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<p>TITLE: BRIDGE RAILING TREATMENTS ON BRIDGE REHABILITATION PROJECTS</p>			
<p>Distribution:</p> <p><input type="checkbox"/> Manufacturers (18) <input type="checkbox"/> Surveyors (33)</p> <p><input checked="" type="checkbox"/> Main Office (30) <input checked="" type="checkbox"/> Consultants (34)</p> <p><input checked="" type="checkbox"/> Local Govt. (31) <input type="checkbox"/> Contractors (39)</p> <p><input checked="" type="checkbox"/> Regions/Agencies(32) <input type="checkbox"/> _____ ()</p>	<p>Approved:</p> <p> J. M. O'CONNELL Deputy Chief Engineer (Structures)</p> <p style="text-align: right;">12/30/99 Date</p>		

EFFECTIVE DATE:

The guidance in the attached document should be considered for all projects currently under design. The documentation requirements should be followed for all projects submitted for letting after April 1, 2000.

PURPOSE:

The purpose of this Engineering Instruction is to distribute the attached guidelines.

BACKGROUND:

The background on this subject can be found in the attached guidelines.

SUPERSEDED ISSUANCES:

This EI supersedes EI 79 - 041 "Criteria for Treatment of Safety Walks and Bridge Railing When Work is Done on a Bridge"

ACTION:

Structures Division, Standards & Policies Unit - The attached shall be incorporated in the next revision of the Bridge Manual.

CONTACT PERSON:

Questions regarding this EI and the attached guidance should be directed to the Standards & Policies Unit at 485-1148.

Guidelines for Bridge Railing Treatments on Bridge Rehabilitation Projects

I. Background

Currently, a majority of the bridge railings on NYSDOT structures have not been crash tested in accordance with NCHRP 350 criteria. As of October 1, 1998, these existing railings were considered non-conforming features and FHWA requires that they be considered when progressing a rehabilitation project on the structure. No current and clear direction exists to guide the decision of whether to retain, retrofit or replace an existing bridge railing when progressing a rehabilitation project.

II. Purpose

These guidelines identify a course of action that will allow the designer to address, in a uniform and consistent manner, the variety of situations encountered in project development and design for all future rehabilitation projects. To do this, the guidelines will:

1. Identify the warrants to be considered in selecting a bridge railing treatment.
2. Categorize situations based on general work strategy.
3. Propose actions for the various categories.
4. Define project decision responsibilities and authorities.

III. Warrants

Numerous considerations factor into selecting the appropriate bridge railing treatment on a rehabilitation project. Evaluation of the following contributing factors should provide sufficient information to identify the criteria that define the logic on which the designer's decision is based:

- A. Existing Bridge Railing** - age, original design criteria, materials, anchorage, snagging characteristics, lack of vaulting causing dimensions, discontinuities, transitions, fascia characteristics, maintenance concerns and other contributing factors.
- B. Required Design Service Level** - Federal and State standards for Design Service Levels as shown in Appendix A.
- C. Roadway System** - NHS, non-NHS, functional class, speed limit, urban, rural, pedestrians, bicycles, etc.

- D. Roadway Characteristics** - horizontal and vertical geometry, visibility, AADT, DHV, percent trucks, width, sidewalk, curb, median/median barrier, feature crossed, structure length, approaches and any other contributing characteristics.
- E. Safety/Accident Evaluation** - number of accidents and their cause, indications of bridge rail hits. Also, the type and amount of damage to the bridge railing.
- F. Historic/Aesthetic Considerations** - community input, SHPO input, Regional discretion.
- G. Drainage** - ability of system to accommodate roadway drainage and snow storage.
- H. Safety Walks** - face of rail to face of curb dimension for vaulting considerations.
- I. Proposed Scope of Work vs. Cost to Improve Ratio** - consider impact of bridge railing upgrade to the scope of work (in terms of cost); cost of upgrade decision (including upgrade & additional work) vs. cost without railing upgrade.
- J. Desired Service Life of the Repair** - a "short term fix" may be appropriate in anticipation of future work strategies.
- K. Traffic** - in some cases maintenance and protection of traffic considerations may greatly influence the scope and type of bridge railing work that is feasible.
- L. Transitions** - current and past Standard Railing systems also have an approved transition to the highway guide railing. Approved transition details are shown on the Bridge Detail sheets which coincide with the appropriate bridge railing.

