Section 6
Bridge Railing

6.1 Introduction

The obvious function of bridge railing is to provide protection at the edges of structures for traffic and pedestrians. In performing this function, the railing must have the strength to withstand the vehicular impact and the geometry and details to safely redirect the vehicle without serious snagging or overturning. The decision of what type of railing to use is based on many factors including traffic volume, design speed, bridge geometry and the number of heavy trucks.

New railing and barrier systems must meet the requirements established in NCHRP 350. NCHRP 350 sets forth the crash test requirements and criteria for accepting railing systems.

A good background reference that discusses bridge railing design issues is FHWA’s October 1998 manual, Improving Highway Safety at Bridges on Local Roads and Streets.

6.2 Types of Railing

The following is a list of the types of railing systems used by NYSDOT:

- **Traffic or Vehicular Railing** - A railing used for the purpose of providing a physical barrier to safely restrain vehicles on the bridge.

- **Pedestrian Railing** - a railing or a fencing system that provides a physical barrier for pedestrians crossing a bridge and of sufficient height to minimize the likelihood of a pedestrian falling over the system.

- **Bicycle Railing** - a railing or fencing system that provides a physical guide for bicyclists crossing a bridge and of sufficient height to minimize the potential for a bicyclist to fall over the system.

- **Combination Railing** - A bicycle or pedestrian railing system added to a traffic railing or concrete barrier system.

- **Vertical Faced Concrete Parapets** - a traffic barrier system of reinforced concrete, usually used adjacent to a sidewalk.

- **Permanent Concrete Traffic or Bridge Barrier** - a traffic barrier system of reinforced concrete having a traffic face which is a safety shape, single-slope, F-shape or Texas-type Barrier.

- **Transition** - a railing system which should provide a gradual change in stiffness from a flexible highway guide rail to a rigid bridge rail or concrete barrier or parapet.
6.3 Railing and Barrier Design for New and Replacement Bridges

6.3.1 Service Levels

The first step in the railing/barrier design process is to establish the proper design service level for the bridge. The service level can be designated in terms of Testing Levels TL-1 thru TL-6 as defined in NCHRP 350 and AASHTO LRFD specifications. An older system of service levels used performance Levels PL-1 thru PL-3. There is essential equivalency in the crash test requirements as follows:

<table>
<thead>
<tr>
<th>NCHRP 350</th>
<th>1989 AASHTO</th>
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<tbody>
<tr>
<td>TL-2</td>
<td>PL-1</td>
</tr>
<tr>
<td>TL-4</td>
<td>PL-2</td>
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<tr>
<td>TL-5</td>
<td>PL-3</td>
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The 1989 AASHTO Guide Specification contains warrants based on ADT, design speed, percentage truck traffic and horizontal and vertical geometry. Although there is an ongoing study to reevaluate these criteria, these warrants provide a rational basis for the railing/barrier selection.

The general descriptions of the service levels to be used are as follows:

- **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 are expected and posted speeds are reduced.

- **TL-4 (PL-2)**—Taken to be generally acceptable for the majority of applications on high-speed highways, 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 high ratio of heavy vehicles for expressways and interstate highways with unfavorable site conditions.

A recommendation of the service level will be made by the designer to the D.C.E.S. based on the general descriptions above and the 1989 AASHTO Guide Specification unless a variance can be justified. The recommended service level will be shown on the preliminary structure plan tear sheet.

6.3.2 Railing/Barrier Design Alternatives

Once the appropriate service level has been established, some functional and geometric criteria need to be established. These criteria are discussed as follows:

**Under-crossing Feature** - Bridges over another highway or railroad must have either a concrete barrier or a curb. This is necessary to prevent roadway drainage from dropping onto the under feature. Bridges over waterways may use a curbless section if not on an interstate or other controlled access highway.
**Pedestrian Traffic (Sidewalk on Bridge)** - Bridges carrying a sidewalk must use a concrete parapet or four-rail railing at the fascia with a minimum height of 1.06 m above the sidewalk surface. It is presumed that bridges with a sidewalk do not carry bicycle traffic on the sidewalk. When a sidewalk is separated from vehicular traffic by a traffic railing, then a minimum 1.06-m high pedestrian railing or fencing must be used on the fascia.

