressed concrete flat slabs and girders with bonded tendons/strands, use the transformed section properties when calculating stresses as follows: at strand transfer; for calculation of prestress losses; for live load application. Use the refined estimates of time-dependent losses (LRFD 5.9.5.4) with a 180 day differential between girder concrete casting and placement of the deck concrete.

C6.4.2

Add the following:

For a detailed explanation of stress calculations in prestressed concrete girders, see NCHRP 496. The correct use of transformed section properties and the refined method for calculation of prestress losses is essential for the precise calculation of stresses at service limit state.

6.4.2.2 Limit States

Replace Table 6-1 with FDOT Table 6-1

6.4.2.3 Condition Factor

Delete the first sentence.

Add the following after Table 6-2:

The Florida DOT prefers load ratings be performed taking account of field measured deterioration. However, in the absence of measurements, global condition factors shall be used.

6.4.2.4 System Factor

Delete the third paragraph.

Replace Table 6-3 with FDOT Tables 6-3A, B, C and D.

Replace the second paragraph with the following:

The system factors of FDOT Tables 6-3A, 6-3B, 6-3C, and 6-3D shall apply for flexural and axial effects at the Strength limit states. Higher values than those tabulated may be considered on a case-by-case basis with the approval of the Department. System factors need not be less than 0.85. In no case shall the system factor exceed 1.3.

6.4.4 Legal Load Ratings

6.4.4.1 Purpose

Replace the 1st sentence of the 1st paragraph with the following:

Bridges that do not have sufficient capacity under the design-load rating operating level (i.e. RF $\leq$ 1.0) shall be load rated for the SU4, C5, and ST5 legal loads to establish the potential need for load posting or strengthening.

6.4.4.2.1 Live Loads

Replace this article with the following:

Use the SU4, C5, and ST5 Florida legal loads defined in Figure 6-3 for legal load rating. Assume the SU4, C5, and ST5 trucks are in each loaded lane; do not mix trucks.

For negative moment loading and loading of spans greater than 200 feet use Appendix B.6.2 b) and B.6.2 c).

6.4.4.2.3 Generalized Live Load Factors

Revise Table 6-5 as follows:

For all Traffic Volumes, revise all Load Factors to 1.35.

C6.4.4.2.3

Add the following:

The LRFD HL-93 live-load model envelopes FDOT legal loads. As such, if the live load factor of 1.35 for the design-load operating rating yields a reliability index consistent with traditional operating ratings, this live load factor can be used for legal-load rating of the FDOT legal loads.

Live load factors for FDOT legal loads are not specified as a function of ADTT.

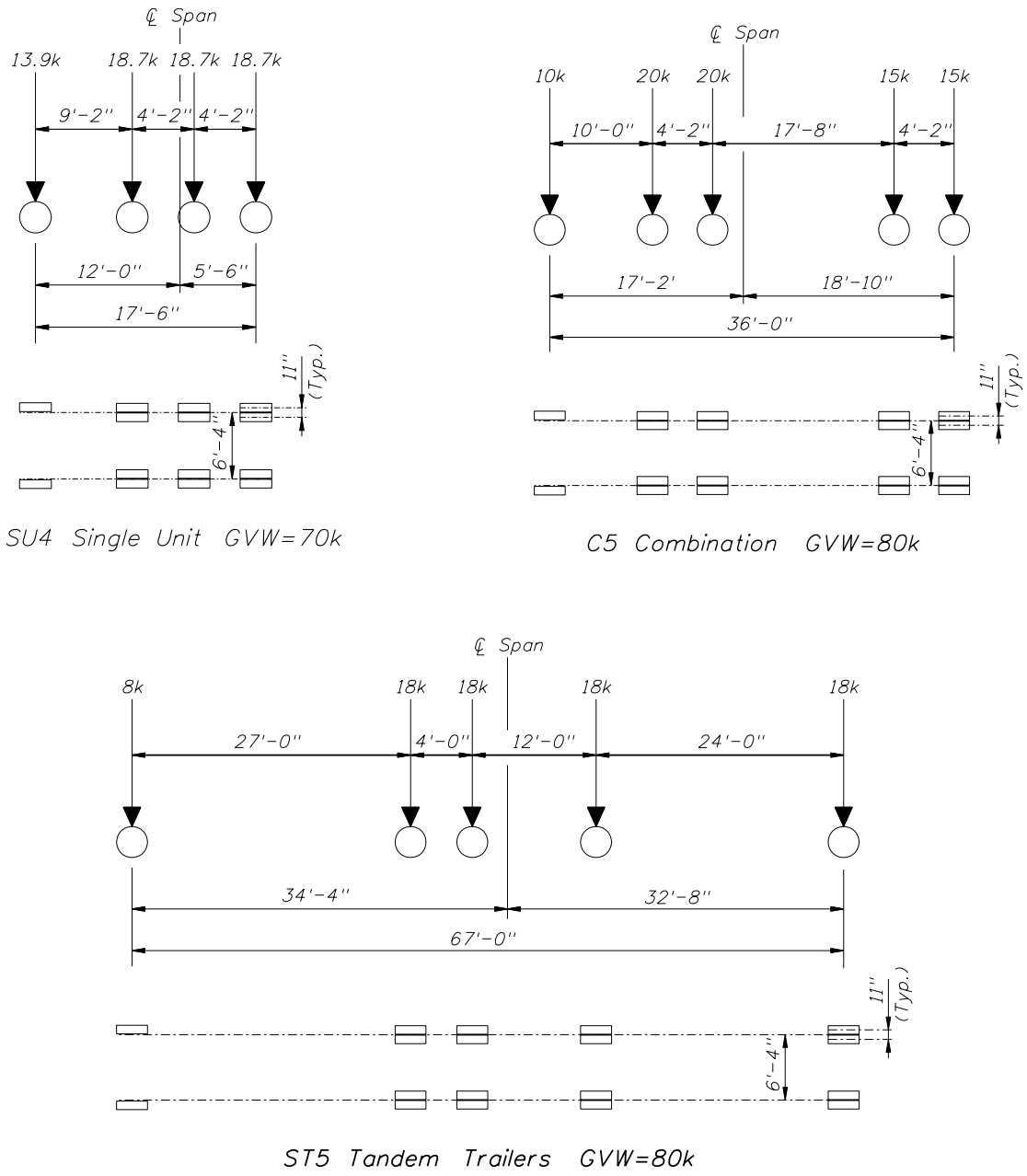

℄ Span
13.9k
18.7k
18.7k
18.7k
9'-2"
4'-2"
4'-2"
12'-0"
5'-6"
17'-6"
11" (Typ.)
6'-4"
SU4 Single Unit GVW=70k
℄ Span
10k
20k
20k
15k
15k
10'-0"
4'-2"
17'-8"
4'-2"
17'-2'
18'-10"
36'-0"
11" (Typ.)
6'-4"
C5 Combination GVW=80k
℄ Span
8k
18k
18k
18k
18k
27'-0"
4'-0"
12'-0"
24'-0"
34'-4"
32'-8"
67'-0"
11" (Typ.)
6'-4"
ST5 Tandem Trailers GVW=80k

Figure 6-3

FDOT Table 6-1

Bridge Type	Direction	Limit State	Load Factors									
			Permanent Load			Transient Load			Design Load		Legal Load	Permit Load
									Inventory	Operating		
			DC	DW	EL	FR	TU(2) CR SH	TG(2)	*LL*	*LL*	*LL*	*LL*
Steel	Longitudinal	Strength I	1.25	1.50					1.75	1.35	1.35	
		Strength II	1.25	1.50								1.35
		Service II (3)	1.00	1.00					1.30	1.00	1.30	0.90
Reinforced Concrete	Longitudinal	Strength I	1.25	1.50					1.75	1.35	1.35	
		Strength II	1.25	1.50								1.35
Prestreessed Concrete (Flat Slab and Deck/Girder)	Longitudinal	Strength I	1.25	1.50					1.75	1.35	1.35	
		Strength II	1.25	1.50								1.35
		Service III (1)	1.00	1.00					0.80	0.80	0.80	0.70
Wood	Longitudinal	Strength I	1.25	1.50					1.75	1.35	1.35	
		Strength II	1.25	1.50								1.35
Post-tensioned Concrete	Longitudinal	Strength I	1.25	1.50	1.00	1.00	0.50		1.75	1.35	1.35	
		Strength II	1.25	1.50	1.00	1.00	0.50					1.35
		Service III (1)	1.00	1.00	1.00	1.00	1.00	0.50	0.80 or SL (4)	0.80 or SL (4)	0.80 or SL (4)	0.70 or 0.90 SL (4)
	Transverse	Strength I	1.25	1.50	1.00				1.75	1.35	1.35	
		Strength II	1.25	1.50	1.00							1.35
		Service I	1.00	1.00	1.00				1.00	1.00	1.00	1.00

(1) Service I Design Inventory tensile stress limit = 3√f `c or 6√f'c; Service III Design Operating, Legal, and Permit tensile stress limit = 7.5√f `c.

(2) TU and TG is considered for Service I and Service III Design Inventory only.

(3) The Service II limit state need only be checked for compact steel girders. For all other steel girders, the Strength limit states will govern.

(4) For I girders use a fractional load factor; for segmental box girders use stripped lanes (SL).

FDOT Table 6-3A General System Factors (ϕ_s)

Superstructure Type	System Factors (ϕ_s)
Welded Members in Two Truss/Arch Bridges	0.85
Riveted Members in Two Truss/Arch Bridges	0.90
Multiple Eye bar Members in Truss Bridges	0.90
Floor beams with Spacing > 12 feet and Non-continuous Stringers and Deck	0.85
Floor beams with Spacing > 12 feet and Non-continuous Stringers but with continuous deck	0.90
Redundant Stringer subsystems between Floor beams	1.00
All beams in non-spliced concrete girder bridges	1.00
Steel Straddle Bents	0.85

FDOT Table 6-3B System Factors (ϕ_s) for Post-Tensioned Concrete Beams

Number of Girders in Cross Section	Span Type	Number of Hinges Required for Mechanism	System Factors (ϕ_s)			
			Number of Tendons per Web			
			1	2	3	4
2	Interior	3	0.85	0.90	0.95	1.00
	End	2	0.85	0.85	0.90	0.95
	Simple	1	0.85	0.85	0.85	0.90
3 or 4	Interior	3	1.00	1.05	1.10	1.15
	End	2	0.95	1.00	1.05	1.10
	Simple	1	0.90	0.95	1.00	1.05
5 or more	Interior	3	1.05	1.10	1.15	1.20
	End	2	1.00	1.05	1.10	1.15
	Simple	1	0.95	1.00	1.05	1.10

- The tabularized values above may be increased by 0.05 for spans containing more than three intermediate, evenly spaced, diaphragms in addition to the diaphragms at the end of each span.

FDOT Table 6-3C System Factors (ϕ_s) for Steel Girder Bridges

Number of Girders in Cross Section	Span Type	# of Hinges required for Mechanism	System Factors
2	Interior	3	0.85
	End	2	0.85
	Simple	1	0.85
3 or 4	Interior	3	1.00
	End	2	0.95
	Simple	1	0.90
5 or more	Interior	3	1.05
	End	2	1.00
	Simple	1	0.95

- The tabularized values above may be increased by 0.10 for spans containing more than three evenly spaced intermediate diaphragms in addition to the diaphragms at the end of each span.
- The above tabularized values may be increased by 0.05 for riveted members

FDOT Table 6-3D System Factors (ϕ_s) for Concrete Box Girder Bridges – see LRFR Table E.6.6-1

6.4.5 Permit Load Ratings

6.4.5.1 Background

Add the following:

Calculate the capacity for permit trucks using "one lane" distribution factor for single trip permits and "two or more lanes" distribution factor for routine or annual permits as shown in Table 6-6. The "two or more lanes" distribution factor assumes the permit vehicle is present in all loaded lanes and LRFD live load distribution equations are used. Do not use LRFD formula 4.6.2.2.4-1 since mixed traffic calculations are not performed.

C6.4.5.1

Add the following:

Florida has chosen to apply a service limit state rating for permitting overload vehicles using load factors that include a reduced reliability factor. The live load factor is applied to a capacity calculated with the rating vehicle placed in all lanes. The load factor was developed to simulate a rating vehicle in the rating lane with adjoining lanes filled with legal vehicles (tractor trailers). The combined effect of these loads is multiplied by the multiple presence factor of 0.9 (Ontario Bridge Code).

6.4.5.2 Purpose

Add the following:

Bridges designed after January 1, 2005 are required to have rating factors for the FL120 permit truck. Rate the FL120 for both Strength and Service Limit State.

6.4.5.4.2 Load Factors

C6.4.5.4.2

Add the following:

Since routine permits are evaluated using the FL120 permit truck and values of ADTT are not well known, a single load factor is specified for routine permit load rating. Similarly, a single load factor is specified for single-trip permits.

6.4.5.4.2.1 Routine (Annual) Permits

Revise Table 6-6 as follows:

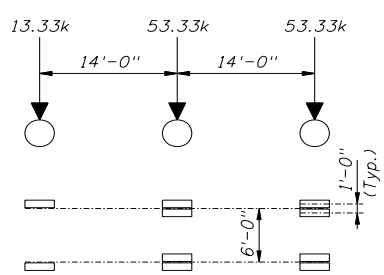
For all Permit Types, revise all the Load Factors by Permit Type to 1.35 except the escorted single trip load factor will remain 1.15.

