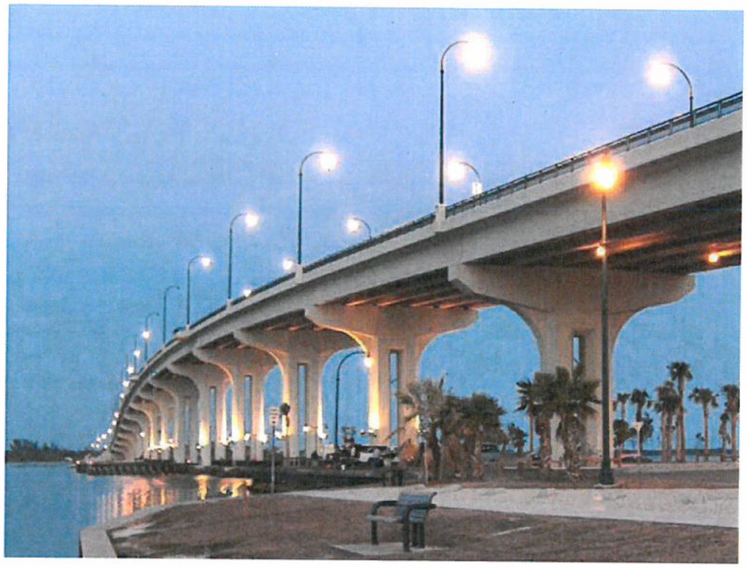
FLORIDA DEPARTMENT OF TRANSPORTATION



STRUCTURES DESIGN GUIDELINES

FDOT STRUCTURES MANUAL
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Structures Design
Florida's Transportation Engineers

B. Operational Importance [1.3.5]

Delete the operational importance factors, η_I, in ***LRFD*** [1.3.5] and use $\eta_I = \mathbf{1.0}$ unless otherwise approved by the Department. For bridges considered critical to the survival of major communities, or to the security and defense of the United States, use $\eta_I = \mathbf{1.05}$.

Modification for Non-Conventional Projects:
Delete ***SDG*** 2.10.B and see the RFP for requirements.

2.11 VESSEL COLLISION [3.14]

2.11.1 General [3.14.1]

The design of all bridges over navigable waters must include consideration for possible Vessel Collision (usually from barges or ocean going ships). Conduct a vessel risk analysis to determine the most economical method for protecting the bridge. The marine vessel traffic characteristics are available for bridges located across inland waterways and rivers carrying predominately barges. The number of vessel passages and the vessel sizes are embedded as an integral part of the Department's Vessel Collision Risk Analysis Software. The vessel traffic provided is based on the year 2000 and an automatic traffic escalation factor is provided by the software for the various past points which one selects. It is recommended that the engineer compare the total vessel trip count being used in the risk analysis with the latest total vessel trip count provided for the appropriate section of waterway as published by the Army Corps. The escalation factor provided by the software can be modified by the engineer. The importance classification is provided for existing bridge sites and will be provided by the Department for any new bridge location. Port facilities and small terminals handling ships are not covered by the catalog of vessel traffic characteristics. In these cases, on-site investigation is required to establish the vessel traffic characteristics. Utilize the ***LRFD*** specification and comply with the procedure described hereinafter.

Modification for Non-Conventional Projects:
Add the following at the end of ***SDG*** 2.11.1: See the RFP for the importance classification.

2.11.2 Research and Information Assembly (Rev. 01/14)

(When not provided by the Department)

A. Data Sources:

1. U.S. Army Corps of Engineers, Waterborne Commerce Statistics Center, P.O. Box 61280, New Orleans, LA 70161. Telephone: (504) 862-1472.
2. U.S. Army Corps of Engineers, Navigation Data Center (http://www.navigationdatacenter.us/publications.htm)
3. U.S. Army Corps of Engineers, "Waterborne Commerce of the United States (WCUS), Parts 1 & 2," Water Resources Support Center (WRSC), Fort Belvoir, VA.
4. U.S. Army Corps of Engineers, "Waterborne Transportation Lines of the United States," WRSC, Fort Belvoir, VA.
5. U.S. Army Corps of Engineers (COE), District Offices.
6. U.S. Coast Guard, Marine Safety Office (MSO).
7. Port Authorities and Water Dependent Industries.
8. Pilot Associations and Merchant Marine Organizations.
9. National Oceanic and Atmospheric Administration (NOAA), "Tidal Current Tables; Tidal Current Charts and Nautical Charts," National Ocean Service, Rockville, Maryland.
10. Bridge tender record for bascule bridge at the District Maintenance Office.
11. Local tug and barge companies.

B. Assembly of Information:

The EOR must assemble the following information:

1. Characteristics of the waterway including:
   a. Nautical chart of the waterway.
   b. Type and geometry of bridge.
   c. Preliminary plan and elevation drawings depicting the number, size and location of the proposed piers, navigation channel, width, depth and geometry.
   d. Average current velocity across the waterway.
2. Characteristics of the vessels and traffic including:
   a. Ship, tug and barge sizes (length, width and height)
   b. Number of passages for ships, tugs and barges per year (last five years and prediction to end of 25 years in the future).
   c. Vessel displacements.
   d. Cargo displacements (deadweight tonnage).
   e. Draft (depth below the waterline) of ships, tugs and barges.
   f. The overall length and speed of tow.
3. Accident reports.
4. Bridge Importance Classification.

