Section 19
Bridge Rehabilitation Projects

19.1 Introduction

This section is a listing, by project stage, of structural engineering activities that contribute to the technical component of the conception, development, and design of a project. These activities assure that proposed alternates are technically compatible with the stated project objectives. For procedural requirements, refer to the NYSDOT Project Development Manual. It is recommended that Section 3 also be reviewed. While Section 3 is written for new or replacement bridges some of the guidance may be applicable, on a case by case basis, for rehabilitations.

Focus must be maintained on the purpose of each project stage and the project control decisions made during and at the conclusion of that stage. These decisions dictate the level of detail required for the activities that are listed.

NYSDOT generally anticipates compressed schedules for bridge rehabilitation projects compared to bridge replacements. Therefore, timely completion of the technical evaluation is particularly important. Bridge rehabilitation projects impart fewer social and environmental impacts than do bridge replacement projects. Hence, procedural requirements are streamlined and project delivery is expedited on most projects.

Rehabilitation work can be described as major or minor. Minor rehabilitations address non-structural repair or improvement of bridge elements (concrete surface repair, deck overlays, joint and bearing restoration, secondary member steel repair, minor repair to primary steel members, and restoration of steel members by adding cover plates and high strength bolts). Major rehabilitations involve structural repair or replacement of primary bridge elements (pier and pier capbeam replacement, deck replacement, superstructure replacement, bridge widening, and primary member replacement or strengthening).

19.1.1 Project Scoping

Scoping is the first major stage of the project production process. Its purpose is to establish consensus among the functional areas about the nature of the proposed project. The end products of this stage are project objectives, design criteria, feasible alternatives, a reasonable cost estimate, and identification of key environmental issues that may need to be addressed throughout project design, e.g., wetlands, endangered species, protected streams, contaminated soil, asbestos, lead based paint, noise, historic properties. Information assembled and analyzed in this stage must be of sufficient detail to demonstrate that the project defined by these “scoping products” is appropriate and should be progressed to the next stage. For further information, see Project Development Manual, Chapter 3, Project Scoping Procedures.
The technical activities described below focus on the feasibility, from a structural engineering perspective, of reasonable alternates and their associated cost. Since these decisions are largely based on correct interpretation of existing data, the project developer should involve the appropriate experienced people to evaluate feasibility of the proposed alternates and should limit data collection and analysis to viable options. While a detailed Rehabilitation vs. Replacement comparison need not be completed in the Scoping Phase, Section 19.2.2 should be referenced for general considerations that help define the feasibility of each alternate.

1. **Preliminary Assessment of the Condition of the Structure**
   
   **Purpose:** Provide an initial assessment of structural needs and appropriate bridge work to address those needs.

   **Method:** Obtain and examine bridge inventory and load rating data and the latest inspection report. Consider the overall condition of the bridge and the specific condition of the major structural elements. The year constructed and design loading provide clues to the potential serviceability of a rehabilitated structure.

2. **Identify Geometry, Details and Materials that may Limit Potential Alternatives**

   **Purpose:** Provide additional information to assess alternate feasibility.

   **Method:** Obtain and examine record plans. Structure width, type of construction, and traffic levels contribute to maintenance of traffic considerations and the potential for operational improvements. Record plans provide information relative to the materials used and fabrication and construction methods employed.

3. **Verify and Complement Documented Information**

   **Purpose:** Assure that information in the bridge inventory and inspection system and on the record plans is accurate. Also, assess impacts of surrounding features that may not be appropriately portrayed by existing data.

   **Method:** Visit the project site. This is not meant to be an in-depth bridge inspection, rather, a verification visit to assist in feasibility assessment.

4. **Evaluate Hydraulic Adequacy of the Structure (if appropriate)**

   **Purpose:** Identify susceptibility to flooding, scour, and damage from floating ice/debris.

   **Method:** Perform a hydraulic assessment. This is included in the scoping stage due to its potentially dramatic impact on the project's scope and cost.

5. **Determine Reasonable Cost and Schedule for the Most Feasible Alternate**

   **Purpose:** Provide project specific programming information.

   **Method:** Compare the general requirements of the work to other projects of similar size and type. Based on these similar projects, estimate a reasonable cost for the work and an approximate schedule. Results are to be included in the Scoping Closure Document.