Add the following:

The FL120 permit truck shall be considered as routine annual permit vehicle to be used to verify overload capacity of Florida bridges. The FL120 shall be checked at Strength Limit State and Service Limit State as noted in FDOT Table 6-1 and the minimum rating factor for new bridges is 1.0.

For spans over 200 feet assume the FL120 permit truck with coincident 0.20 kips per foot lane load. Assume the permit trucks are in each lane; do not mix trucks.

The FL120 permit truck configuration is shown in the figure below:



FL120 Permit Vehicle – GVW=120k

C6.4.5.4.2.1

Add the following:

The FL120 permit truck is conceived to be a benchmark to past load factor design (LFD) practice in which the HS-20 truck was rated at the operating level with a load factor of 1.3. A LRFR Permit Load rating for the FL120 permit truck equal to 1.0 is equivalent to an LFD operating rating for the HS-20 truck equal to 1.67. The axle spacing of the FL120 is not changed to emulate a truck crane.

It is reasonable to use the multiple-lane distribution factor for the permit load rating since the force effects of the permit trucks are similar to the HL-93 notional load have been shown to be very similar. Thus, this application is close to the intent of the AASHTO LRFR methodology where the HL-93 is placed in remote lanes. The FL120 is intended to replicate the traditional HS20 operating rating where all lanes were occupied by the same truck. Thus, the use of multiple-lane distribution factors is equally appropriate for the FL120 permit load rating.

6.4.5.5 Dynamic Load Allowance

End the first sentence after "legal loads".

Add the following:

For exclusive-use vehicles with escort and speeds less than or equal to 5 mph, IM may be decreased to 0%.

6.4.5.8 (new) Adjoining Lane Loading

When performing refined analysis for permit vehicles, combine the permit vehicle with the same permit vehicle in the adjoining lanes. For spans over 200 feet, add a 0.20 kip per foot lane load to all vehicle loadings.

6.4.5.9 (new) Multiple Presence Factors

For Permit load ratings, the LRFD multiple presence factors shall be equal to or less than 1.0.

6.5 CONCRETE STRUCTURES

6.5.2 Material

Add the following:

For concrete made with Florida aggregate calculate the modulus of elasticity by applying a 0.9 factor times the value found in the specifications.

6.5.4 Limit States

6.5.4.1 Design-Load Rating

Add the following:

For prestressed concrete bridges, perform Permit-Load ratings for:

1. Service I transverse compressive and tensile stress checks in the deck of transversely prestressed bridges.
2. Service III tensile stress checks in the longitudinal direction of all prestressed concrete bridges.

The stress limits given in FDOT Table 6-9B shall be satisfied by all prestressed concrete bridges.

C6.5.4.1

Delete the first sentence of the commentary.

6.5.4.2 Legal Load Rating and Permit Load Rating

6.5.4.2.2.1 Legal load Rating

Delete both sentences and replace with the following:

Legal load rating of prestressed concrete bridges is based on satisfying strength and service limit states (see FDOT Table 6-1).

C6.5.4.2.2.1

Delete the entire commentary.

CONDITION	Design Inventory	Design Operating, Legal, and Permit
Compressive Stress (Longitudinal or Transverse)		
Compressive stress under effective prestress, permanent loads, and transient loads (Allowable compressive stress shall be reduced according to LRFD 5.9.4.2.1 when slenderness of flange or web is greater than 15)	0.60f'c	0.60f'c
Longitudinal Tensile Stress in Precompressed Tensile Zone		
For components with bonded pretressing tendons or reinforcement that are subject to not worse than: (a) an aggressive corrosion environment (b) moderately aggressive corrosion environment	 3√f'c psi 6√f'c psi	 7.5√f'c psi 7.5√f'c psi
For components with unbonded prestressing tendons	No Tension	No Tension
For components with Type B joints (dry joints, no epoxy)	100 psi comp	No Tension
Tensile Stress in Other Areas		
Areas without bonded reinforcement	No tension	No tension
Areas with bonded reinforcement sufficient to carry the tensile force in the concrete calculated on the assumption of an uncracked section is provided at a stress of 0.5fy (<30 ksi)	6√f'c psi tension	6√f'c psi tension
Transverse Tension, Bonded PT: Tension in the transverse direction in the precompressed tensile zone calculated on the basis of an uncracked section (i.e. top prestressed slab) for: (a) an aggressive corrosion environment (b) moderately aggressive corrosion environment	 3√f'c psi 6√f'c psi	 6√f'c psi 6√f'c psi
Principal Tensile Stress at Neutral Axis in Webs		
All types of segmental or spliced girder construction with internal and/or external tendons.	3√f'c psi tension	4√f'c psi tension

FDOT Table 6-9B Stress Limits for All Prestressed Concrete Bridges

6.5.4.2.2.2 Permit load Rating

Delete the first sentence and replace with the following:

Permit load rating of prestressed concrete bridges is based on satisfying Strength and Service limit states (see FDOT Table 6-1).

Delete the second paragraph.

6.5.7 Minimum Reinforcement

Delete equation 6-4 and use LRFD Equation 5.7.3.3.2-1.

6.5.9 Evaluation for Shear

Delete the second sentence and replace with the following:

Design and legal loads shall be checked for shear.

6.5.12 Temperature, Creep and Shrinkage Effects

Delete the sentence and replace with the following:

At the service limit state, all prestressed concrete bridges shall include the effect of uniform temperature (TU), when appropriate), creep (CR), and shrinkage (SH). In addition, temperature gradient (TG) shall be included for post-tensioned beam and box girder structures. See FDOT Table 6-1 for clarification.

C6.5.4.2.2.2

Delete the first and second paragraphs.

Florida has elected to use a service limit state for permit analysis and has removed the check for stress in the reinforcing at the strength limit state.

6.6.1 Limit States

Add the following:

Curved steel bridges shall be load rated using Appendix D.6 and the 2003 AASHTO Guide Specification for Horizontally Curved Highway Bridges.

6.6.4 Limit States

6.6.4.1 Design-Load Rating

Delete both paragraphs and replace with the following:

Bridges shall not be rated for fatigue. If the fatigue crack growth is anticipated, Section 7 of the Guide Manual for Condition Evaluation and Load and Resistance Factor Rating of Highway Bridges can be used to estimate the remaining fatigue life.

C6.6.4.1

Add the Following:

The estimate of the remaining fatigue life of Section 7 of the Guide Manual requires a historical record of past truck traffic in terms of average daily truck traffic (ADTT) and projected future traffic. Many times, conservative recreation and projection of traffic volumes produces a worst case scenario which results in low remaining fatigue lives or totally exhausted fatigue lives. As fatigue life estimates are based upon statistical evaluation of laboratory tests, different levels of confidence are presented in Section 7. The minimum expected fatigue life, the evaluation fatigue life and the mean fatigue life are based upon approximately 98%, 85% and 50% probabilities of cracking, respectively. Judgment must be used in evaluating the results of the fatigue-life estimates.

6.6.13 Fracture-Critical Members (FCM's) (new)

As with all other steel members, the appropriate system factors of FDOT Tables 6-3A or 6-3C shall be applied in the ratings of FCM's.

Steel members which are traditionally classified as FCM's may be declassified through analysis if the material satisfies the FCM fracture-toughness of LRFD Table 6.6.2-2. After the approval of an exception based upon an approved refined analysis demonstrating that the bridge with the fractured member can continue to carry a significant portion of the design load, the member may be declassified and treated as a redundant member. See LRFD Article C6.6.2. After declassification, the member may be rated using a system factor of 1.0.

C6.6.13 (new)

Only FCM's which are fabricated from material meeting the FCM fracture-toughness requirements are candidates for declassification. Newer bridges designed, fabricated and constructed since the concept of FCM's was introduced should meet this material requirement. The demonstration of non-fracture criticality must include an analysis of the damaged bridge with the member in question fractured and a corresponding dynamic load representing the energy release of the fracture. Acceptable remaining load carrying capacity may be considered equal to the full factored load of the strength I load combination associated with the number of striped lanes.

6.8 POSTING OF BRIDGES

Add the following:

Posting avoidance is the application of engineering judgment to a load rating by modifying the specification defined procedures through use of variances and exceptions.

A.6.1 LOAD AND RESISTANCE FACTOR RATING FLOW CHART

Replace the flowchart with FDOT Figure 6-1.

A.6.2 LIMIT STATES AND LOAD FACTORS FOR LOAD RATING

Delete all three tables and use FDOT Table 6-1.

B.6.2 AASHTO LEGAL LOADS

Delete section a) and use the Florida legal trucks defined in article 6.4.4.2.1.

D.6 - ALTERNATE LOAD RATING

D.6.1 GENERAL

Add the following paragraph:

Use the 17th Edition of the AASHTO Standard Specification with the allowable stresses shown in FDOT Table 6-9B.

D.6.6 NOMINAL CAPACITY
D.6.6.3 Load Factor Method
D.6.6.3.3 Prestressed Concrete

After the 5th RF equation, add the following heading: Operating Rating

D.6.7 LOADINGS
D.6.7.2 Evaluation for Shear

Delete the last sentence.

E.6 RATING OF SEGMENTAL CONCRETE BRIDGES
E.6.2 GENERAL RATING REQUIREMENTS

Add the following:

Six features of concrete segmental bridges are to be load rated at the Design Load (Inventory and Operating) Levels. Three of these criteria are at the Service Limit State and three at the Strength Limit State, as follows:

At the Service Limit State:

- Longitudinal Box Girder Flexure
- Transverse Top Slab Flexure
- Principle Web Tension

At the Strength Limit State:

- Longitudinal Box Girder Flexure
- Transverse Top Slab Flexure
- Web Shear

In accordance with AASHTO LRFR Equation 6-1, the general Load Rating Factor, RF, shall be determined according to the formula:

$$RF = \frac{C - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_{EL})(P + EL) - (\gamma_{FR})(FR) - (\gamma_{CR})(TU + CR + SH) - (\gamma_{TG})(TG)}{(\gamma_L)(LL + IM)}$$

Where:

For Strength Limit States:

C = Capacity = (φ_c x φ_s x φ) R_n.

φ_c = Condition Factor per Article 6.4.2.3.

φ_s = System Factor per Article E.6.4.2.4.

φ = Strength Reduction Factor per LRFD.

R_n = Nominal member resistance as inspected, measured and calculated according to formulae in LRFD with the exception of shear, for which, capacity is calculated according to the AASHTO Guide Specification for Segmental Bridges.

For Service Limit States:

C = f_R = Allowable stress at the Service Limit State (FDOT Table 6-9B).

E.6.8 APPENDIX E6 STEP-BY-STEP SUPPLEMENT (NEW)

Add new supplemental information.

F.6 POSTING AVOIDANCE (NEW)

Add new appendix.

G.6 LOAD RATING SUMMARY FORMS (NEW)

Add new appendix.

8 – NON DESTRUCTIVE LOAD TESTING

8.8 LOAD RATING THROUGH LOAD TESTING

8.8.1 Introduction

Add the following:

FDOT generally uses proof load testing as described in article 8.8.3. If this methodology is not used, then Table 8-1 shall establish the magnitude of the benefit.

9 – SPECIAL TOPICS

9.2 DIRECT SAFETY ASSESMENT OF BRIDGES

Delete Section 9.2

E.6 RATING OF SEGMENTAL CONCRETE BRIDGES

E.6.8 STEP-BY-STEP SUPPLEMENT (NEW)

E.6.8.1 Load Factors and Load Combinations

Load factors and load combinations for the Strength and Service Limit States shall be made in accordance with FDOT *Table 6-1.* Load factors for permanent (e.g. dead) loads and transient (e.g. temperature) loads are provided. Note: one-half thermal gradient (0.5TG) is used only for longitudinal Service Inventory conditions.

STRENGTH I and II and SERVICE I and III limit states are used in the context of their definitions as given in FDOT Table 6-1 summarizing:

STRENGTH I - applies to Design Load Rating (Inventory and Operating) and Legal Load Rating.

STRENGTH II - applies only to Permit Loads.

SERVICE I - applies primarily for concrete in compression but is also to prevent yield of tension face reinforcement or prestress under overloads (permits). This limit state is extended to concrete tension in transversely prestressed deck slabs, typical of most segmental bridges.

SERVICE III - applies to concrete in longitudinal tension and principal tension. Load factors for SERVICE III for Design Operating, Legal, and Permit ratings have been selected in conjunction with either higher allowable tensile stress or, in the case of joints in segmental bridges that cannot carry tension, use of the number of striped lanes.

The following is a detailed checklist of the load applications, combinations and circumstances necessary to satisfy FDOT and AASHTO LRFR ratings.

E.6.8.2 Design Load Rating - Inventory

Transverse:

- Apply HL93 Truck or Tandem *(FDOT Table 6-1).*
- Do not apply uniform lane load.
- Apply same axle loads in each lane if multiple lane loading apples.
- Apply Dynamic Load Allowance, IM = 1.33 on Truck or Tandem.
- For both Strength and Service Limit States, use number of load lanes per LRFD.
- Apply multi-presence factor: one lane, m =1.20; two lanes, m = 1.00; three, m = 0.85; four or more, m = 0.65. (Maximum value of m = 1.20 is the appropriate AASHTO LRFD / LRFR current criteria to allow for rogue vehicles).
- Place loads in full available width as necessary to create maximum effects.
- Apply pedestrian live load as necessary (counts as one lane for "m").
- Apply no Thermal Gradient transversely.
- Use SERVICE I Limit State with live load factor, γ_L = 1.00 and limit concrete transverse flexural stresses to values in FDOT Table 6-9B. (Note: γ_L = 1.00 as AASHTO LRFR).
- For STRENGTH I Limit State use live load factor, γ_L = 1.75.