2.11.3 Design Vessel [3.14.4][3.14.5.3]

When utilizing the FDOT's Mathcad software for conducting the Vessel Collision risk analysis, a "Design Vessel," which represents all the vessels, is not required. The software computes the risk of collision for several vessel groups with every pier. When calculating the geometric probability, the overall length of each vessel group (LOA) is used instead of the LOA of a single "Design Vessel."

2.11.4 Design Methodology - Damage Permitted [3.14.13]

In addition to utilizing the general design recommendations presented in ***LRFD*** (except as noted herein), the EOR must also use the following design methodology:

A. At least one iteration of secondary effects in columns must be included; i.e., axial load times the initial lateral deflection.

B. The analysis must include the effects of force transfer to the superstructure. Bearings, including neoprene pads, transfer lateral forces to the superstructure. Analysis of force transfer through the mechanisms at the superstructure/ substructure interface must be evaluated by use of generally accepted theory and practice.

C. The nominal bearing resistance (R_n) of axially loaded piles must be limited to the maximum pile driving [RC] resistance values given in ***SDG*** Chapter 3. Load redistribution is not permitted when the maximum pile driving [RC] resistance is reached.

Modification for Non-Conventional Projects:
Delete ***SDG*** 2.11.4.C and substitute the following: C. Load redistribution is not permitted when the maximum pile driving [RC] resistance is reached.

D. Lateral soil-pile response must be determined by concepts utilizing a coefficient of sub-grade modulus provided or approved by the Geotechnical Engineer. Group effects must be considered.

E. For the designer's Vessel Collision risk analysis, the FDOT will determine whether a bridge is critical or non-critical. A list is provided with the Department's software.

F. Use Load Combination "Extreme Event II" as follows:

$$(\text{PermanentLoads}) + \text{WA} + \text{FR} + \text{CV}$$

With all load factors equal to 1.0. Nonlinear structural effects must be included and can be significant. It is anticipated that the entire substructure (including piles) may have to be replaced and the superstructure repaired if a bridge is subjected to this design impact load; however, the superstructure must not collapse. For scour considerations, see ***SDG*** 2.11.8.

*Commentary: Further refinement or complication of this load combination (i.e. variable permanent load factors γ_p and a transient load factor of 0.5 as shown in **LRFD** [Table 3.4.1-1]) is unwarranted.*

G. Distribute the total risk per pier as uniformly as possible while allowing practical construction considerations. Ignore any benefit provided to the channel piers if a fender system is provided.

H. Pier strengths for the first two piers on each side of the channel shall be proportioned such that the Annual Frequency of Collapse per pier shall be less than the Acceptable Risk of Bridge Collapse divided by the total number of piers within a distance of 6 times LOA of the longest vessel group.

2.11.5 Widenings

Major widening of bridges spanning navigable waterways must be designed for Vessel Collision. Minor widenings of bridges spanning navigable waterways will be considered on an individual basis for Vessel Collision design requirements. (See ***SDG*** 7.2)

Modification for Non-Conventional Projects:
Delete second sentence of ***SDG*** 2.11.5 and see the RFP for requirements.

2.11.6 Movable Bridges

For movable bridges, comply with the requirements of this chapter.

2.11.7 Channel Span Unit (Rev. 01/14)

A. The length of the main span between centerlines of piers at the navigable channel must be based upon the Coast Guard requirements, the Vessel Collision risk analysis (in conjunction with a least-cost analysis), and aesthetic considerations.

B. When vessel traffic volume at high level fixed bridges is such that the risk analysis results in channel pier strength requirements in excess of 1,500 kips, provide a channel span unit consisting of one of the following:

   1. A minimum 3-span steel continuous unit in which the channel span is not an end span of the unit.

   2. A minimum 3-span continuous post-tensioned concrete unit in which the channel span is not an end span of the unit.

   3. Prestressed beams made continuous only for live load with a minimum 3-span continuous deck slab and a single monolithic full-width continuity diaphragm at each interior pier. The channel span shall not be an end span of the continuous unit.

Commentary: For channel span units subject to high vessel impact loads, structural redundancy is required from a risk standpoint to maximize survivability of the unit in the case of a vessel collision with one of the piers.

2.11.8 Scour with Vessel Collision [3.14.1]

A. Substructures must be designed for an extreme Vessel Collision load by a ship or barge simultaneous with scour. Design the substructure to withstand the following two Load/Scour (**LS**) combinations:

1. Load/Scour Combination 1:

   $\mathbf{LS_{(1)}}$ = Vessel Collision @ 1/2 Long-term Scour [Eq. 2-3]

   Where:

   Vessel Collision: Assumed to occur at normal operating speed.