**Pedestrian Traffic (No Sidewalk on Bridge)** - A railing or concrete barrier with a minimum height above the roadway of 1.06 m shall be used.

**Bicycle Traffic** - If a bridge bicycle railing is to be used, it shall be a railing or combination concrete barrier and railing with a minimum height of 1.06 m above the roadway surface.

The *Highway Design Manual* (Chapters 17 and 18) should be consulted for warrants to determine when bicycle or pedestrian railing should be provided.

Bridges that carry bicycles on a bikeway that is separate from vehicular traffic may use either of the bicycle/pedestrian railings shown on BD-RP2 or BD-RP3 on the fascia of the bridge. If a steel railing is used to separate the traffic from the bikeway then a rub rail(s) should be placed on the back side of the traffic railing to protect the bicyclists from the railing posts. Fencing can be used as an alternate to the standard details shown, but the posts and rails must be designed to withstand the loads specified in the *NYSDOT LRFD Bridge Design Specifications* for bicycle and pedestrian railing.

Table 6-1 shows the available railing and barrier options for the different design service levels. Current BD Sheets should be consulted for the details of the various systems.
<table>
<thead>
<tr>
<th>TL-2 (Less than 500 AADT)</th>
<th>TL-2 (Less than 1500 AADT)</th>
<th>TL-2 (Greater than 1500 AADT)</th>
<th>TL-4</th>
<th>TL-5 and Controlled Access Interstate</th>
<th>Controlled Access Non-Interstate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Thrie Beam (BD-RL1)</td>
<td>1. Steel Two-Rail Curbless (BD-RL3)</td>
<td>1. 864 mm Safety Shape (BD-RC1)</td>
<td>1. 864 mm Safety Shape (BD-RC1)</td>
<td>1. 1.07 m Single-Slope [CIP and slipform options only] (BD-RC11)</td>
<td>1. 864 mm Safety Shape (BD-RC1)</td>
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<tr>
<td>2. Steel Two-Rail Curbless (BD-RL3)</td>
<td>2. Steel Three-Rail Curbless (BD-RS1)</td>
<td>2. Steel Three-Rail Curbless (BD-RS1)</td>
<td>2. Steel Three-Rail Curbless (BD-RS1)</td>
<td>2. 1.07 m Single-Slope (BD-RC11)</td>
<td>2. 1.07 m Single-Slope (BD-RC11)</td>
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<td>5. Steel Five-Rail Curbless (BD-RS3)</td>
<td>5. Steel Five-Rail Curbless (BD-RS2)</td>
<td>5. Steel Two-Rail with Brush Curb (BD-RS2)</td>
<td>5. Steel Two-Rail with Brush Curb (BD-RS2)</td>
<td>5. Steel Two-Rail with Brush Curb (BD-RS2)</td>
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<tr>
<td>7. Timber Two-Rail (BD-RT1)</td>
<td>7. 864 mm Safety Shape (BD-RC1)</td>
<td>7. 1.07 m F-Shape (BD-RC15)</td>
<td>7. 1.07 m F-Shape (BD-RC15)</td>
<td>7. 1.07 m F-Shape (BD-RC15)</td>
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<td>8. 864 mm Safety Shape (BD-RC1)</td>
<td>8. 1.07 m Single-Slope (BD-RC11)</td>
<td>8. 1.07 m Vertical Parapet (BD-RC2)</td>
<td>8. 1.07 m Vertical Parapet (BD-RC2)</td>
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<tr>
<td>9. 1.07 m Single-Slope (BD-RC11)</td>
<td>9. 1.07 m F-Shape (BD-RC15)</td>
<td>9. 1.07 m Texas-Type (BD-RC8)</td>
<td>9. 1.07 m Texas-Type (BD-RC8)</td>
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<td>10. 1.07 m F-Shape (BD-RC15)</td>
<td>10. 1.07 m Vertical Parapet (BD-RC2)</td>
<td>10. Timber Two-Rail (BD-RT1)</td>
<td>10. Timber Two-Rail (BD-RT1)</td>
<td>10. Timber Two-Rail (BD-RT1)</td>
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<tr>
<td>11. 1.07 m Vertical Parapet (BD-RC2)</td>
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<td>12. 1.07 m Texas-Type (BD-RC8)</td>
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**Table 6-1**