Longitudinal:

- Apply HL93 Truck or Tandem, including 0.64 kip/ft uniform lane load *(FDOT Table 6-1).*
- Apply same load in each lane.
- Apply Dynamic Load Allowance, IM = 1.33 on Truck or Tandem only.
- For both Strength and Service Limit States, use number of load lanes per LRFD.

- Apply multi-presence factor: one lane, m =1.2; two lanes, m = 1.00; three, m = 0.85; four or more, m = 0.65. (Maximum value of m = 1.20 is the appropriate AASHTO LRFD / LRFR current criteria for notional loads and rogue vehicles).
- For negative moment regions: apply 90% of the effect of two Design Trucks of 72 kip GVW spaced a minimum of 50 feet apart between the leading axle of one and the trailing axle of the other, plus 90% of uniform lane load.
- Place loads in full available width as necessary to create maximum effects.
- Apply pedestrian live load as necessary (counts as one lane for "m").
- For Thermal Gradient, apply 0.50TG with live load for Service but zero TG for Strength.

- Use SERVICE III Limit State with live load from striped lanes and limit longitudinal tensile stress to values in FDOT Table 6-9B as appropriate.
- For STRENGTH I Limit State use live load factor, γ_L = 1.75.

E.6.8.3 Design Load Rating - Operating

Transverse:

- Apply one HL93 Truck or Tandem per lane *(FDOT Table 6-1).*
- Do not apply uniform lane load.
- Apply same axle loads in each lane if multiple lane loading apples.
- Apply Dynamic Load Allowance, IM = 1.33 on Truck or Tandem.
- For both Strength and Service Limit States, use number of load lanes per LRFD.
- Apply multi-presence factor: one and two lanes, m =1.0; three, m = 0.85; four or more, m = 0.65. (Maximum limit of 1.0 applies because this is a rating for specific (defined) axle loads, not notional loads or rogue vehicles).
- Place loads in full available width as necessary to create maximum effects.
- Apply pedestrian live load as necessary (counts as one lane for "m").
- Apply no Thermal Gradient transversely.
- Use SERVICE I Limit State with live load factor, γ_L = 1.00 and limit concrete transverse flexural stresses to values in FDOT Table 6-9B
- For STRENGTH I Limit State use live load factor, γ_L = 1.35.

Longitudinal:

- Apply HL93 Truck or Tandem, including 0.64 kip/ft uniform lane load *(FDOT Table 6-1).*
- Apply same load in each lane.
- Apply Dynamic Load Allowance, IM = 1.33 on Truck or Tandem only.
- For the Strength Limit State, use number of load lanes per LRFD.
- For the Service Limit State use the number of striped lanes.
- Place loads in full available width as necessary to create maximum effects (for example, in shoulders).
- Multi-presence factor: HL93 Design Load (including uniform lane load) one lane, m =1.20; two lanes, m = 1.00; three, m = 0.85; four or more, m = 0.65. (The maximum value of 1.20 for one lane is necessary because the load is a notional load with a uniform lane load component).
- For negative moment regions, apply 90% of the effect of two Design Trucks of 72 kip GVW each spaced a minimum of 50 feet apart between the leading axle of one and the trailing axle of the other, plus 90% of 0.64 kip/LF uniform lane load.
- Apply pedestrian live load as necessary (counts as one lane for "m").
- Apply no Thermal Gradient.
- Use SERVICE III Limit State with live load factor developed from striped lanes and limit concrete longitudinal flexural tensile and principal tensile stresses to values in FDOT Table 6-9B.
- For STRENGTH I Limit State use live load factor, γ_L = 1.35.

E.6.8.4 Legal Load Rating

Longitudinal:

- Apply FDOT Legal Load Trucks *SU4, C5 and ST5 (FDOT Table 6-1).*
- Apply same truck load in each lane using only one truck per lane (i.e. do not mix Trucks).
- Apply no uniform lane load.
- Apply Dynamic Load Allowance, IM = 1.33 on Legal, HL93 Truck or Tandem.
- For the Strength Limit State, use number of load lanes per LRFD.
- For Service Limit States, use number of striped lanes.
- Place loads in full available width as necessary to create maximum effects (i.e., in shoulders).
- Use multi-presence factor: one and two lanes, m = 1.00; three, m = 0.85; four or more, m = 0.65.
- Apply no pedestrian live load (unless very specifically necessary for the site - in which case it counts as one lane for establishing "m").
- Apply no Thermal Gradient.
- Use SERVICE III Limit State with live load factor developed from striped lanes and limit concrete longitudinal flexural tensile and principal tensile stresses to values in FDOT Table 6-9B.
- For STRENGTH I Limit State, use live load factor, γ_L = 1.35.

- Negative moments load ratings may be limited by AASHTO LRFR 6.4.4.2.1. If the value of the Rating Factor for the AASHTO Limiting Critical Load is less than 1.00, then the basic rating factor for all FDOT Legal Loads shall be reduced by multiplying by this value. See Appendix B.6.2(c) for load model.

E.6.8.5 Permit Load Rating

Longitudinal, annual "blanket" permits:

- Apply ONE Permit Vehicle (FL120) in all lanes (*FDOT Table 6-1*).
- For spans over 200 feet, apply a uniform lane load of 0.20 kip / LF in the lane with the permit vehicle. This uniform lane load should be applied beyond the footprint of the vehicle to create the maximum effects. However, for convenience, it may be applied coincident with the vehicle.
- For the Strength Limit State, use number of load lanes per LRFD.
- For Service Limit States, use a reduced load factor or see FDOT Table 6-1.
- Place loads in full available width as necessary to create maximum effects (for example, in shoulders).
- Use multi-presence factor: one and two lanes, m = 1.00; three, m = 0.85; four or more, m = 0.65.
- Dynamic Load Allowance, IM = 1.33 on Permit Trucks.
- Apply no pedestrian live load (unless very specifically necessary for the site - in which case it counts as one lane for establishing "m").
- Apply no Thermal Gradient.
- Use SERVICE III Limit State with live load developed from striped lanes and limit concrete longitudinal flexural tensile and principal tensile stresses to values in FDOT Table 6-9B as appropriate.
- For STRENGTH II Limit State, use live load factor, $\gamma_L = 1.35$.
- Reduced Dynamic Load Allowance (IM) or live load factor (γ_L) may be considered only to avoid restrictions.

E.6.8.6 Capacity – Strength Limit State

The capacity of a section in transverse and longitudinal flexure may be determined using any of the relevant formulae or methods in the LRFD Specifications, or AASHTO Guide Specification for Segmental Bridges dated 1999, including more rigorous analysis techniques involving strain compatibility. The latter should be used in particular where the capacity depends upon a combination of both internal (bonded) and external (unbonded) tendons.

For Load Rating, the capacity should be determined based upon actual rather than specified or assumed material strengths and characteristics. Concrete strength should be found from records or verified by suitable tests. If no data is available, the specified design strength may be assumed, appropriately increased for maturity. All new designs will assume the plan specified concrete properties. Post construction will include updated concrete properties.

In particular, for shear or combined shear with torsion, the capacity at the Strength Limit State for segmental bridges should be calculated according to the AASHTO Guide Specification for Segmental Bridges. The "Modified Compression Field Theory" of LRFD may be used as an alternative, but only for structures with continuously bonded reinforcement (e.g. large boxes cast-in-place in cantilever or on falsework).

E.6.8.7 Allowable Stress Limits – Service Limit State

Allowable stresses for the Service Limit State are given in FDOT Table 6-9B. The intent is to ensure a minimum level of durability for FDOT bridges that avoids the development or propagation of cracks or the potential breach of corrosion protection afforded to post-tensioning tendons. Also, these are recommended for the purpose of designing new bridges.

E.6.8.7.1 Longitudinal Tension in Joints

Type "A" Joints with Minimum Bonded Reinforcement

The Service level tensile stress is limited to $3\sqrt{f'c}$ or $6\sqrt{f'c}$ (psi) for cast-in-place joints with continuous longitudinal mild steel reinforcing for Design Inventory Rating. (Reference: AASHTO Guide Specification for Segmental Bridges and LRFD Table 5.9.4.2.2-1). Reduced reliability at Design Operating, Legal and Permit conditions is attained by using the number of striped lanes and by allowing an increase in tensile stress to $7.5\sqrt{f'c}$ (psi) (FDOT Table 6-9B).

Type "A" Epoxy Joints with Discontinuous Reinforcement

The Service level tensile stress is limited to zero tension for epoxy joints for Design Inventory, Design Operating, Legal, and Permit ratings. (Reference: AASHTO Guide Specification for Segmental Bridges and LRFD Table 5.9.4.2.2-1). Reduced reliability is attained by using the number of striped lanes.

Type "B" Dry Joints

Early precast segmental bridges with external tendons and non-epoxy filled, Type-B (dry) joints were designed to zero longitudinal tensile stress. In 1989, a requirement for 200 psi residual compression was introduced with the first edition of the AASHTO Guide Specification for Segmental Bridges. This was subsequently revised in 1998 to 100 psi compression. Service Level Design Inventory Ratings shall be based on a residual compression of 100 psi for dry joints. For Design Operating, Legal, and Permit Ratings, the limit is zero tension. (Reference: AASHTO Guide Specification for Segmental Bridges and LRFD Table 5.9.4.2.2-1). Reduced reliability is attained by using the number of striped lanes.

E.6.8.7.2 Transverse Tensile Stress

For a transversely prestressed deck slab, the allowable flexural stresses for concrete tension are provided in FDOT Table 6-9B: namely, for Inventory $3\sqrt{f'c}$ or $6\sqrt{f'c}$ (psi) and for Operating $6\sqrt{f'c}$ (psi).

E.6.8.7.3 Principal Tensile Stress – Service Limit State

A check of the principal tensile stress has been introduced to verify the adequacy of webs for longitudinal shear at service. This is to be applied to both for the design of new bridges and Load Rating. The verification, made at the neutral axis, is the recommended minimum prescribed procedure, as follows:

Sections should be considered only at locations greater than "H/2" from the edge of the bearing surface or face of diaphragm, where classical beam theory applies: i.e. away from discontinuity regions. In general, verification at the elevation of the neutral axis may be made without regard to any local transverse flexural stress in the web itself given that in most large, well proportioned boxes the maximum web shear force and local web flexure are mutually exclusive load cases. This is a convenient simplification. However, should the neutral axis lie in a part of the web locally thickened by fillets, then the check should be made at the most critical elevation, taking into account any coexistent longitudinal flexural stress. Also, if the neutral axis (or critical elevation) lies within 1 duct diameter of the top or bottom of an internal, grouted duct, the web width for calculating stresses should be reduced by half the duct diameter.

Calculate principle tension without the effect of thermal gradient.

Classical beam theory and Mohr's circle for stress should be used to determine shear and principal tensile stresses. At the Service Limit State, the shear stress and Principal Tensile Stress should be determined at the neutral axis (or critical elevation) under the long-term residual axial force, maximum shear and/or maximum shear force combined with shear from torsion in the highest loaded web, using a live load factor, $\gamma_L = 1.00$. The live load should then be increased in magnitude so the shear stress in the highest loaded web increases until the Principal Tensile Stress reaches its allowable maximum value (FDOT Table 6-9B).

The Service Limit State Rating Factor is the ratio between the live load shear stress required to induce the maximum Principal Tensile Stress to that induced by a live load factor of 1.00.

E.6.8.8 Local Details

Local Details (i.e. diaphragms, anchorage zones, blisters, deviation saddles, etc.) in concrete segmental bridges are discussed in Chapter 4 of Volume 10A Load Rating Post-tensioned Concrete Segmental Bridges. If a detail shows signs of distress (cracks), a structural evaluation should be performed for the Strength Limit State. The influence of anchorage zones shall be checked for principal tension in accordance with Structure Design Guidelines Section 4.5.11, Principal Tensile Stresses.

F.6 POSTING AVOIDANCE (NEW)

The following methods of posting avoidance are presented in an approximate hierarchy judged to return the greatest benefit for the least cost or effort for Florida bridges. This hierarchy is not absolute and may change depending on the particular bridge being load rated.

Under no circumstance shall a posting avoidance technique be used when load rating a newly designed bridge or when calculating permit capacity.

Posting avoidance techniques require either a Variance or an Exception. A Variance must be approved by the FDOT District Structures Engineer with concurrence of the District Structures and Facilities Engineer with a copy sent to the State Structures Design Engineer. An Exception requires the approval of the State Structures Design Engineer and may require notification of the Federal Highway Administration. For bridges where the owner is a local government, concurrence from the bridge owner is required before variance or exceptions are processed by FDOT.

F.6.1 DYNAMIC LOAD ALLOWANCE (IM) FOR IMPROVED SURFACE CONDITIONS (VARIANCE)

Using field observations and engineering judgment for spans greater than 40 feet, the Dynamic Load Allowance may be reduced if the following conditions exist:

- Where the bridge approach and the bridge have a smooth transition and where there are minor surface imperfections or depressions, the Dynamic Load Allowance (IM) may be reduced to 20%.
- Where there is a smooth riding surface on the bridge and where the transitions from the bridge approaches to the bridge deck across the expansion joints are smooth, the Dynamic Load Allowance (IM) may be reduced to 10%. (An example of this would be a deck slab finished by grinding and grooving to remove irregularities with no bumps or steps at expansion joints).

F.6.2 APPROXIMATE AND REFINED METHODS OF ANALYSES (VARIANCE)

When using an approximate method of structural analysis (code defined live load distribution LRFD 4.6.2), a rating factor as low as 0.95 can be rounded up to 1.0.