IV. Identified Work Strategies

The decision regarding bridge railing when considering a project must be consistent with the overall work strategy for the individual bridge. Public safety, timing and economics are important considerations when making this decision. These projects are ones that involve all the railing on a bridge or in the case of a viaduct, major portions of the bridge. Repair of accident damage or isolated deterioration are not covered by these guidelines. The following are guidelines to help the designer:

- A. Long Term Work Strategy** - The projects in this category are long term service life fixes that imply no major work for at least ten years. It is important to consider all work necessary to bring the bridge up to the current standards, especially, those related to public safety. For the bridge railing, the consequences of not addressing it would mean that it

would remain non-standard. This alternative would be considered unacceptable. Therefore, these guidelines recommend the replacement/upgrading of the existing bridge railing in these situations, unless retention of the bridge railing was justified as described in Section V, Article C.

These types of projects inherently impact the existing bridge railing and/or its anchorage and also have long term service life implications. Therefore, it is cost effective, prudent, and timely to proceed with bridge railing replacement/upgrades.

Certain work strategies with applicable defined scope of work will direct that the existing bridge railings be upgraded and/or replaced to current accepted standards. Regardless of the contributing factors as defined earlier in this document, specific types of projects shall always include bridge railing replacement/upgrades. These types of projects shall include, but are not limited to:

- Bridge Superstructure Widening (Consider widened portions only)
- Superstructure Replacement
- Complete Deck Replacement (Thru-girder, truss, P/S box beam and other unique bridges need special consideration)
- Bridge Railing Replacement Contracts
- Major Bridge Rehabilitations

B. Short Term Work Strategy - The projects in this category are intended to provide a short term or interim fix prior to possibly larger programmed work. These type of projects such as minor rehabilitation, and deck asphalt overlay contracts typically have an expected service life of less than 10 years. It is in developing these types of projects that the designer must pay close attention to the intended scope, the objective of the project, and the contributing factors as described earlier in this document. Sound, prudent, and cost effective engineering decisions based on both the short term and long term planning for these structures should prevail.

The types of projects that a designer would typically evaluate as to whether to include bridge railing replacement/upgrade are:

- Bridge Railing Repair
- Asphalt Overlay Projects
- Bridge Curb Replacement/Repair/Modifications
- Extensive Sidewalk and/or Concrete Work (involving railing anchorage)
- "Element Specific" Contracts

Actions such as repair of railing collision damage and localized maintenance repair of curbs, sidewalks and snow fencing do not require an evaluation of bridge railing replacement/upgrade.

In a more general sense, if the anchorage system is exposed or will be exposed by the intended work, strong consideration should be given to replacing/upgrading the bridge railing.

- C. Monolithic Deck Work** - This work is a long term work strategy because it substantially extends the structure's service life and requires a considerable level of effort. Therefore, when progressing a monolithic deck project, the bridge railing shall be replaced with the standard bridge railing with the exception that the existing bridge railing may be proposed for retention, if it has been crash tested to NCHRP 230, and the curb is within 225 mm of the face of rail. If the existing bridge railing is an acceptable NCHRP 230 railing and the curb is not within 225 mm of the face of rail, then the scope of work shall include the safety walk removal. Safety walk removal can be completed by removing and replacing the existing curb such that the curb's face is within 225 mm of the face of rail. Also, the safety walk can be effectively addressed by blocking out the rails such that the curb's face is within 225 mm of the face of rail. If the existing bridge railing is not an acceptable NCHRP 230 railing, the railing must be replaced or upgraded. If the deck does not have the capacity to satisfy the loadings associated with the standard bridge railing, then the deck should be modified, as necessary, to accept the standard railing and associated loadings. See Appendix B, "1987 Bridge Railing Crash Test Report", for a discussion of the crash tests performed on former NYSDOT bridge railing.