Railign and Barrier Selection Table
6.3.3 Railing/Barrier Selection

6.3.3.1 Interstate and Controlled Access Highways

All new and replacement bridges and deck or superstructure replacements on interstate and other controlled access, high-speed highways shall use concrete bridge barrier (parkways without truck traffic and culvert structures are excluded). For interstate bridges, 1.07-m high F-Shape or single-slope barrier shall be used. For other fully or partially controlled access, high speed highways, designers should evaluate the required railing design service level according to Section 6.3.1 to determine if the service level is Test Level-4 and an 865-mm high concrete safety shape barrier can be used.

Exceptions to this guidance should be discussed and justified in the Design Approval Document and be approved by the D.C.E.S. Exceptions that will be considered are in the cases of a deck replacement when the existing superstructure is not adequate for the increased dead load associated with a concrete barrier or where a concrete barrier on the inside of curve would reduce sight distance to less than the allowable.

A number of recent accidents have involved tractor trailers penetrating steel bridge rail and causing severe damage and injury. There is a common misperception that steel bridge railing is designed to contain a heavy tractor trailer impact. In reality, the current standard two-rail and four-rail bridge railings are designed and tested to a Test Level-4, under NCHRP 350, to contain a 2000-kg (4400-lb) pickup truck at 100 km/hr (60 mph) with a 25-degree angle of impact and an 8000 kg (18,000 lb) single-unit van truck at 80 km/hr (50 mph) with a 15-degree angle of impact. The design standards for previous railing systems had significantly lower impact loads.

There are no known steel railing systems designed for an impact by a 36,000 kg (80,000 lb.) tractor trailer (Test Level-5 level of service). It would be extremely difficult to design such a steel railing system because the impact force must be transferred to the deck at each post location. A concrete barrier is much more effective in that it distributes the force to the deck through the continuous deck/barrier interface.

6.3.3.2 Other Highways

The Railing and Barrier Selection Table (Table 6-1) lists the available choices for each design category. The first choice in most design categories is a concrete barrier or parapet. This preference is based on the concrete barrier’s strength, durability and low initial and maintenance costs compared to metal railing systems. Factors that may cause an alternative selection to be made are:

Bridge Deck Drainage - On bridges over waterways where concrete barriers would necessitate the use of scuppers, a curbless railing should be used. Generally, for most bridges it will not be necessary to use scuppers with concrete barriers. It is usually possible to carry the deck drainage off the ends of the structure without scuppers, unless the bridge becomes very long, wide or has a flat profile. The bridge deck hydraulics must be checked.
Aesthetics - In areas where the aesthetics of the railing/barrier is a prime concern, the Texas Type C411 concrete barrier is an option. However, the cost of this barrier is significantly higher than a standard barrier and its use is restricted to situations where a service level of TL-2 (PL-1) applies. A barrier with an outside face treatment using one of the many types of form liners should also be considered. Concrete cover and bridge width must be increased when form liners are used. Concrete barrier can be colored by staining the cured concrete for an aesthetic effect. Color added to the concrete mix is not recommended because of the variability of results. Exposed aggregate finishes should be avoided because of maintenance concerns.

A two-rail timber railing is also available for use in areas such as the Adirondack and Catskill Parks where a rustic appearance is desired. In certain situations it may be desirable to provide a view of scenic under features. An open railing system could be used in these situations.

Bridge or pedestrian railing may be painted the same color as the steel superstructure to achieve a uniform appearance. Care should be taken not to include the railing in the requirements for 572 _ _ _ _ 16 – Shop Applied Structural Steel Paint System. This item leaves the railing interior ungalvanized and subject to deterioration from rusting. Instead, a note should be placed on the plans modifying the requirements of 710-23 to match the color of the surrounding painted structural steel, if it is different from the rustic brown stated in the 710-23 specification.