   Long-Term Scour: Defined in Chapter 4 of the ***FDOT Drainage Manual.***

2. Load/Scour Combination 2:

   $\mathbf{LS_{(2)}}$ = Minimum Impact Vessel @ 1/2 100-Year Scour [Eq. 2-4]

   Where:

   Min. Impact Vessel as defined in ***LRFD*** [3.14.1] with related collision speed.

   100-Year Scour as defined in Chapter 4 of the ***FDOT Drainage Manual.***

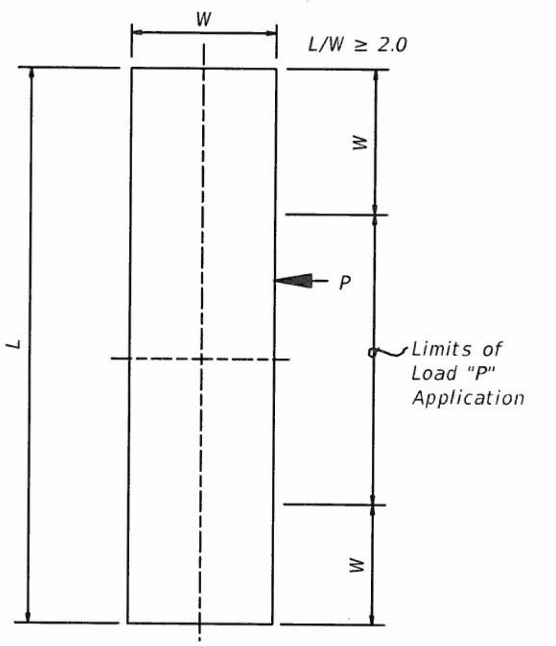
B. When preparing the soil models for computing the substructure strengths, and when otherwise modeling stiffness, analyze and assign soil strength parameters to the soil depth that is subject to Local and Contraction Scour that may have filled back in. The soil model must utilize strength characteristics over this depth that are compatible with the type soil that would be present after having been hydraulically redeposited.

Commentary: In many cases, there may be little difference between the soil strength of the natural streambed and that of the soil that is redeposited subsequent to a scour event.

2.11.9 Application of Impact Forces [3.14.14]

When the length to width ratio (**L/W**) is 2.0 or greater for long narrow footings in the waterway, apply the longitudinal force within the limits of the distance that is equal to the length minus twice the width, (**L-2W**), in accordance with Figure 2.11.9-1.

Figure 2.11.9-1 Application of Longitudinal Vessel Impact Force on Long Footings



2.11.10 Impact Forces on Superstructure [3.14.14.2]

Apply Vessel Impact Forces (superstructure) in accordance with ***LRFD*** [3.14.14.2].

2.12 SUBSTRUCTURE LIMIT STATES

2.12.1 Strength and Service (always required)

Use load combinations as specified in ***LRFD*** [Table 3.4.1-1] with the most severe case of scour, including the 100 year flood event.

2.12.2 Extreme Event (if required)

Use ***LRFD*** load combination Extreme Event II for collision by vessels, collision by vehicles, and check floods as modified below.

A. If vessel collision is considered, use load combination groups as specified in ***SDG*** 2.11.4, Paragraph F and utilizing scour depths as specified in ***SDG*** 2.11.8.

B. See ***SDG*** 2.6 if vehicular collision is considered.

C. If scour is predicted, check for stability during the superflood event using the following load combination (most severe case of scour including the 500-year flood).

$$\gamma_p(DC) + \gamma_p(DW) + \gamma_p(EH) + \gamma_p(EL) + \mathbf{0.5(L)} + \mathbf{1.0(WA)} + \mathbf{1.0(FR)} \qquad \text{[Eq. 2-5]}$$

Where, **L = LL + IM + CE + BR + PL + LS**

(All terms as per ***LRFD***)

2.13 CONSTRUCTION LOADS (Rev. 01/14)

2.13.1 Constructability Limit State Checks

In the absence of more accurate information, the following construction loads can be assumed for investigation of the strength and service limit states during construction in accordance with ***LRFD*** [3.4.2] and ***SDG*** 2.4.3, and for investigation of deck overhang bracket force effects in accordance with ***LRFD*** [6.10.3.4]. These loads are applicable to conventional beam or girder superstructures with cast-in-place decks. All construction loads assumed in the design of the structure shall be listed in the plans.

A. Finishing machine load: The finishing machine load shall be per the manufacturer's specifications and be applied as a moving load positioned to produce the maximum response. In the absence of manufacturer's specifications, assume the following loads:

W = Bridge Width (ft)	Total Weight of Finishing Machine (kips)
26 ≤ W ≤ 32	7
32 < W ≤ 56	11
56 < W ≤ 80	13
80 < W ≤ 120	16

B. Construction live load: 20 lb/sf extended over the entire bridge width and 50 feet in longitudinal length centered on the finishing machine.

C. Removable deck cantilever forms with overhang brackets: 15 lb/sf

D. Live load at or near the outside edge of deck during deck placement: 75 lb/ft applied as a moving load over a length of 20 feet and positioned to produce the maximum response.

Modification for Non-Conventional Projects:
Delete ***SDG*** 2.13.1 and insert the following: List in the plans all construction loads assumed in the design of the structure.