6. **Summarize Conclusion of Scoping Activities**

   Information gathered and conclusions reached should be presented in the Scoping Closure Document. Any obviously unfeasible alternates should be eliminated.
When the scope of a bridge rehabilitation project does not involve evaluation of alternatives, but addresses specific bridge deficiencies, the Scoping Closure Document may also serve as a Design Approval Document (DAD). This may necessitate that some preliminary engineering activities be done prior to the closure of scoping activities. See the Project Development Manual for when this process is appropriate.

19.1.2 Preliminary Design

Preliminary Design refines proposed design alternates, compares them, and selects the most appropriate alternate to be advanced to final design. This phase culminates in the issuance of a Design Approval Document for the chosen alternate. The technical activities in this stage serve to collect and analyze data required to define the appropriate design alternate. The applicability of each activity to the development of a given alternate should be discussed with the appropriate functional manager. Experienced interpretation of existing conditions can either eliminate or highlight the importance of certain activities.

1. Collect Detailed Structure Condition Data

   Purpose: Collect sufficient data to assess the viability of the work alternates. The data should be detailed enough to allow the completion of a Level 1 Load Rating.

   Method: Perform an In-depth bridge inspection in accordance with requirements of the Department’s Specifications for In-depth Bridge Inspection (See Section 19.2.1). This activity could include taking cores of existing concrete elements.

2. Assess Condition of the Structural Deck

   Purpose: Determine whether a bridge deck can be rehabilitated or must be replaced.

   Method: Perform a bridge deck evaluation in accordance with the current Bridge Deck Evaluation Manual. The decision to rehabilitate or replace a deck can significantly impact associated rehabilitative work, design criteria and resulting costs. It is therefore imperative to accurately define the condition of the structural deck.

3. Assess Structural Integrity of the Existing Bridge and the Potential for Restoring Full Capacity Through Rehabilitation Actions

   Purpose: Assure serviceability of the structure during construction and define the extent of rehabilitative work required.

   Method: Perform a Level 1 Load Rating. The Level 1 Load Rating will provide a base structural capacity for the bridge from which the necessity of and potential for improvement can be judged.

4. Assess the Structure’s Vulnerabilities to Potential Modes of Failure

   Purpose: Identify the impact to the project scope and cost of any work to address a structure’s vulnerabilities prior to the issuance of design approval.

   Method: Evaluate the structure and its details using the procedures provided in the Bridge Safety Assurance Policy.
5. **Assess Feasibility of Rehabilitation versus Replacement**

   **Purpose:** Refine project cost and further assess the alternate's cost effectiveness and technical feasibility.

   **Method:** Update project costs and schedule based on more detailed information. Perform a rehabilitation versus replacement evaluation as outlined in Section 19.2.2. This evaluation provides direction concerning reasonable costs of various alternates and technical considerations that correspond to feasibility.

6. **Perform a Technical Progress Review**

   **Purpose:** Provide general advice to ensure that bridge projects are developed in accordance with appropriate policies, standard practice, and sound engineering judgment.

   **Method:** The draft Design Approval Document should be submitted to all parties that have a role in the final design of the project. Functional managers will review the document for standards compliance, scope, cost, and schedule. See Section 20 for technical progress review responsibility for bridge projects.

7. **Summarize Key Design Features of the Chosen Alternate**

   **Purpose:** Provide the grantee of design approval with a concise representation of the important project features.

   **Method:** Prepare a Design Approval Document. For bridge rehabilitations, also prepare a Structure Rehabilitation Concept Plan Package. This package should include a 250-scale project plan with horizontal alignment control data, a representation of the vertical alignment with appropriate control data, existing and proposed transverse sections, and a Temporary Traffic Control strategy. This package is a portion of the Design Approval Document and aids in the project control decision. The information gathered and the conclusions reached through these activities must be appropriately represented in the project's Design Approval Document.

The format of the Design Approval Document should correspond with the appropriate sections of the *NYSDOT Project Development Manual*.

### 19.1.3 Final Design

Final Design adds necessary engineering and detailing to the design alternate selected from the Preliminary Engineering stage and culminates with submission of the Plans, Specifications, and Estimate (PS&E) package. Technical activities of this phase serve to develop a contract package that enables the Department to advertise, let, award, and construct the project.

1. **Prepare Structure Study Plan (Bridge Widening and Superstructure Replacement Projects only)**

   **Purpose:** Ensure conformance to accepted standards and policies or highlight the need to consider exceptions; allow an initial constructability review; provide a means for the designer to acquire information necessary to advance the proposed design.
Method: Prepare a Structure Study Plan which is a conceptual presentation of the proposed work.

