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SUBJECT: Temporary Design Bulletin C06-06
Roadway Design Bulletin 06-10
Policy for Pier Protection

REQUIREMENTS(6)

Add to PPM Volume 1, Section 1.5, RRR Design:

Pier Protection and Design Shall comply with the requirements provided in ***Structures Design Guidelines Section 2.6.***

Delete the current PPM Volume 1 Section 6.3.4 and substitute the following:

See the Structures Design Guidelines for crash wall requirements.

Delete PPM Volume 1, Section 25.1.2 Application, paragraph 1, second sentence and substitute the following sentence:

Interstate and freeway RRR projects are designed using new construction criteria except that the requirements of ***Section 25.4.25.3 Bridge Railing***, ***Section 25.4.26 Roadside Safety Hardware*** and ***Structures Design Guidelines Section 2.6*** will apply and the standards used for horizontal alignment, vertical alignment, widths of median, traveled way and shoulders may be the AASHTO interstate standards that were in effect at the time of original construction or inclusion into the interstate system.

Add new section to PPM Volume 1 Chapter 25, Section 25.4.25.6 Pier Protection and Design with the following text:

Pier Protection and Design Shall comply with the requirements provided in ***Structures Design Guidelines Section 2.6.***

Add the following paragraph before the last sentence of PPM Volume 1 Section 25.4.26.1 Longitudinal Barriers, Guardrails, Median Barriers:

The above applies to barriers used for shielding roadside hazards not involving pier protection. See ***Structures Design Guidelines Section 2.6*** for barrier requirements for pier protection.

Delete the current SDG Section 2.6 Vehicular Collision Force [3.6.5] and substitute the following:

2.6 Vehicular Collision Force and Pier Protection [3.6.5]
2.6.1 Pier Design and Protection
Design structures according to ***LRFD*** [3.6.5] with the following modifications:

As used in this section, "setback distance" is as defined by ***LRFD*** [3.6.5.2] and "clear zone" and "horizontal clearance" are as defined by ***PPM Vol. I***, Chapter 4. Consider planned widenings or future realignments of lower roadways when establishing limits of setback distances and clear zones or horizontal clearance limits.

Select a 42" or 54" tall Test Level 5 (TL-5) Pier Protection Barrier based on the location of the barrier relative to the pier it is shielding in accordance with the requirements of ***LRFD*** and ***Design Standards*** Index No. 411.

A. End Bents and Retaining Walls:

   End bents located behind conventional cantilever retaining walls or within mechanically stabilized earth retaining walls are considered to be sufficiently shielded with respect to the requirements of ***LRFD*** [3.6.5] and thus do not require additional protection from vehicular collision. Retaining walls generally do not require protection from vehicular collision.

   Roadside barriers may however still be required at these locations in accordance with the requirements of ***PPM Vol. I***, Chapter 4.

B. New Structures over or adjacent to roadways:

   Design all piers located within the setback distance for the ***LRFD*** equivalent static force regardless of the type pier protection used. Utilize the shear reinforcement required at the pier

base to a distance of eight feet above the adjacent ground surface.

Provide roadside barriers in accordance with ***PPM Vol. I***, Chapter 4 for piers located within the clear zone or horizontal clearance limit.

Do not use pile bents within the setback distance.

C. Roadway work beneath or adjacent to existing structures:

1.) For existing piers located within the setback distance that are theoretically capable of resisting the ***LRFD*** equivalent static force, provide roadside barriers in accordance with ***PPM Vol. I***, Chapter 4 or Chapter 25, as applicable, unless a need can be documented to provide ***Design Standards*** Index No. 411 Pier Protection Barriers or other TL-5 barriers. Consider local crash histories of both large and small vehicles, site conditions, shoulder widths, traffic counts, traffic mixes, design speed, sight distances, pedestrian facilities, utilities and redundancy within the pier when documenting the need to provide 42" or 54" Pier Protection Barriers.

2.) For existing piers and pile bents located within the setback distance that are not theoretically capable of resisting the ***LRFD*** equivalent static force and that are unshielded, shielded by guardrail or shielded by non-crash tested concrete barrier wall:

a.) When RRR criteria applies and on freeway resurfacing projects, determine the need for roadside barriers in accordance with ***PPM Vol. I***, Chapter 4 or Chapter 25, as applicable. New guardrail and existing guardrail conforming to the requirements of Index 400 may be used. Existing guardrail that does not conform to the requirements of Index 400 must be upgraded or replaced. If there is insufficient deflection space for guardrail and new concrete barrier wall is determined to be required, provide ***Design Standards*** Index No. 411 Pier Protection Barriers or other TL-5 barriers in lieu of ***Design Standards*** Index No. 410 Concrete Barrier walls. Where required sight distances cannot be maintained using ***Design Standards*** Index No. 411 Pier Protection Barriers or other TL-5 barriers, instead provide ***Design Standards*** Index No. 410 Concrete Barrier Walls to shield piers. An exception for pier strength is not required.

b.) When new construction criteria applies except on freeway resurfacing projects, provide ***Design Standards*** Index No. 411 Pier Protection Barriers or other TL-5 barriers.