Special consideration is needed when applying the above guidelines to viaducts. Viaducts are more complex structures which may involve many bridges and connecting ramps presenting unique problems. Due to their nature, there exists no reasonable, logical termini for bridge railing and/or safety walks. As a result, the designer may be faced with chasing the bridge railing modification, upgrade or replacement for exceptionally long distances impacting other bridge structures and/or spans which may not be receiving any other improvements. This can ultimately alter the scope of the capital project which was originally conceived for the purposes of replacing the wearing surface of the concrete deck (monodeck rehabilitation work only). The cost implications of such an action could preclude the Region from pursuing monolithic deck work and opting for a more interim fix.

These guidelines allow flexibility when dealing with viaducts and large interchanges. Each situation requires close examination and an evaluation of a number of different factors:

- The accident history problem and if so, what is it attributed to. Are the safety walks and bridge railing contributing elements or involved with the problem?
- Relative to project cost and the Region's budget, the impact of addressing the bridge railing and safety walks.
- Uniqueness of this capital project for the viaduct or is it one of many future projects on the viaducts? In other words, if the Region is planning to systematically progress

a series of contracts to address the entire viaduct then conditions may be such that it is prudent to include the additional work now.

- Aesthetics have to be considered. Most viaducts are located in highly populated, urban areas; "Entrances to cities". The visual impact of segmenting work could be negative for a prolonged period. The Region may be better served addressing all the bridge railing at once and all the safety walk issues under a separate contract. This notably must be weighed against impacts to safety, traffic, cost, remobilization efforts, etc.

Viaducts require close examination and have to be considered as a separate entity on a case by case basis. The designer should document all information that supports the final decision.

V. Actions to be Taken

Generally, all actions should be based on the warrants, the work strategy and design service level for the bridge. The warrants and the work strategy are discussed in Sections III & IV and the required design service level for a bridge is determined according to Appendix A. The following actions are applicable to all roadway systems, unless otherwise noted:

- A. Replacing the Bridge Railing/Barrier** - The standard systems for replacement bridge railing and barriers shall be as defined in Section 6 of the *Bridge Manual* and as detailed in the current Bridge Detail sheets. Acceptance of these systems is based on a crash tested system in accordance with NCHRP 350.
- B. Upgrading the Bridge Railing/Barrier** - The upgraded bridge railing/barrier must meet the requirements of the bridge's design service level to qualify as an acceptable system. A railing/barrier can be upgraded to a TL-2 (PL-1) or TL-4 (PL-2) service level. Due to the strength requirements, it is not possible to upgrade to a TL-5 (PL-3) service level and, therefore, the railing/barrier will need to be replaced for that level.

In addition, the retrofitted railing/barrier must qualify by providing similar snagging and vaulting characteristics of a crash tested system. An acceptable system demonstrates this equivalence through similarity of rail, post and curb locations to crash tested systems. This also includes cutting any safety walk back to preferably 150 mm, but not more than 225 mm, from the face of railing. The required strength of the posts and anchorage can be satisfied by calculation in accordance with the assumed loads specified in AASHTO "*LRFD Bridge Design Specifications*", Section 13.

Typical details for upgrading steel railing to TL-2 or TL-4 levels are shown on the Bridge Detail sheets. TL-2 upgrading consists of a single 150 mm x 150 mm box beam rail. TL-4 upgrading consists of double 150 mm x 150 mm box beam rails.

- C. Retaining the Bridge Railing** - Generally, the decision to retain bridge railing should be based on the warrants, the work strategy and the bridge railings ability to meet the requirements of the roadway as described in Appendix A. When considering long term service life of a bridge, there are a few cases where retaining the non-standard bridge railing is desirable. These cases must be justified and well documented similar to the procedure described in the Highway Design Manual, Article 2.8.