2. *Prepare Structure Justification Report (Bridge Widening and Superstructure Replacement Projects only)*

   Purpose: Provide a mechanism to achieve Department consensus on the appropriateness of the proposed structure.

   Method: Prepare a Structure Justification Report (See Appendix 3H) which is a presentation of the logic behind the decisions to select or discard various design alternates for the project.

3. *Perform Technical Progress Review*

   Purpose: Ensure that the structural solution being developed is consistent with the scope of the project, is technically and economically appropriate, and addresses the site conditions that have been identified.

   Method: A designer independently reviews the Structure Study Plan and Structure Justification Report to ensure that an appropriate solution has been selected prior to spending resources on detailed plans.

4. *Prepare Preliminary Structure Plan*

   Purpose: Represent details of the project structure's scope of work.

   Method: The designer prepares a Preliminary Structure Plan sheet which is a concise representation of the bridge project and the required work. See Appendix 19A for the Rehabilitation Preliminary Checklist.

5. *Perform Technical Progress Review*

   Purpose: Show consensus within the Department prior to distribution to outside agencies.

   Method: A designer conducts an independent review, including an ‘approval’ review by the Office of Structures when required by Section 20 or when requested by the Region.

6. *Detailed Design of the Chosen Alternate*

   Purpose: Provide a contract package that allows the advertisement, letting, award and construction of the project.

   Method: Assemble an Advance Detail Plan package (plans, special specifications, and ADP estimate) designed in accordance with current NYSDOT specifications and standards.
7. Technical Progress Review

   Purpose: Ensure that NYSDOT policies, standards, and sound engineering judgment are incorporated into the contract documents.

   Method: A designer conducts an independent technical review of the plans, special specifications, and estimates.

8. Assemble Construction Package - PS&E Package

   Purpose: Assemble a contract package that enables the Department to advertise, let, award, and construct the project.

   Method: Submit the Plans, Specifications, and Estimate (PS&E) package for the project.

19.2 Existing Structure Evaluation

19.2.1 In-Depth Inspections

In-depth bridge inspections assist in making rehabilitation vs. replacement decisions and assist designers in progressing bridge rehabilitation projects. In general, an in-depth bridge inspection is a detailed inspection of an entire bridge which can include both destructive and non-destructive testing. It is more complete than a general inspection and the results can be used to satisfy the Uniform Code of Bridge Inspection requirements for a general inspection.

The Code requires that in-depth inspections be done in accordance with the Department's Specifications for In-depth Bridge Inspection. A professional engineer should review the Specification for applicability to a particular bridge or project and, if necessary, develop modifications in the form of an addendum to the Specification or develop a substitute Specification that will be used for the in-depth inspection. The goal of a bridge inspection is to collect enough data to make an informed decision about the scope of the project. Other criteria, such as physical characteristics, capacity demands, hydraulic adequacy and required maintenance of traffic could dictate decisions on the scope of work for a bridge project, regardless of what the inspection data provides. The designer should consider all factors when determining which bridge elements do not need to be inspected.

As an example, there is no need to inspect the girders and deck on a bridge with concrete tee beams that cannot be retrofitted and rate at HS15 when the project objective is to increase the capacity of the structure to HS20. In this case, the scope of the project should be at least a superstructure replacement because the concrete tee beams cannot be sufficiently strengthened to accommodate the project objectives. Nevertheless, it is critical to get expert interpretation of the existing conditions and their influence on each element of the structure before eliminating them from the rehabilitation inspection.

For element-specific projects, the required inspection can normally be limited to the elements being addressed in the project. See Appendix 7 of the NYSDOT Project Development Manual for guidelines on element specific bridge work.
19.2.2 Bridge Rehabilitation vs. Replacement Selection Guidelines

These guidelines are for use during project scoping, after a decision has been made to progress the project. The rationale presented is appropriate any time these two alternatives are possible. For the purposes of these guidelines, bridge rehabilitation is defined as a complete rehabilitation removing all deficiencies or justifying their retention.

These guidelines were developed to provide guidance in this difficult decision area, and are not absolutes. It is expected, however, that when they are not followed, it is for compelling reasons which are to be documented in the project file.

Several factors must be considered in a rehabilitation vs. replacement decision. These factors are all interrelated; each factor must be investigated and considered both individually and collectively. All conclusions reached shall be fully documented in the project file and in all other appropriate documents, such as the Design Approval Document.