Visibility - When intersections or driveways are close to the end of the bridge, an open railing system may be selected over a concrete barrier to increase visibility of oncoming traffic from the intersecting roadway. It should be pointed out that the visibility through the steel railings is limited and becomes even less with the addition of pedestrian fencing or permanent snow fence to the railing. This factor should only be a consideration in unusual circumstances.

Snow Accumulation - In areas with heavy snowfall, Regions sometimes consider using open railing on bridges over waterways to mitigate the effect of snow accumulation on the shoulders. The intent is to push snow through an open railing during snow plowing operations to reduce the need for maintenance forces to remove accumulated snow from the bridge shoulder. However, the ability to push snow through the relatively close spacing of the rails is limited at best. Bridges over highways and railroads will ordinarily carry a snow fence on the structure. Therefore, snow accumulation is usually not a factor in the railing/barrier decision on such bridges.

Geometric design policy for new and replacement bridges ordinarily results in a shoulder wide enough to permit snow storage. The factor of snow accumulation driving a decision to use open railing rather than a concrete barrier should occur only in unusual circumstances.

6.3.4 Weathering Steel Bridge Railing

Use of weathering steel for bridge railing to achieve a “rustic” appearance is no longer allowed because accelerated deterioration has been noted inside the railing tubes. In most cases, standard galvanized guide rail should be used. If a rustic appearance is required, timber bridge railing or painted galvanized steel may be used.
6.3.5 Transitions

Approved transitions from bridge railing and barrier to highway railing are shown in the BD – RC, RL, RS and RT series. If it is necessary to transition from corrugated beam highway rail to box beam highway rail (or vice versa), make the transition away from the bridge in accordance with the details shown on the Highway Standard Sheets. The purpose of bridge railing/barrier transitions is to provide a smooth transition from the rigid bridge rail to the flexible highway guide rail without forming a snagging pocket.

When driveways or other roadways are in close proximity to the end of the bridge and make the use of the full transition length impossible, the designer shall utilize as much of the transition as possible. The highway guide rail shall be terminated in accordance with the highway standard sheets where conditions permit.
6.3.6 Modifications

Modifications to any of the standard railing/barrier systems may be made only with the approval of the D.C.E.S. Any substantial modifications would generally require a crash test to qualify the system. This will also be determined by the D.C.E.S.

6.4 Precast Concrete Barrier

Concrete Barrier can be constructed by one of three methods, cast-in-place, slip formed or precast at the Contractor’s option. If the precast method is chosen, the Contractor must use one of the preapproved precast barrier systems. The approved systems are listed on the Department’s Approval Material list. The approved systems are specific in their details, materials and method of attachment to the deck slab.

In certain circumstances the designer may wish to require the use of a precast concrete barrier system. In that event, the normal barrier pay item can be used, but a note on the plans should state that only the precast option is allowed. No details of the barrier reinforcement or anchorage should be shown on the plans. A note should be placed to state that the precast barrier must be one of the approved systems.

6.5 Pedestrian Fencing

On bridges over railroads or highways where there is a potential for vandalism from pedestrians, pedestrian fencing should be provided. The fencing is attached to the back side of steel railings, concrete barriers and parapets. It is located on the back side to minimize the potential danger from flying debris if a truck impacts the railing or barrier and leans into the pedestrian fencing. As an alternate, fencing may be mounted to the top of a barrier through a longer base plate or corbelled edge as long as the standard distance from the face of the barrier to the fencing is maintained. Details are shown on the BD Sheets.

Pedestrian fencing over railroads shall be carried a minimum of 6.0 m past the center line of any single track or from the centerline of the two most external tracks. If there is an off-track maintenance roadway adjacent to the tracks, the fencing should be extended a distance of 1.0 m past the edge of the maintenance roadway. If the required limits of pedestrian fencing over the railroad corridor beneath the structure is a significant portion of the overall structure length, the Region may decided to simply run the pedestrian fencing along the entire length of the structure.

Pedestrian fencing shall have a minimum height of 2.44 m as detailed on the current BD sheets and extend to a point 3.0 m beyond edge of the shoulder of the under roadway.
6.6 Permanent Snow Fencing

Structures with open railing that pass over a roadway should be equipped with snow fence in the area over the under roadway. The purpose is to retain and disperse the snow from snow plowing operations. Permanent snow fence should be chain link fence mounted to the back side of the railing. If used, the recommended height of snow fence is 1.22 m as detailed on the current BD sheets.