3.) For existing piers and pile bents located within the setback distance that are not theoretically capable of resisting the ***LRFD*** equivalent static force and that are shielded by ***Design Standards*** Index No. 410 New Jersey Shape or F-Shape Concrete Barrier Wall, leave the existing barrier wall in place unless a need can be documented to either retrofit the pier as described below or replace the existing barrier wall with a ***Design Standards*** Index No. 411 Pier Protection Barrier or other TL-5 barrier. Consider local crash histories of both large and small vehicles, site conditions, shoulder widths, traffic counts, traffic mixes, design speed, sight distances, pedestrian facilities, utilities and redundancy within the pier or bent when documenting the need

to replace the existing barrier wall. An exception for pier strength is not required.

4.) In lieu of providing 42" or 54" Pier Protection Barriers, consider providing integral crash walls, struts, collars, etc. to retrofit or strengthen existing piers and pile bents to resist the ***LRFD*** equivalent static force. This approach may be appropriate where the use of 42" or 54" Pier Protection Barriers would adversely affect adjacent pedestrian facilities, utilities, sight distances on adjacent roadways, etc.

D. Widening of Existing Structures over or adjacent to roadways:

Design new columns of piers lengthened for bridge widenings that are located within the setback distance for the ***LRFD*** equivalent static force. Utilize the shear reinforcement required at the column base to a distance of eight feet above the adjacent ground surface. Maintain the scale and proportions of existing columns when designing the new columns.

Provide ***Design Standards*** Index No. 400, 410 or 411 barriers as described above for existing structures. Lengthen existing installations of ***Design Standards*** Index No. 410 Concrete Barrier Walls as required to shield the entire lengthened piers unless a need can be documented to replace the barriers with ***Design Standards*** Index No. 411 Pier Protection Barriers or other TL-5 barriers.

Pile bents may be lengthened within the clear zone.

E. Bridge superstructures adjacent to piers of other bridges:

Provide TL-5 bridge traffic railings on lower level bridges adjacent to pier columns of upper level bridges (e.g. bridges on multi-level interchanges) if the gutter line of the lower level bridge traffic railing is within 5 feet of the upper level bridge pier column. Do not design the upper level bridge pier column for the ***LRFD*** equivalent static force at this location. Evaluate existing installations on a case by case basis to determine the potential need to retrofit the existing lower bridge traffic railing.

F. New, Existing and Widened Structures over or adjacent to railroad and light rail tracks:

The following information is based on requirements of the current ***American Railway Engineering and Maintenance-of-Way Association (AREMA)*** Manual for Railway Engineering and is intended only as a guide to the minimum requirements for piers adjacent to railroad tracks and crash walls used to shield them. Follow the ***AREMA*** specifications and the specific railroad requirements in identifying the need for and the designing of crash walls.

Crash walls are required for piers located 25 feet or less from the centerline of the track, measured perpendicular to the track, unless the size of the pier satisfies the criteria for heavy construction. A pier or column shall be considered of heavy construction if it has a minimum cross-sectional area of 30 square feet. The minimum dimension shall be 2'-6", and the larger dimension of rectangular piers or columns shall be parallel to the track. Multiple column piers with individual columns meeting the requirements of heavy construction do not require crash walls.

Crash walls for piers located from 12 to 25 feet from the centerline of track shall have a minimum height of 6 feet above the top of rail. Piers less than 12 feet from the centerline of track shall have a minimum crash wall height of 12 feet above the top of rail.

The face of the crash wall shall present a smooth surface, extending a distance of at least 6 inches beyond the face of the column on the side of the wall adjacent to the track. The crash wall shall extend at least 4 feet below the lowest surrounding grade. The crash wall shall be anchored with dowels to each column and footing. The bottom of footings shall be at or below the bottom of the crash wall. If piles are used to support the crash wall, they shall typically be of the same type and size as the piles used to support the bridge and shall be driven to the minimum penetration required by the FDOT Specifications.

The crash wall shall be at least 2'-6" thick. When a pier consists of a single column, the crash wall shall be a minimum of 12 feet in length, parallel to the track, and centered longitudinally on the pier. When two or more light columns compose a pier, the crash wall shall connect the columns and extend at least 1 foot beyond the outermost columns, parallel to the track.