The following factors are presented for rehabilitation vs. replacement consideration. They are presented one at a time and are not necessarily in any particular order of importance.

Cost - The estimating of both rehabilitation and replacement costs is usually performed after all other factors have been investigated, because the other factors may affect or determine the scope of the rehabilitation or replacement option. The replacement estimate is to be done in accordance with current NYSDOT procedures. The current system is a shoulder break square foot unit cost basis developed by the Office of Structures for use early in projects where bridge particulars, such as abutment heights and locations are not known (see Section 3.5.1). This methodology compensates for positioning abutments anywhere within the shoulder break length along the shoulder break slope line. This replacement estimating process provides the user with project level information.

When considering rehabilitation, the first step is to check the load rating. If the bridge is posted or if the current load rating appears suspect, rerate the bridge before proceeding with the estimate.

The rehabilitation estimate is much more difficult to develop. This estimate cannot be developed from the biennial inspection report. It requires close reinspection and examination of the bridge. This inspection must be of sufficient detail to develop a practical idea of the extent of the necessary work. The inspector should keep in mind that the actual rehabilitation construction work will most likely not be done for several years. Consequently, the estimate of quantities should have reasonable projections to compensate for continued deterioration.

The rehabilitation reinspection should examine the type and extent of deterioration of all bridge components (e.g., abutments, piers, beams and decks) with the intent of developing contract plans and a reasonable estimate for the work. Reinspection should include actual measurements of section loss in the beams to determine the current load rating. Also, the reinspection should include the location and depth of areas of concrete in the abutments and piers that require removal and replacement to restore them to like-new condition. The inspector must examine abutments and piers by sounding to locate possible delaminations and chipping to determine the depth of the poor concrete. Unless these investigations convince the inspector that the concrete is sound and needs only insignificant repairs, such as a spot patch on a pier column during a deck replacement project, cores should be taken. Significant repair is defined...
as more than isolated repairs or more than a nominal amount of money. Substructure cores should not be taken when concrete condition is obviously beyond rehabilitation.

In addition to the reinspection, concrete cores of the structural deck are commonly required to determine if the deck is to be retained and repaired. The policy and procedure for deck coring are given in the *Bridge Deck Evaluation Manual*.

Taking and testing concrete cores confirms the depth of poor concrete and the presence of delaminations, and provides a measure of the concrete’s strength and durability against freeze thaw cycles. Cores should be taken to finalize the type and amount of rehabilitation work unless the amount of work is insignificant or the concrete element is clearly in need of replacement.

Like the replacement estimate, the bridge rehabilitation estimate should include all highway and project costs necessary to develop the complete cost estimate.

All rehabilitation and replacement costs shall include the cost for the appropriate Temporary Traffic Control plan chosen for that alternate.

The next step is to compare rehabilitation and replacement costs of the portion of the project directly related to the structure assuming both are viable possibilities. This relationship should be established in terms of the rehabilitation cost being a percentage of the replacement cost (RH/RP percentage). Due to the inherent uncertainties of estimating practices, the cost percentage determinations between rehabilitation and replacement are broken down into three ranges. These ranges were developed by examining the life cycle costs of rehabilitation and replacement for several bridge models. These models varied the type of work to determine the effect on annualized costs. The models assumed a gradually increasing annual maintenance cost and a 4% discount rate.

First range: RH/RP percentage less than 65%. The preliminary choice is rehabilitation. Other factors, such as bridge type, must be examined to ensure compatibility with rehabilitation.

Second range: RH/RP percentage between 65% and 85%. Rehabilitation or replacement may be the preliminary choice. Other factors must be examined to establish the appropriate type of work.

Third range: RH/RP percentage greater than 85%. The preliminary choice is replacement. Other factors must again be examined for compatibility with replacement. For example, detouring traffic in highly urbanized areas may not be feasible from a capacity point of view and constructing a temporary structure may not be possible from a right-of-way point of view. Construction of a replacement bridge alongside the existing bridge may not be possible due to right-of-way restrictions, even with stage construction. In this case, an expensive rehabilitation would be done rather than a replacement.
There has been discussion whether "user costs" should be included in the estimate. For the purposes of this guideline, user costs are not included in the total costs associated with rehabilitation or replacement because, in both cases, traffic is usually restored to the same condition that existed before construction. It may be necessary to take user costs into account on bridge removal and bridge capacity improvement projects since there would be a change that would impact the traveling public on a permanent basis. These costs would be considered on an individual project basis as they are only significant in a small percentage of situations.