Bridges with concrete traffic barriers (864 mm high) may need snow fence installed on the back of the barrier depending on local conditions. It is recommended that bridges over interstate highways have such fencing. Bridges with higher concrete barrier or parapet (1.07 m) ordinarily do not require snow fence. If used, permanent snow fence on concrete barrier should have a height of 600 mm above the top of the barrier. Permanent snow fence should be installed on the back side of railing and barrier for the same reason discussed under Pedestrian Fencing. As an alternate, it can be mounted to the top with certain restrictions as discussed in Section 6.5.

Permanent snow fence should be used judiciously. It has the potential to create more problems than it solves (particularly on concrete barrier) and may be unattractive. When snow fence is used, it should extend to a point 3.0 m beyond the edge of the shoulder of the under roadway.

6.7 Railing/Parapet Design Dead Loads

The following uniform dead loads based on current BD sheets in kN/m can be assumed for design purposes:

- Two-Rail with brush curb (625 mm wide) 3.00
- Four-Rail curbless 1.25
- Safety Shape Concrete Barrier 6.75
- Vertical Concrete Parapet 6.50
- Texas-Type Barrier 6.25
- Single-Slope Concrete Barrier 8.75
- F-Shape Concrete Barrier 8.50
- Timber Rail 1.10
- Single-Slope Median Barrier 10.40
- Single-Slope Median Wide Barrier 13.00
- Permanent Concrete Median Barrier (Type A) 6.00
- Permanent Concrete Median Barrier (Type B) 7.55
- Permanent Concrete Median Barrier (Type C) 8.90
6.8 Guidelines for Railing Treatments on Rehabilitation Projects

6.8.1 Background

A majority of the bridge railings currently on NYSDOT structures have not been crash tested in accordance with NCHRP 350 criteria. As of October 1, 1998, these existing railings are considered nonconforming features and FHWA requires that they be considered when progressing a rehabilitation project on the structure.

6.8.2 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 rehabilitation project development and design. These rehabilitation 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.

Railing treatments on rehabilitation projects is a complex subject with many project specific considerations. Although these guidelines have been adopted, it is realized that they cannot cover every situation and engineering judgment will be required in their interpretation. A flow chart outlining these guidelines is shown in Appendix 6B.

6.8.3 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, vaulting causing features, 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 Section 6.3.1.

C. Roadway System - NHS, non-NHS, functional class, design speed, 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 and severity 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 and curb height for vaulting considerations.

I. **Scope of Work** - consider the railing upgrade/replacement in view of the rehabilitation project from the perspective of appropriateness of work and increase in project cost.

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.

### 6.8.4 Identified Work Strategies

The decision regarding bridge railing must be consistent with the overall work strategy for the individual bridge. Public safety, timing and economics are important considerations when making this decision. The work strategies discussed below 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:

#### 6.8.4.1 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 after project completion. 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 nonconforming. 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 6.8.5.3.

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:
6.8.4.2 Short-Term Work Strategy

The projects in this category are intended to provide a short-term or interim fix prior to possible 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)
- Other “Element Specific” Contracts (excluding monolithic deck projects)

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.

6.8.4.3 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. Although monolithic deck projects are a long-term work strategy, it is desirable for programmatic reasons to allow additional flexibility. It is for this reason that monolithic deck projects are treated separately. On monolithic deck projects, if a standard railing system is not installed, 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 to accept the standard railing and associated loadings. See Appendix 6A “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 are 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 to replace 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 opt 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 and place in the project file or design report all information that supports the final decision.

### 6.8.5 Actions to be Taken

Generally, all actions should be based on the warrants and the work strategy for the bridge. The warrants and the work strategy are discussed in Sections 6.8.3 and 6.8.4. The required design service level for the bridge railing is determined according to Section 6.3.1. The following actions are applicable to all roadway systems, unless otherwise noted.
6.8.5.1 Replacing the Bridge Railing/Barrier

The standard systems for replacement bridge railing and barriers shall be as defined in Section 6.4.2 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.