Lengthen existing crash walls shielding existing piers or bents that are lengthened to accommodate a bridge widening. The lengthened section of crash wall shall meet the requirements for new construction.

Construct new crash walls to shield existing piers or bents that are lengthened to accommodate a bridge widening if the piers or bents do not meet the criteria for heavy construction and do not have existing crash walls.

For piers located more than 25 feet from the centerline of track but still within the setback distance, provide project specific 42" or 54" tall pier protection barriers based on ***Design Standards*** Index No. 411 or design the piers for the ***LRFD*** equivalent static force if pier protection barriers are not used. Consideration may be given to providing protection for bridge piers located beyond the setback distance as conditions warrant. In making this determination, account shall be taken of such factors as horizontal and vertical alignment of the track, embankment height, and an assessment of the consequences of serious damage in the case of a collision.

These requirements generally do not apply to automated people mover systems. Evaluate the need for pier protection on a project specific basis for people mover systems.

2.6.2 Design and Analysis Methods

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

A. Consider the LRFD 400 kip impact force as a shear acting on the pier column (no distribution of force due to frame action within the pier, foundation and superstructure).

B. Check the column shear capacity by the use of generally accepted theory and practice. For the purposes of this analysis, assume the pier column is fixed at the base of the column / top of the foundation and top of the column / bottom of the cap.

C. The impacted structure is expected to remain stable and to continue to support the bridge superstructure subsequent to the collision event. Note that resistance factors are taken as 1.0, inelastic behavior is anticipated and proper detailing is required.

COMMENTARY

Design Standards Index No. 411 Pier Protection Barriers comply with the requirements of ***LRFD*** [3.6.5.1] for NCHRP Report 350 Test Level 5 barriers used for pier protection. The intended purpose of these barriers is to shield a pier from traffic, primarily large trucks and tractor trailers, so as to reduce the potentials for damage to the pier and collapse of the bridge that might be the results of a truck collision with a pier.

Consider overall safety at a given location, including vehicle and pedestrian traffic, when selecting the appropriate type of pier protection to be used. Consider the effect 42" and 54" tall barriers might have on sight distances, particularly near intersections, and the end treatments that will be required for these taller barriers.

Generally for new construction, reinforced concrete pier columns can be designed to resist the ***LRFD*** 400 kip equivalent static force. Therefore, only a ***Design Standards*** Index No. 400 guardrail or Index No. 410 Concrete Barrier Wall might be necessary to shield traffic from the pier.

The 32" tall Concrete Barrier Wall shown in ***Design Standards*** Index No. 410 has provided overall satisfactory performance in shielding bridge piers for many years. Therefore, replacement of existing installations of these walls is not warranted at most locations, in particular on low speed roadways, unless there is a crash history at the site that indicates otherwise.

Field observation of bridge piers that have been impacted and crash testing of other roadside hardware items indicate little opportunity for an impacted structure to distribute the dynamic impact force during the extremely brief duration of a crash event. The theoretical behavior of a modeled

pier when loaded with the equivalent static impact force will likely be substantially different than the behavior of an actual pier subjected to the dynamic impact force from a vehicle crash. Thus a more refined analysis of the force distribution within the pier, foundation and into the superstructure using the equivalent static force is not warranted.

As stated in the ***AREMA*** Manual for Railway Engineering, the crash wall provisions are not intended to create a structure that will resist the full impact of a direct collision by a loaded train at high speed. Rather, the intent is to reduce the damage caused by shifted loads or derailed equipment that might impact a pier.

BACKGROUND

Traffic counts, traffic mixes, design speed and site geometry combine to influence the probability of a vehicle collision with a bridge pier and the magnitude of the consequences of such a collision. Even though a single column of a multiple column pier may have sustained severe collision damage, the probability of collapse of the bridge is still relatively small due to redundancy and frame action within the pier and beam action within end diaphragms. Current ***LRFD*** requirements do not account for these factors. In addition, the magnitude of the 400 kip equivalent static force was established from data available at the time the current ***LRFD*** requirements were prepared. Additional data and information are now available and more are needed to address whether the magnitude of the 400 kip equivalent static force should be changed. More information for heavily loaded articulated vehicles is also still needed. Planned research will use a probabilistic risk analysis for determining the requirements for designing piers and abutments for vehicle collisions. The current ***LRFD*** requirements and the requirements of this section will likely be modified in the future using the results of this planned research.

IMPLEMENTATION

These requirements are effective immediately on all projects that have not yet begun design, and are to be incorporated to the extent practical on all projects currently in design where it can be done so without impact to production schedules and budgets.

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