**Safety** - Accident history and potential must be examined for the project bridge. In terms of safety for the RH/RP decision, accident history is the most important element. Accident history can be determined by examining the accident reports on file. Although sometimes inconclusive, this review should look for trends in accident patterns that would point to whether the bridge caused or contributed to the accidents.

While not as significant as accident history, accident potential should also be considered. Geometrics which contain clear potential for accident problems should be considered for improvement. That improvement may have a direct impact on the RH/RP decision. The review of geometrics should include, but not be limited to: sight distance, bridge width, horizontal clearances, alignments, etc. These elements should be compared to the standards and evaluated with regard to accident potential. Current bridge standards are shown in Table 19-1.

<table>
<thead>
<tr>
<th><strong>CURRENT BRIDGE STANDARDS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FUND SOURCE</strong></td>
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<tr>
<td></td>
</tr>
<tr>
<td>Federal</td>
</tr>
<tr>
<td>State</td>
</tr>
</tbody>
</table>

A - Current AASHTO Policy on Design Standards: Interstate System  
B - Current AASHTO Policy on Geometric Design of Highways and Streets  
C - Current NYSDOT Geometric Design Policy for Bridges  
*National Highway System

**Table 19-1**  
Current Bridge Standards

If either the accident history or accident potential indicates the bridge geometrics are unacceptable, the safety problem must be addressed by either widening the structure under a rehabilitation or replacing the existing bridge with a wider structure.
Type of Bridge - Some bridges, by their very type, will signal a probable rehabilitation or replacement strategy. One significant factor is redundancy. NYSDOT gives special consideration to nonredundant bridges where failure of one principal load carrying member would result in probable collapse of the bridge. This consideration includes a review of the type of nonredundant structure and its sensitivity to being nonredundant, the consequences of no action, and the possibility of adding redundancy to the bridge. Some nonredundant structures, such as trusses, are of less concern regarding failure than others, such as two girder bridges with welded construction. The rehabilitation vs. replacement decision should take into account the redundancy of the bridge. Non-redundancy should be a factor in favor of replacement.

Other bridges should also be considered for replacement because of their type of construction, but for a different reason. For example, concrete arches, concrete rigid frames and jack arches are difficult and expensive to rehabilitate because of their monolithic construction. Past rehabilitation work on these types of bridges has been quite costly, so they should generally not be rehabilitated. Also, because of their long life, it is often most cost effective to simply let these bridges "live out" their full useful life.

Another example of construction type impacting rehabilitation vs. replacement decisions are existing stream substructure units without piles that exhibit scour problems. The "no pile" situation may push the decision toward replacement.

Bridge Safety Assurance vulnerability also needs to be taken into account in any rehabilitation/replacement decision. The six vulnerability manuals (Overload, Hydraulics, Steel Details, Concrete Details, Collision and Seismic) should be consulted for further information.

Bridge Standards - When any bridge is considered for rehabilitation, that bridge should be reviewed for compliance with current standards. Existing vertical clearance, horizontal clearance, load capacity, free board, seismic capacity, lane width and shoulder width should be compared to current standards. The hydraulic history of the bridge should also be reviewed. If the existing features are nonstandard, consideration should be given to improving them under rehabilitation or by replacing the bridge. If improvements cannot be made or the improvements that can be made will not meet current standards, a nonstandard feature justification will be required. This should be taken into account when making the rehabilitation vs. replacement decision. See Chapter 2 of the Highway Design Manual for further information on justification of nonstandard features.

Temporary Traffic Control - All bridge work involves managing existing traffic during construction. There may be several feasible alternatives, including detouring traffic around the project site. They may include maintaining traffic on a temporary bridge, maintaining traffic on the existing structure while a new structure is constructed on a new alignment, or maintaining traffic on a portion of the existing structure by stage construction. These alternatives must be carefully considered as to their practicality, overall cost, delay to traffic, and impact on the surrounding community. In some cases, the type of bridge work will be driven by the fact that there is only one practical solution to managing the traffic.
Feature Crossed - The feature crossed can have a significant effect on the type of work chosen and its cost. Environmental or Coast Guard concerns may push the rehabilitation vs. replacement decision in the direction of rehabilitation while hydraulic inadequacies and poor stream alignment may push the decision toward replacement.