6.8.5.2 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 152 mm x 152 mm box beam rail. TL-4 upgrading consists of double 152 mm x 152 mm box beam rails.

6.8.5.3 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 (design service levels) as described in Section 6.3.1. When considering long term service life of a bridge, there are a few cases where retaining the nonconforming bridge railing is desirable. These cases must be justified and well documented similar to the procedure described in the Highway Design Manual, Section 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.

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 nonconforming bridge railing:

- Bridge Painting/Cleaning/Sealing
- Joint Repair/Replacement
- Bearing Repair/Replacement
- Striping
- Steel Repair (Impact Damage, Localized Corrosion, etc.)
- Scour Work
- Sign Projects
- Navigational Light Repair/Installation
- Preventive Maintenance Work (Cyclic Work to Reduce Deterioration)
- 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 BDD sheets issued since 1977 are acceptable and adequate for a TL-2 service level without upgrading. See Appendix 6A, “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 is permissible if there are no obvious safety hazards such as snagging points and there is approval by the D.C.E.S.

2. Historic Preservation or Other Project Specific Reasons

For projects which deal with historic or aesthetic considerations, the decision regarding bridge railing can be much more difficult. The deficiencies of the proposed nonconforming bridge railing, relative to its conformance with the required service level, shall be clearly documented and shall be presented to the approving authority noted in Section 6.8.6. This information shall be accompanied by the cost differential between the two bridge railings and the logic supporting the decision to employ the nonconforming bridge railing.
6.8.5.4 Anchorage of Steel Bridge Railing

It is NYSDOT policy to allow drilling and grouting of anchor bolts for steel bridge railing during rehabilitation projects. All anchor rods must be proof-load tested to ensure the quality of the existing concrete and the grout selected. It is recommended that the contractor install and test several bolts prior to grouting all the bolts in case of a concrete/anchor/grout incompatibility.

The recommended embedment depth for M24 bolts is 300 mm.

Although the anchorage is compliant with current loading requirement, the overhang reinforcement in the superstructure may not be adequate. The deck reinforcement should be investigated to ensure that it can resist the larger loadings this railing system is capable of transmitting, or a determination must be made to accept the damage to the deck that may occur during a severe impact.

6.8.6 Responsibilities and Authorities

Approval authority will be in accordance with the Design-Related Approval Matrix in the NYSDOT *Project Development Manual*, Exhibit 4-2.

6.9 Bridge Railing/Transition Shop Drawing Requirements

Bridge Railing and Transition Shop Drawing “Approvals” are not required in most cases. Since the recent implementation of new crash-tested bridge railing and transition details, it has become obvious that the shop drawing review process provides little value when compared to the effort of reviewing and approving shop drawings for these items. In most cases, the contract document details and construction specifications are adequate to ensure that the railing system will be fabricated in a manner that will satisfy safety and construction tolerance criteria.

Nevertheless, there are situations that warrant the review and approval of shop drawings for these items, as follows:

- Transitions requiring connections between existing bridge rail and existing highway rail.
- Transitions requiring connections between existing bridge rail and new, upgraded bridge rail or between existing bridge rail and existing truss members.
- Unique and complex end transitions.
- All nonstandard concrete and steel railing systems and all timber rail systems.

When these situations occur, Note 70 in Section 17 shall be placed in the contract plans.
Appendix 6A
1987 Bridge Railing Crash Test Report

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 11\(\frac{3}{8}\) inches above the tested rails for a six inch curb, and 41\(\frac{7}{8}\) 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 25 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 from 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.”
Appendix 6B
Railing Treatments on Rehabilitation Projects

Consider Warrants

Consider Work Strategy

Long Term Project (> 10 Yrs)
- Must Upgrade/Replace
  OR
- Must Justify Retaining

Monodeck Project (Long Term > 10 Yrs)
- Meets NCHRP 230

Short Term Project (≤10 Yrs)
- Evaluate for Upgrade/Replace
  OR
- Defer to Future Project

Meets NCHRP 230

Must Upgrade/Replace AND
- Modify Deck Overhang (If Necessary)

Curb to Rail Face < 225 mm
- Yes
  - May Retain

No
- No
  - Remove Safety Walk OR Blockout Railing