Refined methods of structural analyses (e.g. using finite elements) may be performed in order to establish an enhanced live load distribution and improved load rating. For fully continuous structures, a more sophisticated analysis of this type does not eliminate the need for a time-dependent construction analysis to determine overall longitudinal effects from permanent loads (e.g. BD 2 analysis).

F.6.3 SHEAR CAPACITY BY AASHTO LRFD FOR SEGMENTAL BOX GIRDER BRIDGES (VARIANCE)

When calculated in accordance with the AASHTO LRFD 5.8.6, the shear capacity, at the strength limit state, is based upon an assumed crack angle of 45°, and may lead to an unsatisfactory load rating. The assumed angle of crack may be reconsidered and the capacity recalculated according to the procedure in this Appendix B of "Volume 10 A Load Rating Post-Tensioned Concrete Segmental Bridges" (Dated Oct. 8, 2004).

F.6.4 EXISTING BRIDGE INVENTORY BEFORE JANUARY 2005 (VARIANCE)

If the bridge load carrying capacity as determined by Service III Limit State is causing unusual hardship and the current bridge inspection is showing no signs of either shear or flexural cracking, the capacity established for load posting and overweight vehicle permitting can be established using Strength Limit State.

F.6.5 SHEAR CAPACITY – SEGMENTAL CONCRETE BRIDGES (BOX GIRDER) - CRACK ANGLE AND PRINCIPAL TENSION (VARIANCE)

To calculate a crack angle more exactly than the assumed 45 degree angle use the specifications, use the procedure found in Appendix B of "Volume 10 A Load Rating Post-Tensioned Concrete Segmental Bridges" (dated Oct. 8, 2004) found on the Structures Design Office internet web site.

F.6.6 STIFFNESS OF TRAFFIC BARRIER (EXCEPTION)

Barrier stiffness should be considered and appropriately included if necessary. Inclusion of the barriers acting compositely with the deck slab and beams should improve longitudinal load ratings. When barriers are considered in this manner, the difference in the modulus of elasticity of the lower strength barrier concrete relative to that of the deck slab and to that of the beams should be taken into account. The presence of joints in a barrier reduces the overall effective section at the joint to that of the deck slab plus beam. This may result in a local concentration of longitudinal stress that should be appropriately considered.

Nevertheless, load ratings should benefit from reasonable consideration of barrier stiffness.

F.6.7 CONCRETE BOX GIRDER - LONGITUDINAL TENSION IN EPOXY JOINTS (EXCEPTION)

The AASHTO Guide Specification for Segmental Bridges and LRFD limit longitudinal tensile stresses to zero at epoxied match-cast joints under Service level conditions. The ability of the epoxy joint to accept tension is not considered. However, in properly prepared epoxy joints the bond usually exceeds the tensile strength of the concrete. Consequently, for posting avoidance, tensile stresses may be accepted as a function of the location and quality of the epoxy joint:

- For top fiber stresses on the roadway surface – no tension is permitted for all load rating calculations.
- For bottom fiber stresses –
  (a) Allow 200 psi tension at good quality epoxy joints (i.e. no leaks and fully sealed).
  (b) No tension allowed for poor quality epoxy joints (i.e. leaky or not filled, gaps).

F.6.8 CONCRETE BOX GIRDER - TRANSVERSE TENSILE STRESS LIMIT IN TOP SLAB (EXCEPTION)

For Legal and Permit loads, the permissible tensile stress in a transversely post-tensioned slab is set at $6.0\sqrt{f'c}$, regardless of the environment (FDOT Table 6-9B). For posting avoidance, up to $7.5\sqrt{f'c}$ may be allowed providing that:

a) There is sufficient bonded reinforcement to carry the calculated tensile force in the concrete computed on the assumption of an uncracked section at a stress of 0.5fy, and,
b) It is verified by field inspection that there are no cracks in the bridge deck as a consequence of routine or historically heavy vehicular traffic.

F.6.9 CONCRETE BOX GIRDER - PRINCIPAL TENSILE STRESS (EXCEPTION)

If the load rating based upon the limiting principal tensile stress at the neutral axis of the basic beam or composite section is not satisfactory, the rating factor with regard to principal tension may be taken as 1.00 providing that:

a) There is no visible evidence of any representative cracking in the webs.
b) The capacity is satisfactory under the required Strength Limit State.

However, if during field inspection, cracks are discovered at or near a critical section where, by calculation, the principal tensile stress is found to be less than the allowable, then further study is recommended to determine the origin of the cracks and their significance to normal use of the structure. If possible, a check should be made of construction records to determine if there was any change of construction, temporary loads or support reactions that may have induced a significant but temporary local affect.

F.6.10 REDUCED STRUCTURAL (DC) DEAD LOAD (EXCEPTION)

A lower dead load factor may be considered in accordance with the following criteria. Under no circumstance should this load factor be less than 1.10. For the self weight determined by:

a) Design Plan or Shop Drawing dimensions and assumed average density for concrete, reinforcement and embedded items: $\gamma_{DC} = 1.25$.
b) As-built dimensions, deck slab thickness and build-up using concrete density determined from construction records, adjusted for weight of embedded reinforcing: $\gamma_{DC} = 1.15$.
c) Actual beam weights measured during construction: $\gamma_{DC} = 1.10$.

Cases (b) and (c) may only be used providing that neither additional structural component (DC) nor superimposed dead loads (DW) has been added whose weight cannot be accurately ascertained.

In using either (a) or (b) above, and when it is known that the original design was based on an assumed density for normal concrete and that a check or investigation can verify that a bridge has been constructed with Florida Limerock, then the unit

weight may be reduced to 138 lbs per cubic foot for the concrete plus an allowance for the weight of steel.

F.6.11 REDUCED SUPERIMPOSED (DW) DEAD LOAD (EXCEPTION)

The load factor for superimposed dead loads including wearing surface and utilities is normally $\gamma_{DW} = 1.50$. A lower factor may be considered if weights are determined from an accurate survey. Under no circumstance should this be taken less than $\gamma_{DW} = 1.25$.

Load Rating Summary for Steel Girder Bridges

Table 1 – LRFR using Appendix D.6 (LFD or ASD)[5]

Level	Vehicle	Weight (tons)	Load Factors		Minimum. Rating Factor	Moment (Strength) or Stress (Service)						Shear (Strength)				
			LL	DL		Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Comments: Interior/exterior beam DF method if other than Standard Spec. Other appropriate comments
Inventory (Inv)	HS-20	36.0	2.17	1.30	N/A											
Operating (Op)	HS-20	36.0	1.30	1.30	N/A											
	SU4	35.0	1.30	1.30	N/A											
	C5	36.6	1.30	1.30	N/A											
	ST5	40.0	1.30	1.30	N/A											

General Notes:
1. This table is based on the requirements established in the Jan/July 2xxx "Structures Manual".

Table 2 Notes:
1. Permit capacity is determined by using the permit vehicle in all lanes.
2. If the Design Operating Load Rating is greater than 1, Load Rating using Legal Vehicles SU4, C5, and ST5 is not required.

Notes to Designer:
1. Modify the Rating Location sketch to resemble the bridge being rated.
2. Fill in the date in General Note number 1 above.
3. For Girder, Floorbeam, Stringer Bridges, use one Summary sheet for each member type."
4. Design Service Limit State ratings are only required for compact members.
5. See Volume 8 of the "Structures Manual" for appropriate rating methods.

Load Rating Summary for Steel Girder Bridges

Table 2 – LRFR w/o Appendix D.6 (LFD)[5]

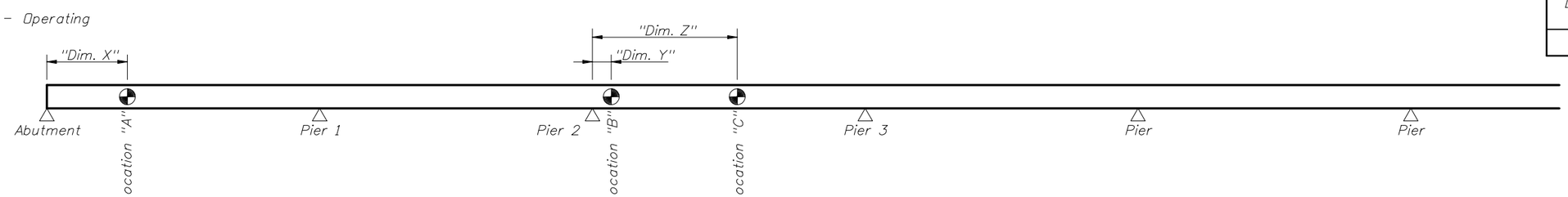
Level	Limit State	Vehicle	Weight (tons)	Load Factors			Minimum. Rating Factor	Moment (Strength) or Stress (Service)					Shear (Strength)					
				LL	DC	DW		Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Comments: Interior/exterior beam DF method if other than LRFD. Other appropriate comments
Design Load Rating	Strength I (Inv)	HL-93	N/A	1.75	1.25	1.50	1.00			N/A					N/A			
	Strength I (Op)	HL-93	N/A	1.35	1.25	1.50	1.00			N/A					N/A			
	Sevice II (Inv)[4]	HL-93	N/A	1.30	1.00	1.00	1.00			N/A			N/A	N/A	N/A	N/A	N/A	
	Service II (Op)[4]	HL-93	N/A	1.00	1.00	1.00	1.00			N/A			N/A	N/A	N/A	N/A	N/A	
Legal Load Rating	Strength I	SU4	35.0	1.35	1.25	1.50	N/A											
	Strength I	C5	36.6	1.35	1.25	1.50	N/A											
	Strength I	ST5	40.0	1.35	1.25	1.50	N/A											
	Service II[4]	SU4	35.0	1.30	1.00	1.00	N/A						N/A	N/A	N/A	N/A	N/A	
	Service II[4]	C5	36.6	1.30	1.00	1.00	N/A						N/A	N/A	N/A	N/A	N/A	
	Service II[4]	ST5	40.0	1.30	1.00	1.00	N/A						N/A	N/A	N/A	N/A	N/A	
Permit Load Rating	Strength II	FL120	60.0	1.35	1.25	1.50	1.00											
	Service II[4]	FL120	60.0	0.90	1.00	1.00	1.00						N/A	N/A	N/A	N/A	N/A	

Abbreviations:

Inv – Inventory

Op – Operating

Controlling Load Rating			
Limit State	Vehicle	Weight (Tons)	Rating Factor



RATING LOCATIONS

REVISIONS

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ROAD NO.	COUNTY	FINANCIAL PROJECT ID

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PROJECT NAME:

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Load Rating Summary for Reinforced Concrete Bridges

Table 1 – LRFR using Appendix D.6 (LFD or ASD)[3]

Level	Vehicle	Weight (tons)	Load Factors		Minimum. Rating Factor	Moment (Strength) or Stress (Service)						Shear (Strength)				
			LL	DL		Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Comments: Interior/exterior beam DF method if other than Standard Spec. Other appropriate comments
Inventory (Inv)	HS-20	36.0	2.17	1.30	N/A											
Operating (Op)	HS-20	36.0	1.30	1.30	N/A											
	SU4	35.0	1.30	1.30	N/A											
	C5	36.6	1.30	1.30	N/A											
	ST5	40.0	1.30	1.30	N/A											

General Notes:
1. This table is based on the requirements established in the Jan/July 2xxx "Structures Manual".

Table 2 Notes:
1. Permit capacity is determined by using the permit vehicle in all lanes.
2. If the Design Operating Load Rating is greater than 1, Load Rating using Legal Vehicles SU4, C5, and ST5 is not required.

Notes to Designer:
1. Modify the Rating Location sketch to resemble the bridge being rated.
2. Fill in the date in General Note number 1 above.
3. See Volume 8 of the "Structures Manual" for appropriate rating methods.

Load Rating Summary for Reinforced Concrete Bridges

Table 2 – LRFR w/o Appendix D.6 (LFD)[3]

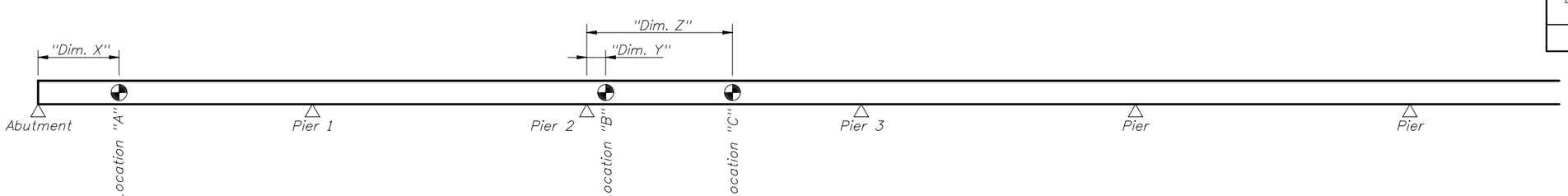
Level	Limit State	Vehicle	Weight (tons)	Load Factors			Minimum. Rating Factor	Moment (Strength) or Stress (Service)					Shear (Strength)					
				LL	DC	DW		Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Comments: Interior/exterior beam DF method if other than LRFD. Other appropriate comments
Design Load Rating	Strength I (Inv)	HL-93	N/A	1.75	1.25	1.50	1.00			N/A					N/A			
	Strength I (Op)	HL-93	N/A	1.35	1.25	1.50	1.00			N/A					N/A			
Legal Load Rating	Strength I	SU4	35.0	1.35	1.25	1.50	N/A											
	Strength I	C5	36.6	1.35	1.25	1.50	N/A											
	Strength I	ST5	40.0	1.35	1.25	1.50	N/A											
Permit Load Rating	Strength II	FL120	60.0	1.35	1.25	1.50	1.00											

Abbreviations:

Inv – Inventory

Op – Operating

Controlling Load Rating			
Limit State	Vehicle	Weight (Tons)	Rating Factor



RATING LOCATIONS

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Load Rating Summary for Prestressed Concrete Bridges (Flat Slab and Deck/Girder)

Table 1 – LRFR using Appendix D.6 (LFD or ASD)[3]

Level	Vehicle	Weight (tons)	Load Factors		Minimum. Rating Factor	Moment (Strength) or Stress (Service)						Shear (Strength)				
			LL	DL		Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Comments: Interior/exterior beam DF method if other than Standard Spec. Other appropriate comments
Inventory (Inv)	HS-20	36.0	2.17	1.30	N/A											
Operating (Op)	HS-20	36.0	1.30	1.30	N/A											
	SU4	35.0	1.30	1.30	N/A											
	C5	36.6	1.30	1.30	N/A											
	ST5	40.0	1.30	1.30	N/A											

General Notes:
1. This table is based on the requirements established in the Jan/July 2xxx "Structures Manual".