Other Factors - Other considerations in the rehabilitation vs. replacement decision may have nothing to do with the structural adequacy of the structure. These considerations are historical, social, political and capacity related. Although not covered in many textbooks, these considerations can and do influence the rehabilitation vs. replacement decision on individual bridge projects. They are difficult to categorize into specific indicators which trigger a particular decision. Consequently, they have not been included in the narrative or worksheet. When these or any other considerations surface on a project, they should be treated as additional subjective factors and given the weight they deserve in the decision process.

In general, all bridge replacement candidates must first be considered for superstructure replacement only. In considering superstructure replacement, the substructures must be evaluated. This evaluation may include reinspection and taking cores to verify their condition.

There may be additional factors on a specific bridge, such as the functional importance of the bridge and how important the bridge is to the overall transportation system of the area. Since many factors involve subjectivity, the people and agencies involved may reach different conclusions. Instead of this being a stumbling block, this can be a good opportunity to discuss differing view points and gain the knowledge and experience of others.

All conclusions drawn in the replacement vs. rehabilitation discussion process must be fully documented in the Design Approval Document.
<table>
<thead>
<tr>
<th>Factor</th>
<th>Review</th>
<th>Prelim. RH/RP* Direction (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Cost</td>
<td>A. Is the rehabilitation cost ≤ 0.65 of the replacement cost?</td>
<td>Yes......................................................RH No.............................................Proceed to I.B.</td>
</tr>
<tr>
<td></td>
<td>B. Is the rehabilitation cost between 0.65 and 0.85 of the replacement cost?</td>
<td>Yes.............................Consider other factors No.............................................Proceed to I.C.</td>
</tr>
<tr>
<td></td>
<td>C. Is the rehabilitation cost ≥ 0.85 of the replacement cost?</td>
<td>Yes......................................................RP</td>
</tr>
<tr>
<td>II. Safety</td>
<td>A. Are there accidents attributable to the bridge geometry or highway approach geometry?</td>
<td>Yes.............................................Proceed to II.B No.............................................RP or RH</td>
</tr>
<tr>
<td></td>
<td>B. If there were accidents, were there any fatalities or is the number of accidents above the Statewide average?</td>
<td>Yes.................RP or RH with corrections to the safety problem No.............................................RP or RH</td>
</tr>
<tr>
<td></td>
<td>C. Is there an accident potential? (Highway, waterway, or railroad)</td>
<td>Yes.................RP or RH with corrections to accident potential problems No.............................................RP or RH</td>
</tr>
<tr>
<td>III. Bridge Type</td>
<td>A. Is the bridge nonredundant?</td>
<td>Yes.............................................RP or RH including adding redundancy No.............................................RP or RH</td>
</tr>
<tr>
<td></td>
<td>B. Does the bridge have fatigue sensitive details?</td>
<td>Yes.................RP or RH removing or modifying critical details No.............................................RP or RH</td>
</tr>
<tr>
<td></td>
<td>C. Is bridge concrete arch, concrete rigid frame, jack arch, etc.?</td>
<td>Yes.................Bridge usually not RH’d No.............................................RP or RH</td>
</tr>
<tr>
<td>IV. Standards</td>
<td>A. Does existing bridge conform to all current standards?</td>
<td>Yes.............................................RP or RH No.............................................Proceed to IV.B.</td>
</tr>
<tr>
<td></td>
<td>B. Can bridge be rehabilitated and brought up to standards?</td>
<td>Yes.................Bridge may be RH’d No.............................................Bridge should be RP’d</td>
</tr>
<tr>
<td></td>
<td>C. Can the nonstandard feature be justified?</td>
<td>Yes.................Bridge may be RH’d No.............................................Bridge should be RP’d</td>
</tr>
</tbody>
</table>
### Bridge Rehabilitation Projects

#### V. Feature Crossed

<table>
<thead>
<tr>
<th>Feature Crossed</th>
<th>If existing bridge is over water, have there been hydraulic problems indicating an inadequate opening or poor stream alignment which would require a span adjustment?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes .................................................................................................................. RP or RH</td>
</tr>
<tr>
<td></td>
<td>No .................................................................................................................. RP or RH</td>
</tr>
</tbody>
</table>

B. Does existing bridge span anything that requires special treatment or are special conditions associated with it, such as a railroad, historic feature, environmentally or politically sensitive feature?