When it is determined by the designer that bridge railing replacement/upgrade is not warranted, then documentation supporting the decision shall include the existing bridge rail condition (including anchorage), evaluation of contributing factors, the intended scope and objective of the project. This documentation should be provided to the project file, Region Design Engineer, Region Structures Engineer and Region Bridge Maintenance Engineer for the purpose of determining future work needs and programs.

However, when considering short term work strategies where bridge railing is not in the scope of the work, justification to retain the bridge railing would generally not be required.

The following guidelines are for the retention of existing bridge railing:

1. Project Specific Reasons

The following projects will typically not include bridge railing replacement/upgrades and would not require written documentation/justification for retaining non-standard bridge railing:

- Bridge Painting/Cleaning/Sealing
- Joint Repair/Replacement
- Bearing Repair/Replacement
- Striping
- Steel Repair
- Scour Work
- Sign Projects
- Navigational Light Repair/Installation
- Preventive Maintenance Work
- Corrective Maintenance
- Snow Fence Installation

However, if the designer notices potential problems with the bridge railing, the anchorage system, or other associated bridge rail hardware, it shall be communicated to the RSE and the RBME for their action.

The former two-rail and four-rail steel bridge railings detailed on various Bridge Detail sheets issued since 1977 are acceptable and adequate for a TL-2 service level without

upgrading. See Appendix B, "1987 Bridge Railing Crash Test Report", for further discussion. However, any transition to highway guide railing containing the "tuning fork" detail is not adequate for a TL-2 service level.

In addition, *for non-NHS roadways only*, compliance to the TL-2 Service Level can be analytically determined by verifying the bridge railing as structurally adequate using the assumed loads given in AASHTO "LRFD Bridge Design Specifications", Section 13. Some variance in rail, post and curb positions from crash tested systems are permissible if there are no obvious safety hazards and approved by the D.C.E.S.

2. Historic Preservation or Other Project Specific Reasons

For those projects which deal with historic or aesthetic considerations, the decision regarding bridge railing can be much more difficult. The deficiencies of the proposed non-standard bridge railing, relative to its conformance with the required performance level, shall be clearly documented and shall be presented to the approving authority noted in Section VI. This information shall be accompanied by the cost differential between the two bridge railings and the logic supporting the decision to employ the non-standard bridge railing.

VI. Responsibilities and Authorities

Approval authority will be in accordance with the Design Related Approval Matrix in the NYSDOT Design Procedure Manual, Appendix F.

APPENDIX A

RAILING DESIGN SERVICE LEVELS

Design service levels for bridge railing is defined in NCHRP 350 and the AASHTO LRFD specifications. The following are general descriptions of the design service levels. Additional service levels are defined in NCHRP 350 and AASHTO LRFD, but are not currently used in New York State for bridge railing purposes.

- TL-2 (PL-1)** Taken to be generally acceptable for most local and collector roads with favorable site conditions, work zones and where a small number of heavy vehicles is expected and posted speeds are reduced.
- TL-4 (PL-2)** Taken to be generally acceptable for the majority of applications on high speed highways, freeways, expressways and interstate highways with a mixture of trucks and heavy vehicles.
- TL-5 (PL-3)** Taken to be generally acceptable for applications on high speed, high traffic volume and higher ratio of heavy vehicles for expressways and interstate highways with unfavorable site conditions.

An older system of bridge railing design service levels was given in the 1989 AASHTO "*Guide Specification for Bridge Railing*". This system used service levels from PL-1 through PL-3. PL-1 is generally equivalent to TL-2, PL-2 is generally equivalent to TL-4 and PL-3 is generally equivalent to TL-5. The guide specification also contains detailed warrants for selecting the appropriate service level.

On bridge rehabilitation projects, designers shall select the railing design service level by considering the general descriptions given above and the warrants contained in the 1989 AASHTO Guide Specification.

Appendix B

1987 BRIDGE RAILING CRASH TEST REPORT

May 25, 1999

By Harry L. White 2nd, P.E.