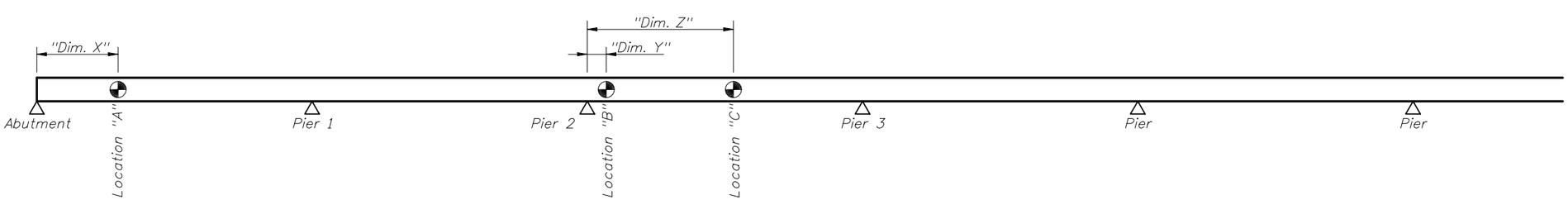
Table 2 Notes:
1. Permit capacity is determined by using the permit vehicle in all lanes.
2. If the Design Operating Load Rating is greater than 1, Load Rating using Legal Vehicles SU4, C5, and ST5 is not required.
3. Service III Inventory Design tensile stress limits = $3\sqrt{f'c}$ or $6\sqrt{f'c}$. Service III Operating Design, Legal, and Permit tensile stress limits = $7.5\sqrt{f'c}$.

Notes to Designer:
1. Modify the Rating Location sketch to resemble the bridge being rated.
2. Fill in the date in General Note number 1 above.
3. See Volume 8 of the "Structures Manual" for appropriate rating methods.

Load Rating Summary for Prestressed Concrete Bridges (Flat Slab and Deck/Girder)

Table 2 – LRFR w/o Appendix D.6 (LFD)[3]

Level	Limit State	Vehicle	Weight (tons)	Load Factors			Minimum. Rating Factor	Moment (Strength) or Stress (Service)					Shear (Strength)					
				LL	DC	DW		Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Comments: Interior/exterior beam DF method if other than LRFD. Other appropriate comments
Design Load Rating	Strength I (Inv)	HL-93	N/A	1.75	1.25	1.50	1.00			N/A					N/A			
	Strength I (Op)	HL-93	N/A	1.35	1.25	1.50	1.00			N/A					N/A			
	Service III (Inv)	HL-93	N/A	0.80	1.00	1.00	1.00			N/A			N/A	N/A	N/A	N/A	N/A	
	Service III (Op)	HL-93	N/A	0.80	1.00	1.00	1.00			N/A			N/A	N/A	N/A	N/A	N/A	
Legal Load Rating	Strength I	SU4	35.0	1.35	1.25	1.50	N/A											
	Strength I	C5	36.6	1.35	1.25	1.50	N/A											
	Strength I	ST5	40.0	1.35	1.25	1.50	N/A											
	Service III	SU4	35.0	0.80	1.00	1.00	N/A						N/A	N/A	N/A	N/A	N/A	
	Service III	C5	36.6	0.80	1.00	1.00	N/A						N/A	N/A	N/A	N/A	N/A	
	Service III	ST5	40.0	0.80	1.00	1.00	N/A						N/A	N/A	N/A	N/A	N/A	
Permit Load Rating	Strength II	FL120	60.0	1.35	1.25	1.50	1.00											
	Service III	FL120	60.0	0.70	1.00	1.00	1.00						N/A	N/A	N/A	N/A	N/A	



RATING LOCATIONS

Abbreviations:

Inv – Inventory

Op – Operating

Controlling Load Rating			
Limit State	Vehicle	Weight (Tons)	Rating Factor

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Load Rating Summary for Concrete Box Girder Bridges

Table 1 – LRFR w/o Appendix D.6 and with Appendix E.6

Level	Direction	Limit State	Vehicle	Weight (tons)	Load Factors							Minimum Rating Factor	Moment (Strength) or Stress (Service)					Shear (Strength)					
					DC	DW	EL	FR	TUCRSH	TG	LL		Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Comments: Interior/exterior beam DF method if other than LRFD. Other appropriate comments
Design Load Rating	Longitudinal	Strength I (Inv)	HL-93	N/A	1.25	1.50	1.00	1.00	0.50	N/A	1.75	1.00			N/A					N/A			
		Strength I (Op)	HL-93	N/A	1.25	1.50	1.00	1.00	0.50	N/A	1.35	1.00			N/A					N/A			
		Service III (Inv)	HL-93	N/A	1.00	1.00	1.00	1.00	1.00	0.50	0.80	1.00			N/A			N/A	N/A	N/A	N/A	N/A	
		Service III (Op)	HL-93	N/A	1.00	1.00	1.00	1.00	1.00	N/A	SL	1.00			N/A			N/A	N/A	N/A	N/A	N/A	
	Transverse	Strength I (Inv)	single axle	16.0	1.25	1.50	1.00	N/A	N/A	N/A	1.75	1.00						N/A	N/A	N/A	N/A	N/A	
		Strength I (Inv)	tandem axle	25.0	1.25	1.50	1.00	N/A	N/A	N/A	1.75	1.00						N/A	N/A	N/A	N/A	N/A	
		Strength I (Op)	single axle	16.0	1.25	1.50	1.00	N/A	N/A	N/A	1.35	1.00						N/A	N/A	N/A	N/A	N/A	
		Strength I (Op)	tandem axle	25.0	1.25	1.50	1.00	N/A	N/A	N/A	1.35	1.00						N/A	N/A	N/A	N/A	N/A	
		Service I (Inv)	single axle	16.0	1.00	1.00	1.00	N/A	N/A	N/A	1.00	1.00						N/A	N/A	N/A	N/A	N/A	
		Service I (Inv)	tandem axle	25.0	1.00	1.00	1.00	N/A	N/A	N/A	1.00	1.00						N/A	N/A	N/A	N/A	N/A	
		Service I (Op)	single axle	16.0	1.00	1.00	1.00	N/A	N/A	N/A	1.00	1.00						N/A	N/A	N/A	N/A	N/A	
		Service I (Op)	tandem axle	25.0	1.00	1.00	1.00	N/A	N/A	N/A	1.00	1.00						N/A	N/A	N/A	N/A	N/A	
Lega Load Rating	Longitudinal	Strength I	SU4	35.0	1.25	1.50	1.00	1.00	0.50	N/A	1.35	N/A											
		Strength I	C5	36.6	1.25	1.50	1.00	1.00	0.50	N/A	1.35	N/A											
		Strength I	ST5	40.0	1.25	1.50	1.00	1.00	0.50	N/A	1.35	N/A											
		Service III	SU4	35.0	1.00	1.00	1.00	1.00	1.00	N/A	SL	N/A						N/A	N/A	N/A	N/A	N/A	
		Service III	C5	36.6	1.00	1.00	1.00	1.00	1.00	N/A	SL	N/A						N/A	N/A	N/A	N/A	N/A	
		Service III	ST5	40.0	1.00	1.00	1.00	1.00	1.00	N/A	SL	N/A						N/A	N/A	N/A	N/A	N/A	
Permit Load Rating	Longitudinal	Strength II	FL120	60.0	1.25	1.50	1.00	1.00	0.50	N/A	1.35	1.00											
		Service III	FL120	60.0	1.00	1.00	1.00	1.00	1.00	N/A	0.90SL	1.00						N/A	N/A	N/A	N/A	N/A	

Abbreviations:

Inv – Inventory

Op – Operating

SL – Striped Lanes

NOTES

General Notes:

1. This table is based on the requirements established in the January/July 2xxx "Structures Manual".
2. Permit capacity is determined by using the permit vehicle in all lanes.
3. If the Design Operating Load Rating is greater than 1, Load Rating using Legal Vehicles SU4, C5, and ST5 is not required.
4. Service III Inventory Design tensile stress limit = $3\sqrt{f'c}$ or $6\sqrt{f'c}$; Service III Operating Design, Legal, and Permit tensile stress limit = $7.5\sqrt{f'c}$; Service III Principal Tension Limit = $3\sqrt{f'c}$.
5. Service I Transverse Inventory Design tensile stress limit = $3\sqrt{f'c}$ or $6\sqrt{f'c}$; Service I Transverse Operating Design tensile stress limit = $6\sqrt{f'c}$.

Notes to Designer:

1. Modify the Rating Location sketch to resemble the bridge being rated.
2. Fill in the date in General Note number 1 above.
3. In the comments section for Service Limit III, state whether the rating is for principal tension stress or bending stress.

Controlling Load Rating			
Limit State	Vehicle	Weight (Tons)	Rating Factor

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

	NAMES	DATES
DRAWN BY		
CHECKED BY		
DESIGNED BY		
CHECKED BY		
APPROVED BY		

ENGINEER OF RECORD:

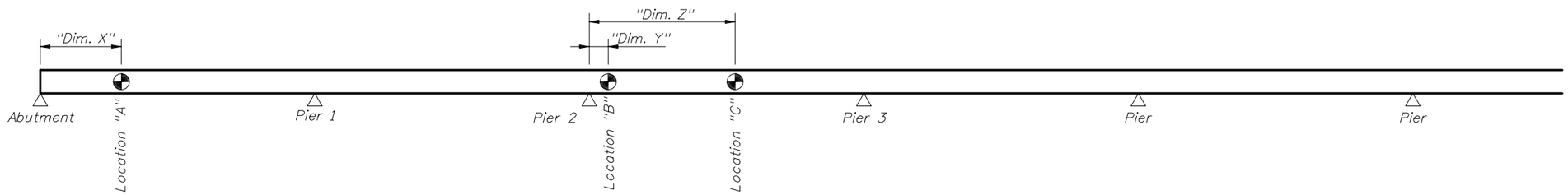
FLORIDA DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID

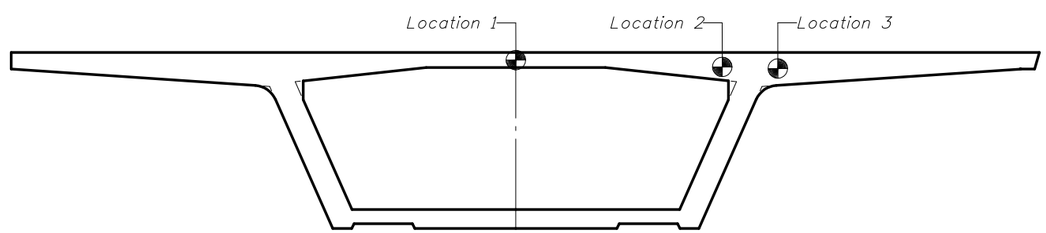
SHEET TITLE:

PROJECT NAME:

SHEET NO.



RATING LOCATIONS



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ENGINEER OF RECORD:

FLORIDA DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID

SHEET TITLE:

PROJECT NAME:

SHEET NO.