<table>
<thead>
<tr>
<th></th>
<th>Yes .................................................................................................................. RP or RH*</th>
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<tbody>
<tr>
<td></td>
<td>No .................................................................................................................. RP or RH</td>
</tr>
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</table>

* The sensitive feature must be thoroughly examined and considered in RH/RP analysis with special attention to the cost necessary to accommodate the sensitivity.

#### VI. WZTC

<table>
<thead>
<tr>
<th>WZTC</th>
<th>Can traffic be detoured off the project site?</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Yes .................................................................................................................. RP or RH</td>
</tr>
<tr>
<td></td>
<td>No .................................................................................................................. Proceed to VI.B</td>
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</tbody>
</table>

B. Can traffic be maintained on the existing bridge with a new bridge built alongside?

<table>
<thead>
<tr>
<th></th>
<th>Yes .................................................................................................................. RP</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>No .................................................................................................................. Proceed to VI.C</td>
</tr>
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</table>

C. Can construction be staged?

<table>
<thead>
<tr>
<th></th>
<th>Yes .................................................................................................................. RP or RH</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>No .................................................................................................................. Proceed to VI.D</td>
</tr>
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</table>

D. Can a temporary structure be used on the project site?

<table>
<thead>
<tr>
<th></th>
<th>Yes .................................................................................................................. RP or RH</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>No. STOP. All traffic strategies have been rejected.</td>
</tr>
</tbody>
</table>

* RH = Rehabilitate  
  RP = Replace

### Table 19-2

**Bridge Rehabilitation vs Replacement Worksheet**

#### 19.3 Concrete Rehabilitation

Repair of concrete in rehabilitated structures can be a very complex subject. Only a few topics are discussed in this manual. For information on specific applications and repair techniques, the designer is urged to contact the Materials Bureau. Also, for information on Fiber Reinforced Polymer repair, see Structures Design Advisory 02-002 and Engineering Instruction EI 05-001.

An important factor to keep in mind for a rehabilitation project is that the quantity of concrete repair necessary will almost always increase between the time of inspection and the time the work is performed. The designer needs to exercise judgment in the rate of deterioration when preparing the estimate of quantities.
19.3.1 Concrete Scaling

There are two kinds of hardened concrete scaling: surface and deep. The probable causes of deep scaling are lack of entrained air or an improper water to cement ratio. Treatment options are to either place a bonded concrete encasement around the affected area or to replace the concrete entirely.

Surface scaling is generally caused by improper construction techniques, such as watering the concrete during finishing. If detected early, regular sealing of the surface may inhibit scaling. Otherwise, a bonded concrete encasement can be placed or the concrete surface can be ground out and a new surface installed. Another possible option is to ignore the problem until the scaling becomes severe enough to warrant replacement.

When concrete is placed against soil with a high sulfate content, the chemical attack causes surface scaling that progresses to deep scaling. The only treatments for this type of attack are to place a bonded concrete encasement or complete replacement.

19.3.2 Concrete Spalling

When reinforcing steel in concrete corrodes, the volume of the reinforcing bar increases. This expansion causes tensile stresses on the concrete surface which leads to a regular pattern of cracks and spalls over the entire surface. The possible treatments are to patch the surface, replace the concrete with a thicker cover, or completely replace the concrete.

If the concrete is batched with aggregate that is not chemically inert with the cement, a pattern of map cracking and spalling can develop. Treatments for this condition are either to place a thicker cover over the reinforcing bars or the complete replacement of the concrete.

Another cause of concrete spalling is the combination of freezing temperatures and water penetration into the pores, cracks, voids, or porous stone aggregates of the concrete. This cycle of freezing and thawing causes spalls and popouts of the concrete surface as the water freezes and expands below the surface of the concrete. Treatment for this condition is to provide proper drainage to prevent ponding of water on the surface, patch or replace all cracks and spalls, or to provide a bonded concrete encasement or overlay.

19.3.3 Concrete Cracking

The causes of cracking are the same as for spalling, with the addition of drying shrinkage and structural distress. Under drying shrinkage, tension develops on the surface of the concrete as the volume of the concrete decreases as the concrete cures and water evaporates from the surface. These cracks can range from singular cracks in thin narrow members, to craze or map cracking for deeper members. Singular cracks can be treated by epoxy injection, flexible sealant, complete replacement, or encasement with reflective crack control. Craze or map cracking can be treated by either surface replacement or placement of bonded concrete.
Under structural distress, concrete produces singular cracks when subjected to excessive loads, unanticipated settlements, or insufficient reinforcement. Treatments for this failure are to reduce the loads, correct the settlement, add pressure relief joints, replace the concrete with proper reinforcement, epoxy inject to bond fresh cracks, or stitching.