PURPOSE

This report is intended to document the results of the 1987 crash tests of the NYSDOT two-rail steel bridge railing. The testing done by Southwest Research Institute is documented in NCHRP Report 289. The crash testing done by the NYSDOT was never documented in a final report. The following information is intended to document the facts behind the NYSDOT bridge railing rehabilitation guidelines.

BACKGROUND

In 1987, NYSDOT conducted voluntary crash tests of the two-rail curbless steel bridge railing and steel railing transitions. Both systems were in wide use at that time. The crash testing procedures used were established in a FHWA document titled NCHRP Report 230, which provides several crash test levels using specific vehicle types, speeds and entrance angles for each scenario. These crash tests do not directly correspond to any performance level or testing level currently used.

A review of the NYSDOT standard sheets revealed that the two-rail curbless bridge railing existed in the tested form as far back as 1977, and was found on BDD 77-51. That same year, BDD 77-51 R1 was issued and detailed a shorter post for the two rail on a brush curb. This new sheet adjusted the height of the rails to $1\frac{1}{8}$ inches above the tested rails for a six inch curb, and $4\frac{1}{8}$ inches above the tested rails for a nine inch curb. In 1989, this revised sheet later came to be known as BDD 89-59A, and the curbless details remained on the BDD sheets with the 51 number.

METHODOLOGY

The testing done by Southwest Research Institute used a 1,990 lb. compact car to determine the geometric adequacy of the two-rail curbless railing. The vehicle velocity was 61 mph at an entrance angle of 14.2 degrees. These factors meet the minimums set by NCHRP Report 230 - Test #12 that requires a 1,800 lb. car, 60 mph and 15 degree entrance angle. The results of this test are given in NCHRP Report 289.

The tested bridge rail was standard except that it was attached to a concrete cantilever intended to simulate a bridge deck overhang.

The testing done by NYSDOT used a 4,600 lb. large car to determine the strength capacity of the railing. The vehicle velocity was 60 mph and an entrance angle of 15 degrees. These factors meet the minimums set by NCHRP Report 230 - Test #10 that requires a 4,500 lb. car, 60 mph and 25 degree entrance angle. The results of this test are summarized in a memorandum to D.J. Massimillian of the Structures Division from R.J. Perry of the Engineering R&D Bureau. All of the raw test data and video footage is available, but the results were never compiled into a standard test report. The bridge rail was standard except for the anchorage system.

The bridge rail was constructed on a three foot by three foot concrete footing intended to simulate the concrete bridge deck. The anchor bolts were not cast in place as detailed on the standard sheets. Instead, the anchor bolts were drilled and grouted into the footings using the Kelken-Gold brand grout system.

CONCLUSIONS

The overall conclusion drawn from the crash tests and available data is that the two-rail curbless steel bridge railing, mounted as either curbless or with a six inch brush curb and shorter post, passed all of the requirements of NCHRP Report 230 - Test #10 and Test #12.

The following is a short excerpt for NCHRP Report 289 - Test #10 explaining the results of the crash test:

“The test vehicle was redirected after significant wheel snagging on the first downstream post occurred... The redirected vehicle remained essentially parallel to the bridge rail for a considerable distance. No barrier deflection was evident. The damage to the vehicle was severe,... No significant damage to the barrier system was evident. Measured values indicate compliance with NCHRP Report 230.”

The following is a short excerpt from the memorandum to D.J. Massimilian from R.J. Perry regarding Test #12 conducted by the NYSDOT:

“... The test vehicle sustained substantial damage to the right front corner, but there was no intrusion into the passenger compartment. Bridge rail posts 3, 4, and 5 were...partially dislodged from the deck by pullout of the anchor bolts.

Vehicle Trajectory results were marginal in some respects... the vehicle initially departed the bridge rail at a steep angle, it quickly turned back toward the railing... Considering these points, we believe this test met the intent of the Vehicle Trajectory criteria, even though some of the suggested values were exceeded.”