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Load Rating Summary for Continuous Post-Tensioned I Girder Bridges

Table 1 - LRFR w/o Appendix D.6 and with Appendix E.6

Level	Limit State	Vehicle	Weight (tons)	Load Factors							Minimum. Rating Factor	Moment (Strength) or Stress (Service)					Shear (Strength)					
				DC	DW	EL	FR	TUCRSH	TG	LL		Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Distribution Factor (DF)	Rating Factor	Tons	Location	Dimension	Comments: Interior/exterior beam DF method if other than LRFD. Other appropriate comments
Design Load Rating	Strength I (Inv)	HL-93	N/A	1.25	1.50	1.00	1.00	0.50	N/A	1.75	1.00			N/A					N/A			
	Strength I (Op)	HL-93	N/A	1.25	1.50	1.00	1.00	0.50	N/A	1.35	1.00			N/A					N/A			
	Service III (Inv)	HL-93	N/A	1.00	1.00	1.00	1.00	1.00	0.50	0.80	1.00			N/A			N/A	N/A	N/A	N/A	N/A	
	Service III (Op)	HL-93	N/A	1.00	1.00	1.00	1.00	1.00	N/A	0.80	1.00			N/A			N/A	N/A	N/A	N/A	N/A	
Lega Load Rating	Strength I	SU4	35.0	1.25	1.50	1.00	1.00	0.50	N/A	1.35	N/A											
	Strength I	C5	36.6	1.25	1.50	1.00	1.00	0.50	N/A	1.35	N/A											
	Strength I	ST5	40.0	1.25	1.50	1.00	1.00	0.50	N/A	1.35	N/A											
	Service III	SU4	35.0	1.00	1.00	1.00	1.00	1.00	N/A	0.80	N/A						N/A	N/A	N/A	N/A	N/A	
	Service III	C5	36.6	1.00	1.00	1.00	1.00	1.00	N/A	0.80	N/A						N/A	N/A	N/A	N/A	N/A	
	Service III	ST5	40.0	1.00	1.00	1.00	1.00	1.00	N/A	0.80	N/A								N/A			
Permit Load Rating	Strength II	FL120	60.0	1.25	1.50	1.00	1.00	0.50	N/A	1.35	1.00											
	Service III	FL120	60.0	1.00	1.00	1.00	1.00	1.00	N/A	0.70	1.00						N/A	N/A	N/A	N/A	N/A	

Abbreviations:

Inv - Inventory

Op - Operating

NOTES

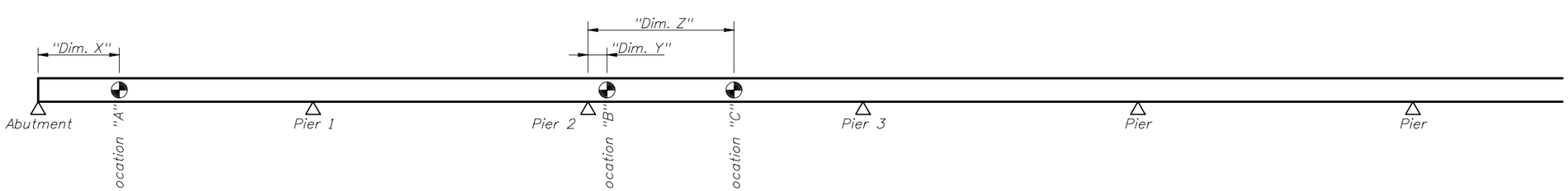
General Notes:

1. This table is based on the requirements established in the January/July 2xxx "Structures Manual".
2. Permit capacity is determined by using the permit vehicle in all lanes.
3. If the Design Operating Load Rating is greater than 1, Load Rating using Legal Vehicles SU4, C5, and ST5 is not required.
4. Service III Inventory Design tensile stress limit = $3\sqrt{f'c}$ or $6\sqrt{f'c}$; Service III Operating Design, Legal, and Permit tensile stress limit = $7.5\sqrt{f'c}$.

Notes to Designer:

1. Modify the Rating Location sketch to resemble the bridge being rated.
2. Fill in the date in General Note number 1 above.

Controlling Load Rating			
Limit State	Vehicle	Weight (Tons)	Rating Factor



RATING LOCATIONS

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

	NAMES	DATES
DRAWN BY		
CHECKED BY		
DESIGNED BY		
CHECKED BY		
APPROVED BY		

ENGINEER OF RECORD:

FLORIDA DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID

SHEET TITLE:

PROJECT NAME:

SHEET NO.

G.6 - LOAD RATING SUMMARY FORMS (NEW)

"ASK THE PROFESSOR" QUESTIONS
LOAD RATING SUMMIT

DECEMBER 7 AND 8, 2005

FLORIDA DEPARTMENT OF TRANSPORTATION
STRUCTURES DESIGN OFFICE
Mail Station 33
605 Suwannee Street
Tallahassee, FL 32399-0450

LOAD RATING SUMMIT: LRFR for Florida's Bridges
Ask the Professor

FDOT & FHWA Policies & Procedures

1. A project has 2 phases, one in which a bridge is at 100% with load rating done in LFD, the second contains a yet to be designed bridge. Will the yet-to-be-design bridge be required to be LRFR (since it's less than 60%) or LFD?

   For projects where the design is not more than 60 % complete the load rating must be performed using LRFR.

2. As a matter of FDOT policy, when does LRFR become effective and will it be retro-active to current LRFD designed bridges?

   January 6, 2005 all jobs that were 60% or less are under the guidance with LRFR in accordance with the Design Bulletin. One of the chores that Andre and his group have got to face this next roll out of the Structures Manual in January is how we are going to date stamp what version of the Structures Manual which will freeze in time which version of AASHTO Manual are being deployed for the load ratings and for the design itself. We are already under LRFR to an extent for jobs that were in the pipeline. If you have a job that was beyond 60% in January then the DSDE and the DSFE are expecting it to be LFD. If you want to make a change and move forward with it, I don't think anyone will be upset about it, but the problem is that The rating factor for the FL120 may not come up to 1.0 it may be something short of that and if we go back and deploy D.6.1 which is what the Design Bulletin says, which is LFD then the rating factor for that which is called HS-32 in the Design Bulletin is expected to be the 167 ratio which should get you back to that 60 ton routing vehicle to pass.

3. Does the Department plan to publish examples of LRFR bridge ratings on their website (like they now have for LRFD)?

   In the future the FDOT may develop LRFD load rating examples.

4. How will LRFR be applied to:
   1. Existing structures that receive a rehab (i.e. railing)>
   2. How (i.e. what method) should widened structures be rated?

   Chapter 7 of the Structure Design Guidelines entitled "Widening and Rehabilitation," addresses issues regarding LRFR applied to widening and rehabilitation.

5. Am I clear that FL Greenbook Specs are now required to be followed for all off system bridges (i.e. city bridges). Ex. City Hydro clearance =1' – Green Book = 2' – Who controls?

   The Green book now has statutory authority; therefore, it is the governing document over city and county regulations.

6. After AASHTO issues "Manual for Bridge Evaluation" how soon will FDOT revise revisions to LRFR to be revisions to "Manual for Bridge Evaluation"?

   The Manual for Bridge Evaluation is the renaming of the "Manual for Condition Evaluation and Load and Resistance Factor Rating (LRFR)". Within six months after the publication the FDOT will update Vol.8 of the Structures Manual.

7. When a bridge is "value engineered" by a contractor do the load rating criteria in the design guideline still apply? Who enforces this?

Why isn't service based on durability? Do we risk making strong bridges that have a 20 year life?

Yes, the District Structures Design Engineer and the Engineer of Record (if it is outsourced) have the responsibility to ensure that the load rating has been done and updated to reflect whatever idea comes forward from construction.

It should be based on durability, which is what the calibrations are all about. The Service II limit state for steel tries to make sure that as little by little you exceed the yield strength you don't start getting a kink in the girder and you don't start to have a problem with the alignment of the bridge. The Service III limit state really should address how many times you will allow a crack in a beam to open up in the lifetime of the bridge.

8. There seems to be a lot of details that will impact the load ratings that have not been finalized. When is it anticipated that we will have a stable spec to do the load ratings?

   Subsequent to the Load Rating Summit, a final FDOT LRFR process was released on March 1, 2006, as Revisions to "Guide Manual for condition Evaluation and Load and Resistance Factor Rating of Highway Bridges."

9. Does the "Manual for Bridge Evaluation" replace the Manual for Condition Rating in the code of Federal Regs?

   It will, AASHTO voted to adopt it. Modjeski and Masters has been tasked to put the manual together. Upon completion and printing it will be incorporated into the Federal Registry.

10. Will the FHWA require the use of LRFR? Will there be a permit vehicle to equate to tonnage?

    FHWA does not require the use of LRFR. LFR load ratings may continue to be reported in the NBI. FDOT mandates that all new bridges be rated using LRFR. The FL120 permit vehicle will be used to provide a rating factor and corresponding tonnage for issuing permits.

11. With LRFR still in development in Florida, how can we consultants be required to do LRFR ratings now? Can Mr. Nickas instruct all districts to not require LRFR ratings until all the dust settles?

    Subsequent to the Load Rating Summit, a final FDOT LRFR process was released on March 1, 2006, as Revisions to "Guide Manual for condition Evaluation and Load and Resistance Factor Rating of Highway Bridges."

12. VECP Load Rating - Who will enforce the requirement of having a new load rating completed prior to the approval of a VECP design? Is construction on board?

    Standard scopes-of-work now require the load rating to be performed by the Engineer of Record. If the Engineer of Record is transferred to the VECP engineer then the VECP engineer is responsible for the load rating.

13. On page 303 of 414, it appears that it has us doing LRFR and then if built before 1/2005 doing LFR. Please explain.

    LRFR is suggested for all bridges to achieve a uniform rating standard, but bridges built prior to January 2005 may be rated using the LFR provisions of LRFR Appendix D6. January 2005 marks the issuance of the temporary design bulletin mandating LRFR.

14. Why is LRFR not being adopted across the board for both new and existing bridges?

FDOT is not mandating LRFR for new and existing bridges. LRFR is suggested for all bridges to achieve a uniform rating standard, but bridges built prior to January 2005 may be rated using the LFR provisions of LRFR Appendix D6.

15. Appendix D of the handout shows proposed load rating forms. One form can be used for only one beam (in a typical slab - on – AASHTO beams bridge). However, critical load rating for different LR levels can be for different beams. Is the intention to use multiple sheets for a bridge? Potentially in a widening of a bridge one may use (2 – 3 sheets) x number of spans.

    Generally, the load rating is for the most critical location throughout the bridge and one detailed summary sheet will be sufficient.

16. If both design load inventory ratings are greater than 1, load rating using legal vehicles SU4, C5 and ST5 is not required. If this the case, what we are going enter in our "current" capacity sheet for SU2, C5 and ST5? Will be blank or N.A. (not applicable) or need to revise form.

    If the HL-93 operating rating is equal to or greater than 1, the bridge will not be load posted because the HL-93 loading is more severe than the legal loads. In this case no data will be entered into the legal truck data fields.

17. What written requirements do you propose to address load rating results that are less that anticipated?

    Posting-avoidance procedures for use by the Department are included in Appendix F6 of FDOT LRFR. These procedures require either a variance or an exception.

18. Chapter 6 of the LRFR specification is short. Could FDOT issue a revised copy of Chapter 6 rather than requiring us to look at two documents simultaneously?

    It is the policy of the Structures Design Office to utilize the ASSHTO specifications amended by the FDOT to meet the specific requirements of the FDOT.

19. What do we do if an existing bridge does <u>not</u> meet strength at operational limits? Should the existing bridge be load rated before continuing design of widened portion?

    Chapter 7 of the Structure Design Guidelines entitled "Widening and Rehabilitation," addresses issues regarding LRFR applied to widening and rehabilitation. It states "Before a variance or exception is approved for a bridge widening, use LRFR Appendix D.6.1 to determine LFD inventory rating factor. If any rating for design and legal vehicles is below 1.0, replacement is preferred, and a Variance or Exception is required for rehabilitation."

<u>Loads</u>

20. How does the HL93 loading compare to the old truck/vehicle train loading?

    The LRFD HL-93 loading envelopes the old HS20 loading as well as the Florida legal trucks and most permit trucks.

21. If a RF > 1.0 is achieved for design load rating, the legal loads do not have to be checked? How well does the HL93 envelope all the AASHTO and FL legal loads?

    It has been shown that the notional HL-93 live-load model (including the design truck or design tandem superimposed upon the design lane) envelopes the AASHTO and FDOT legal loads.

22. Has the AASHTO 3-3 vehicle been removed from the load rating process?

    The AASHTO 3-3 legal load is not a part of the FDOT rating process.

23. Does Florida use AASHTO 3-3, etc. for posting?

If the HL-93 design-load operating rating is less than 1.0, the FDOT rating process uses the Florida legal-loads; the SU4, C5 and ST5 for posting purposes.

24. Why hasn't AASHTO standardized the "permit vehicle(s)" for all states?

Permit issuance is a State responsibility not a National one, and thus AASHTO has not attempted to standardized permit vehicles.

25. Does notional load include the clause "Axles that do not contribute …" for HL93 in LRFR? What about legal loads or permit?

LRFR uses the notional HL-93 live-load model exactly as specified in LRFD. LRFR includes the effects of the all of the axles of the legal and permit loads at all times.

What about LRFD (Design) in Florida?

For design, Florida does not deviate from the HL-93 loading except to add the FL120 permit as a strength II check.

26. S7 Does slide 17 include the effect of the design tandem on short span bridges?

The effect of either the design truck or the design tandem (whichever governs) are represented by the notional load in the figure.

27. For permit ratings, is it necessary to analyze mixed loading (permit & HL-93) if all lanes loaded with permit vehicles rate above 1.0? Mixed loading requires more analysis and seems unnecessary if bridge rates.

For simplicity, the permit load is assumed to be in all lanes when considering multiple loaded lanes (see FDOT LRFR Article 6.4.5.1).

28. Slide 23 (Page 96) HS-32 and T-160 (FL20) w/ coincident 0.2 KLF lane load. There is a superscript but no footnote to explain. This is the only place that this additional lane load is shown. Is it required for permit loads?

AASHTO LRFR Article 6.5.4.5.1 states that for permit-load rating "For spans between 200 and 300 feet, . . . an additional lane load shall be applied . . ." The lane load is 200 plf.

29. Please clarify the use of permit vehicle HS-33 in LRFR load rating analysis. It is not identified in FDOT Revisions to AASHTO LRFR Figure 6-1.

The truck that was originally termed the HS-33 has been renamed the FL120. For the FDOT rating process, the FL120 permit load provides a benchmark to the past. The FL120 is the traditional HS20 truck with the axle loads increased by 1.67 to simulate the traditional HS20 operating rating level. This truck and its permit rating will be used to judge permit applications.

30. Can you please explain the concept of HS-32. Is this to be used for design/inventory or rating/operating level?

The truck that was originally termed the HS-32 has been renamed the FL120. For the FDOT rating process, the FL120 permit load provides a benchmark to the past. The FL120 is the traditional HS20 truck with the axle loads increased by 1.67 to simulate the traditional HS20 operating rating level. This truck and its permit rating will be used to judge permit applications.

31. How would you input the pedestrian live load for the sidewalks?

AASHTO LRFR Article 6.2.3.4 states "Pedestrian loads on sidewalks need not be considered simultaneously with vehicular loads when rating a bridge unless" it is expected that significant pedestrian loads will be present.

System Factors & Redundancy

32. What φ_s system factor should be used for concrete box culverts; either 4 sided monolithic or 2-piec (simple top slab with 3-sided bottom section) and 3-sided box/arch culverts? Note: 4 sided monolithic boxes are very redundant especially when continuous.

System factors have not been specified for culverts. The system factors of AASHTO LRFR and the FDOT rating process are based upon NCHRP Report 406 entitled "Redundancy in Highway Superstructures." No comparable research is available for culverts.

33. No system factors are utilized in design. Will the system factor concept be integrated into AASHTO LRFD specifications? In some cases, new bridges will be rated lower than design.

While system factors are not included on the resistance side of the basic LRFD equation (LRFD Equation 1.3.2.1-1), a factor relating to redundancy, η_R, is included on the load side of the equation. Currently, the η_R values in the LRFD Specifications are qualitatively based. The system factors of AASHTO LRFR and the additional system factors of the FDOT rating process are being proposed as interim changes to the AASHTO LRFD Specifications but would appear as η_R factors with values equal to the inverse of the corresponding system factors. Most of the bridge component types with system factors less than 1.0 are prohibited of frowned upon for new design.

34. Steel gets benefits from the load path redundancy only. Concrete segmental also gets structural and internal redundancy benefits. Why the difference?

Both concrete and steel components benefit from structural (for example, interior versus end steel-girder spans) and internal redundancy (for example, welded versus riveted steel members) through system factors where appropriate.

35. Segmental bridge designs are generally controlled by service limit states. Can the system factors be developed for service limit states?

System factors relate to the re-distribution of load after damage. Thus system factors are only applicable to the strength limit states.

36. Will applying the redundancy factor in the design mean that if a component cracks then the span won't fail?

A system factor equal to 1.0 is assigned to simple-span multi-girder bridges. In the case of a multi-girder bridge, it is expected that one girder can fail (cracking or otherwise) and the span will not collapse due to load-path redundancy. A system factor greater than 1.0 suggests that the damaged bridge has less likelihood to collapse; less than 1.0 suggest it is more likely to collapse.

Does this jive with fatigue stress limits?

The LRFD fatigue-resistance equations do not deal with redundancy. They are based upon the projected number of cycles to fatigue cracking to achieve a 75-year life. The concept of system factor (or load modifier in LRFD Article 1.3.4) has only been applied to strength limit states.

Analysis

37. Prestressed Concrete Girders – Transforming the Prestressing Steel:
If the draped strands or debonded strands are used, the section properties along the girder will vary. In addition the development of the strands should be considered. For simple spans, deflections will be affected. For continuous structures, deflection and load distribution will be affected.

Just as with a steel plate girder with changing plate sizes along its length, a prestressed concrete beam with draped or debonded strands will have varying properties along its length when transformed sections are used in the analysis. Development and transfer length of the prestressing should also be considered.

38. What is the best way to establish distribution factors on a prestressed beam bridge widening with variable beam spacing and perhaps size (i.e. modified beams on widening)?

In Chapter 7 of the Structure Design Guidelines entitled "Widening and Rehabilitation," Article 7.3 .3 mandates to "proportion the main load carrying members of the widening to provide longitudinal and transverse load distribution characteristics similar to the existing structure." Further, it suggests that "this can be achieved by using the same cross-sections and member lengths as were used in the existing structure."

39. Why is it acceptable to use FEA for steel and not concrete?

According to AASHTO LRFR and the FDOT rating process (see LRFR Article 6.3.2), if an AASHTO LRFD load-distribution factor is available for the bridge type being rated (see LRFD Table 4.6.2.2.1-1), it must be used. Refined analysis, including finite-element analysis (FEA), is only acceptable for routine rating of bridges where an AASHTO LRFD load-distribution factor is not available. Refined analysis, including FEA, can be used as a posting-avoidance procedure. There is no distinction between steel and concrete bridges.

40. Is composite section properties use warranted <u>AT ALL</u> for those PT structures where tendons are not bonded? This goes against very definition of composite section.

Transformed-section analysis is not appropriate for sections with unbonded tendons.

41. What are the results when you design using a line girder model and load rate using a grillage model? Do the results always get better, worse, or can they go either way?

We've seen that if you use a line-girder analysis but with the relatively good LRFD distribution factor you don't get as much benefit when you go to a grid model. If you've used the S/5.5 in the past, you will probably see great benefit by going to a grid model when you rate the bridge. We saw much more benefit in the HDR study for one of the bridges because it was a relatively wide bridge that had wide sidewalks and only had two lanes on the bridge with a curb. So when we used the distribution factor equations, the distribution factor equations assume that you can place trucks really close to all of the girders where you needed to, but when you actually went in and did a grid model and used the curb line to push the trucks around you couldn't get the trucks in as bad a position as the distribution factor models assumed you could, so in that case we saw really good improvement. The down side to that is that if that bridge was designed using that grid model keeping the trucks within the curb line, if you wanted to widen that bridge, the exterior girder could be problematic. Any limitation for using refined analysis to obtain live load distribution factors if AASHTO formulas are not applicable?

According to AASHTO LRFR and the FDOT rating process (see LRFR Article 6.3.2), if an AASHTO LRFD load-distribution factor is available for the bridge type being rated (see LRFD Table 4.6.2.2.1-1), it must be used. Refined analysis is only acceptable for bridges where an AASHTO LRFD load-distribution factor is not available.

FDOT Rating Process

42. Would it be appropriate to reduce the acceptable operating factor from 1.0 to say 0.8 to temporarily address the discrepancy between LFR and LRFR (service controlled) operating ratings, until a more rational selection for a new β factor can be determined as proposed in Slide #50?

    Rating factors are not typically varied. To maintain an increment between the inventory and operating rating levels to allow the issuance of permits, varying load factors have been specified for the inventory and operating levels of the service limit states. See FDOT LRFR Table 6-1.

43. How do you justify γ live loads values less than 1 in areas of Florida where we are reasonably sure that there is high probability that all lanes will be loaded w/a combination of permit vehicle and legal truck?

    The consequences of failure are a part of the establishment of the target reliability indices. Since the exceeding the service limit states (cracking, yielding, etc.) has less consequence than potential collapse due to exceeding a strength limit state, the beta for service could be less than that for strength. Thus, the live load factors for service limit states may be less than 1.0.

44. With the change to LRFD the live load became larger. The live load changed from HS-20 to HL-93 but the allowable stress for prestressed beams stayed basically the same. This results in dramatically higher concrete strength required compared to standard design.

    Actually, a simplistic "calibration" of the service III limit state load combination was made based upon trial designs by the States. This resulted in a live load factor of 0.8 in the LRFD Specifications. Thus "old" HS20 load factor design (LFD) designs should generally "work" for HL-93 and LRFD. Live load factors less than 1.0 are also included in FDOT LRFR for the service limit states.

45. How does the LRFR/FDOT process differ for reinforced concrete box culverts?

    Culverts are treated as any reinforced concrete component.

    Are load rating forms for culverts (similar to page 367 of 414 in our handouts) being developed?

    No special forms exist for the load rating of culverts. One should use the reinforced concrete form for culverts.

46. How is tonnage for permit vehicles going to be determined?

    The FL120 permit vehicle will be used to provide a rating factor and corresponding tonnage for issuing permits.

47. Is the concept of beta β suitable for use at both strength and service limit states?

    Yes, the only issue is the appropriate level of beta, β. The consequences of failure are a part of the establishment of the target beta. Since the exceeding the service limit states (cracking, yielding, etc.) has less consequence than potential collapse due to exceeding a strength limit state, the beta for service could be less than that for strength.

48. Note 1 of Table 2 notes in Appendix D indicates permit capacity is based on permit loads in all lanes. However, slide 23 for longitudinal rating indicates that remote lanes contain the HL93 load. Is this a discrepancy?

    No, if you are doing a refined analysis, and actually get to place vehicles on the bridge, we want you to put HL-93 in remote lanes. What we are working on is when you don't place lanes on the bridge, but

use distribution factors we would like to give you a correction factor so you can more simplistically get the answer of the permit load in one lane and HL-93's in the others without going to the trouble of using the method of using two different distribution factors. If we are not successful in finding a modification factor we are going to have to go back to using the one using two different distribution factors. It may seam like a discrepancy, but it is not necessarily, but we are going to have to go back and clear that up in the final manual.

49. How will the LRFR method be implemented for existing bridges?

For a new bridge, you are going to have to make sure the new bridge rate for HL-93 with a rating factor of 1.0. You also want to make sure it works for the T160 and the FL120. If it is an existing bridge it may not work for the HL-93 and if it doesn't work for the HL-93, we are interested in how the bridge might have to be posted. When the operating rating for an existing bridge is not 1.0 or greater or .95 or greater, you then have to go look at the SU4, C5 or the ST5 at the legal load limit and then those would get you the load that you can use with the picture that you can use for posting the bridge. If that doesn't work then you go down the road to do the legal load rating and hopefully the legal load rating factors above 1 and we still wont have to post it but we will be under those operational rules that which we deploy which include post and avoidance strategies to be able to be able to fully operate our system. That's what John Harris and Richard Kerr and Mr. Ducher do everyday is utilize those best numbers to route our overloads and produce crane maps, etc.

50. What effect will the new design criteria for permit vehicles have on the cost of bridge structures?

The only permit vehicle to be considered is the FL120. This is equivalent to an HS20 truck with an inventory rating of 1.0 and an operating rating of 1.67. This is consistent with past practice and new bridge construction costs should remain essentially the same.

51. Does LRFR consider internal and external tendon different for box girder or equal? If equal, does the anchor block on the external have a $\beta = 3.5$?

Segmental bridges with internal or external tendons are treated equally in LRFD and LRFR. Theoretically, the anchor blocks for externally post-tensioned components should, in the Professor's opinion, be assigned a reliability index greater than the rest of the system (much as a bolted field splice in a steel plate girder). Neither the calibrations of the LRFD nor LRFR dealt specifically with segmental bridges.

52. When rating an existing beam if the existing beam has enough flexural capacity and rating is over 1.0 but doesn't satisfy minimum steel requirement how does it affect our rating results?

According to LRFR Article 6.5.7, the flexural resistance used in the rating calculations shall be reduced by a factor which is a function of the cracking moment and the factored flexural demand.

53. Could the impact factor be lowered to 25% for permit/legal loads?

An impact factor of 33% is applied to the vehicles only, not the lane loads. Use of a lower impact factor is permitted only as a posting-avoidance method after a variance is approved. Lower impact can be assigned with permit vehicles when escorts, speed control and exclusive use are specified.

Could the distributed live load be moved to the numerator portion of the equation for permit and legal load rating? For example:

$$RF = \frac{\text{CAPACITY - DL EFFECTS – DIST. LIVELOAD}}{\text{LL + I OF PERMIT OR LEGAL VEHICLE}}$$

This makes computer analysis of permit loads easier for the big ones. Since permit/legal load rating calculated with HL93 load in other lanes.

LRFR treats the lane load is a portion of the rated live load and has been included in the denominator.

How should special permits be handled when actual load is wide enough to take up 2 or more lanes! (Currently we simply divide by the number of lanes occupied and compare to HS operating rating)

AASHTO and FDOT LRFR are silent on vehicles with a gage significantly different than 6 feet. AASHTO LRFD Article 4.6.2.2.1 states "distribution factors, specified herein, may be used for permit and rating vehicles whose overall width is comparable to the width of the design truck." It is silent on wider vehicles. It is suggested to use refined analysis in these circumstances.

54. Will the FDOT bridge database need to be formatted for FDOT LRFR? (Where legal loads may not be evaluated if permit load rating passes) Is there a span length that will require a train of FL legal load trucks or will the rating always be for single trucks?

When performing potential load posting analysis use a single legal truck in each lane for spans up to 200 feet. For spans over 200 feet use the load model show in Appendix B.6.2. of the LRFR manual.

55. In the AASHTO LRFR text, are the worked out examples sufficiently relevant to FDOT goals?

While the examples in the Appendix A of AASHTO LRFR generally illustrate the LRFR load rating process, sufficient revisions have been made in simplifying the application of LRFR to Florida's bridges that the usefulness of the AASHTO LRFR examples is questionable. In the case of segmental bridges, the FDOT revisions have added complexity to the rating process reflecting the complex nature of these bridges.

56. For FDOT rating of new bridges: If rating of HL93 is greater than 1.0, what other trucks do we need to rate for? Do we still need T160 and HS32 at strength?

The first step in the FDOT rating process is to perform an HL-93 design load rating at inventory and operating levels and an FL120 permit-load rating. These three ratings are always required. If the HL-93 design-load operating rating is equal to or greater than 1.0, no additional rating is required for FDOT bridges.

57. What effort is being made through AASHTO to calibrate service limit state?

AASHTO funded Modjeski Masters and John Kulicki, with Dr. Mertz as a sub to prepare a roadmap which will address calibrating service limit state. Florida is on the forefront of addressing service limit state especially in regards to transverse direction of segmental bridges.

58. It appears the load rating of bridges is concentrated on superstructures, how about substructures?

According to AASHTO LRFR (see LRFR Article 6.1.8.2), "substructures need not be routinely checked for load capacity." Substructure components such as straddle bents or columns should be checked where their capacity may govern the load capacity of the entire bridge.

59. Permit capacity is determined by using the permit vehicle in the governing lane combined with HS-20 loading in adjoining lanes. Need to know LRFR Article No. for this provision or interpretation. This analysis is for widening H-OV (I-95). In this case how you decide governing lane?

Permit loads are assumed to be in all lanes when considering multiple loaded lanes (see FDOT LRFR Article 6.4.5.1).

60. If there is no future wearing surface on the bridge when the rating is being done, should it ever be included?

The bridge should be rated in its current condition without the wearing surface.

61. In assessing strength capacity, how would you differentiate tensile stress cracks to cracks caused by differential movements?

LRFR does not specifically address differential movements. However, cracks caused by settlement can be identified by the pattern of the crack and by survey data.

62. If we use a simplified method (shear, DF, or analysis) and higher φ factor will we be negating the main benefit of LRFD, i.e. uniform safety? Won't we get a larger scatter?

AASHTO and FDOT LRFR were developed to be consistent with the reliability principles of the LRFD Specifications. More scatter may result, but the resultant scatter will still be much less than that associated with load factor or allowable stress design.

63. The LRFD limit states are calibrated based upon past practices. Regarding the use of high strength concrete these years, how can recalibration be conducted? How often?

The strength limit states of the LRFD Specifications can be re-calibrated by re-doing the original calibration over with newer statistical data on uncertainty and in this case higher-strength concretes. When the issue is merely newer statistical data suggesting less uncertainty due to quality etc., the existing bridge set can be used. When issues such as higher-strength concrete are considered, the bridge set must be augmented with bridges designed with the higher-strength concretes.

64. For an existing bridge designed by ASD or LFD, that is to be widened, how will existing beams that do not pass an LRFR analysis be treated? Will the bridge rating be reported to FHWA with LFD or LRFR rating results?

Chapter 7 of the Structure Design Guidelines entitled "Widening and Rehabilitation," addresses issues regarding LRFR applied to widening and rehabilitation. It states "Before a variance or exception is approved for a bridge widening, use LRFR Appendix D.6.1 to determine LFD inventory rating factor. If any rating for design and legal vehicles is below 1.0, replacement is preferred, and a Variance or Exception is required for rehabilitation."

65. What is your opinion concerning the use of reasonable service limit state for rating of prestressed concrete bridges for permit capacity?

In rating a bridge for issuing permits, the task is to determine the load that will not cause permanent damage to the bridge. The service limit states must be considered to manage the risk due to cracking concrete and yielding of steel.

66. Since service limit states have not been calibrated, when they are calibrated will this result in changes to methods and thus need to reanalyze already LRFR load rated structures?

If and when the service limit states of the LRFD Specifications are calibrated based upon reliability theory (at least 5-10 years in the future), everything will change. It is Professor Mertz's opinion that the calibration of the service limit states will liberalize design and rating. Thus, existing bridges should eventually rate higher for service after calibration.

67. Why to we have a rating specification? Years past, the rating specification provided missing information. Wouldn't it be better to be including this information in the design specification than create a separate document? Do it right one time, instead of twice.

Aspects of AASHTO LRFR and the FDOT rating process that impact design (such as system factors) are being moved into the LRFD Specifications through the AASHTO interim change process. Other aspects such as differentiating between inventory and operating levels; and design-load, legal-load and permit-load ratings are unique to rating and thus a separate rating specification is required.

What are the results when you design using a line girder model and load rate using a grillage model? Do the results always get better, worse, or can they go either way?

According to AASHTO LRFR and the FDOT rating process (see LRFR Article 6.3.2), if an AASHTO LRFD load-distribution factor is available for the bridge type being rated (see LRFD Table 4.6.2.2.1-1), it must be used. Refined analysis is only acceptable for routine rating of bridges where an AASHTO LRFD load-distribution factor is not available. Refined analysis can be used as a posting-avoidance procedure. Theoretically, the results of a refined analysis could result in a greater or lesser rating. For the most part, an improved rating would be anticipated. How much improvement in general is difficult to predict.

68. For sufficient ratings the HS20 Inv rating is used to compare capacity between bridges (when the load capacity score is <55). How can this be done when old bridges use HS20 and new bridges use HL93?

The first step in the FDOT rating process is to perform an HL-93 design load rating at inventory and operating levels and an FL120 permit-load rating. These three ratings are always required. For the FDOT rating process, the FL120 permit load provides a benchmark to the past. The FL120 is the traditional HS20 truck with the axle loads increased by 1.67 to simulate the traditional HS20 operating rating level. The FHWA is currently accepting LFR HS20 or LRFR HL-93 inventory load ratings in the NBI. They are currently developing means to compare LFR HS20 and LRFR HL-93.

69. S10 Is it correct to use reduced multiple presence factors when determining tension in service limit state calculations?

Multiple presence factors are to be applied only when analysis procedures that require the engineer to "place lanes on the bridge" are employed. Multiple presence factors should not be used in conjunction with distribution factors. They should thusly be applied where appropriate for service limit state tensile-stress checks.

70. FDOT has Mathcad programs that design pretensioned concrete beams. Are there any plans to create programs in Mathcad that work with the existing programs that will load rate these girders?

LRFR ratings are now commercially available through LEAP and SMART BRIDGE. The FDOT Structures Design Office plans to modify the current MATHCAD program used to analyze prestressed concrete girders to include a rating option by January 1, 2007.

71. S10 What is the basis of the multiple presence factors in the LRFD specification and are they more restrictive than required?

The LRFD multiple presence factors are based upon probability. The baseline load case is two lanes loaded. The magnitude of the HL-93 live-load model is based upon this case. Then, one truck "weighing" 120% of the HL-93 model, three trucks side-by-side "weighing" 85% of the HL-93 model and four or more trucks side-by-side "weighing" 65% of the HL-93 model, all have the same probability of occurrence as two HL-93 models side-by-side. Thusly, the multiple presence factors were developed.

72. If the Inventory RF is less than 1.0 as shown on the example, was the beam designed properly? Inventory RF in the past was a check of the original design.

A bridge properly designed using AASHTO LRFD and the FDOT Structures Design Guidelines will yield an inventory rating of 1.0 or greater. For bridges designed to lesser standards the inventory rating may be less than 1.0.

73. Aren't the permit loads and legal loads philosophically inconsistent with the HL-93 load in that there is no provision for multiple vehicles in the same lane? For example what impact factor should be used for legal loads? 1.25 or 1.33?

    Neither AASHTO nor FDOT LRFR applies multiple vehicles in the same lane. For longer spans (span greater than 200 feet), a 200 plf lane load is superimposed on the vehicle much as the HL-93 live-load model.

    An impact factor of 33% is applied to the vehicles only, not the lane loads. Use of a lower impact factor is permitted only as a posting-avoidance method after a variance is approved.

74. Given the wide array of load rating variables (barrier distribution, build-up over beams, etc.) and the current absence of Central Office guidance on these variables, how is the consultant to respond to FDOT reviewers who want you to redo load ratings assessing the variables differently that the way you did it?

    One of the primary goals of the new Volume 8 of the Structures Manual is to standardize the load rating process. The manual clearly separates the standard load rating process from posting avoidance measures.

75. Re: Page 10, "Diagnostic Cont'd. Does the LLDF of 0.49 for the test suggest a question about conservation of LRFR where LLDF = 0.45?

    Answer: There is always some uncertainty in anything. This just shows that for this particular bridge the LRFD 0.45 versus the 0 .49 of the test is pretty good. You can't change the national code because of one test on one bridge. Day 1 – 10:00 – 12:00 (1:30:15)

76. In the study (NCHRP 20-07) what were the bridges originally designed for? LRFD or LFD? What can be expected when LRFR is used to rate bridges designed by LFD?

    In putting the database together for the NCHRP, we tried to get bridges with different design methodologies and loads, and we had trouble getting them to run in the beta version of BRASS Girder LRFD, so in the end we didn't get a good distribution of things like that, but typically they were not designed using LRFD and your Florida bridges were more likely designed using LRFD.

77. If bridges can be tested will all components participating in the resistance, why do we not perform FEM models to take advantage of this extra strength?

    I have fought tooth and nail against the idea of using barrier walls to improve distributions, because the barrier wall is designed to take a yield line into the barrier and it is not supposed to start or include the slab as the primary support element. If you start counting on a bridge that has the barrier wall enhancing its characteristics and you take a hit in that barrier with a fully loaded truck what is the probability of exceedance or potential for something else happening whether that bridge comes down partially or all the way, I am not interested in going there. The code definition of barrier walls and the yield line theory in the code in my opinion preclude that from happening

78. Are there any ideas at work to deal with small number "effect" in tensile service checks (Service III)?

    Basis for Question: Small discrepancies lead to potentially large differences in rating factors.

    No.

79. We're worried about frequency of permit vehicles to check for serviceability. Should they be design vehicles if the frequency is that high? Is HL-93 enough?

The force effects associated with the HL-93 notional live-load model are extreme effects and envelope grandfather exemption loads. In addition, in Florida, the FL120 permit vehicle is used at the strength II load combination for design also.

80. For sufficient ratings the HS20 Inv rating is used to compare capacity between bridges (when the load capacity score is <55). How can this be done when old bridges use HS20 and new bridges use HL93?

Tom is going to close out in a little while, but I think he addressed the purposes of those scores generally from a national level are from an appropriations standpoint. From a posting and routing, which has been our focus, we utilize the ratings and rating factors for operating for posting of the Florida bridge system so while we presented the scoring process and what bridge inspectors do element by element there are folks in the room that know this a lot better than I and do it every day it is a way of quantifying and reporting the inventory of the nations bridges back to the NBI system. I don't want to get wrapped around scores, while we did use that in LRFR to pick and choose damage factors or reduction factors, knock downs if you want to call them that, to do global, Florida is kind of adopting lets measure, lets assess the damage in reality so those are indicators to us and those are tools but those won't really be used because we are going to use trucks, routing vehicles and specific analysis for that bridge in order for Mr. Ducher to route the trucks through the State of Florida like he has to do everyday.

81. Does it concern you that you have so many of these questions sheets? (It worries me).

We were actually afraid we wouldn't get any of these questions and we wouldn't have any and William has been adding these frequently asked questions whenever he rolls out something new and it works pretty well I think and I guess that you don't understand or you can't comprehend whether we have confidence when we're answering the questions or whether we're just sort of making it up as we are answering the questions and I think I can say for myself, that when you ask a question we most of the times look at it and we know what the answer is because Andre and I and Larry and Henry have been thinking about this stuff for too long, frankly, so we are not concerned, I don't think about the number of questions were getting, we are just happy to see you are thinking about it as carefully as you are and are grasping the problems that we have in trying to implement the new LRFR Spec.

82. Is there any intent to begin load rating substructures?

According to AASHTO LRFR (see LRFR Article 6.1.8.2), "substructures need not be routinely checked for load capacity." Substructure components such as straddle bents or columns should be checked where their capacity may govern the load capacity of the entire bridge.

Will FDOT be requiring load ratings performed with different software than was used for design? (William alluded to such)

No, the Structures Design Office has no plans to dictate the use of any specific software for the purpose of load rating bridges.

83. If the 0.8 factor was developed so old designs would meet LRFR criteria, why are inventory ratings still less than 1.0? How much less than 1.0 can the inventory rating be?

The live load factor of the LRFD service III load combination was roughly "calibrated" to allow HS20 designs to "work" for HL-93 live load. Many factors enter into such a rough "calibration" including load distribution, losses, section-analysis methods and live load plus impact. Until a rigorous calibration of the service limit states is made, design-load service-based inventory level will vary about a value of 1.0. The degree of variation has not been quantified.

84. On AASHTO girder bridge hit load ratings, in some cases strands are completely exposed (no concrete surrounds the strand), do you ignore their capacity or do you include them in the rating?

AASHTO and FDOT LRFR are silent on the specific analysis of such damage. FDOT LRFR Article C6.4.2.3 states that consideration of such damage is preferable to the application of global condition factors. The rater must use engineering judgment based upon the extent of damage to determine how to proceed.

85. Clarify reference to Chapter 7 for fatigue of LRFR or LRFD. Which?

Chapter 7 of AASHTO LRFR entitled "Fatigue Evaluation of Steel Bridges" provides guidance on the fatigue evaluation of existing steel bridges.

86. In regards to the barrier distribution discussion on Wednesday, please address the situation where a bridge contains an 8' sound barrier wall on one side only.

Article 2.8 of the Structures Design Guidelines entitled "Barrier/Railing Distribution for Beam-Slab Bridges" addresses the situation of a barrier on one side of a span only.

87. Does LRFD apply to steel curve girder design?

With the release of the 2005 interim changes to the LRFD Specifications, horizontally curved steel I and tub girders are an integral part of Section 6.

88. With varying assumption, the design and the load rating will vary greatly, as witnessed yesterday. Until the FDOT declares how to handle every little item this will be the case. This thwarts the entire effort of those who wrote LRFD and LRFR. All reliability is lost. Please comment.

There are many acceptable options in the design and rating processes. This is true of allowable stress design, load factor design and load and resistance factor design. Unless the design code becomes overbearingly prescriptive these options will remain. Nonetheless, the calibration of the LRFD and the LRFR specifications provides more uniformity than in the past. Reliability indices despite the various design/rating options cluster more closely than in the past, providing more uniform reliability.