Treatment of concrete cracks may depend on the type and size of the crack. The two types of cracks are working cracks and nonworking cracks. The width of a working crack, such as a transverse deck crack, changes due to applied loads or temperature effects. The width of a nonworking crack, such as shrinkage cracks in an abutment stem, does not change.

Silane sealer should be applied to both working and nonworking cracks up to 0.012”. Cracks greater than 0.012” require removal and replacement with a thin bonded concrete overlay. If only occasional cracking occurs, it may be more cost effective to rout and seal or inject as follows:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Working Cracks</th>
<th>Nonworking Cracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal with Epoxy Injection</td>
<td>Not Applicable</td>
<td>≥ 0.002” to 1⁄8”</td>
</tr>
<tr>
<td>Rout and Seal with Silicone</td>
<td>3⁄8” to 1½”</td>
<td>3⁄8” to 1½”</td>
</tr>
</tbody>
</table>

Table 19-3
Concrete Cracking Treatments

19.3.4 Concrete Sealers

Sealers can be a cost-effective means of inhibiting corrosion of uncoated reinforcing steel, steel with too little concrete cover, or steel embedded in concrete which exhibits hairline cracks. However, sealers are not considered a cost-effective means of inhibiting corrosion when applied to mature concrete of standard quality that utilizes other means of corrosion protection, such as epoxy-coated steel, specialty overlays, etc. Also, sealers cannot be used below grade or below the water line, because they provide no protection when submerged.

There are two types of sealers: coating and penetrating. Penetrating sealers should normally be selected as they are more effective in blocking the ingress of water and chlorides and are less expensive than coating sealers. When a penetrating sealer is applied to concrete, it penetrates the surface, chemically bonds to the concrete, and inhibits the intrusion of water and chlorides. Because penetrating sealers bond below, not on, the surface, they are not abraded away easily. Coating sealers should only be used when a uniform appearance is necessary (e.g., when sealing over partial “patch” repairs). Coating sealers can provide a uniform color to hide underlying repairs while providing protection. They should not be used on newly constructed concrete structures, unless the intended color of the new structure is other than grey.
Usage Guidelines: Apply a protective sealer according to Item 559.1696—18 to all other concrete elements vulnerable to chlorides and characterized by one or more of the following conditions: uncoated reinforcing steel, less than the current standard design concrete cover, hairline cracks (0.007” wide or less). All repairs to concrete elements with a history of corrosion related distress should also be sealed according to Item 559.1696—18. These elements include, but are not limited to, concrete barriers, concrete pier protection, columns, piers, wingwalls, retaining walls, and substructure elements under deck joint systems. The application of concrete sealers is important in marine environments and along coastal waters where salt water spray is prevalent. Do not apply sealers to areas of concrete elements which will be more than 1 ft. below grade or under water.

19.4 Steel Rehabilitations

Once the decision has been made to rehabilitate a steel superstructure, several design considerations must be examined. These pertain especially to structures riveted and fabricated before circa 1957. It is critical to field verify the principal controlling dimensions of the structure.

19.4.1 Deck Replacements

A large number of skewed steel girder superstructures were constructed with staggered diaphragms in the past. Plate girders with thin webs (< ⅜”) and staggered diaphragms have shown a tendency to form web cracks adjacent to the web plate snipe due to out of plane bending. Due to this issue, when designing a deck replacement on a steel superstructure with staggered diaphragms, designers shall either detail replacement of the staggered diaphragms with ones that are in-line and follow the current standards or detail a retrofit that alleviates the stress concentrations in the area of the fatigue prone detail. The determination of which approach to take shall be made on a case by case basis.

For additional information, see Inspection Technical Advisory 02-001.

19.4.2 Structure Widening/Stage Construction

It is imperative when designing additional girders for a structure widening where the existing deck is not being replaced that the deflected profile of the new girders match the profile of the existing girders. For example, the new girders should not include camber for superimposed dead load if the existing girders were not cambered for that load. The designer must provide for differential deflection between existing and new girders.

Constructability of the structure or widening should be carefully considered. Shop and field welded joints should be worked out so that the sub assemblies fabricated are able to fit properly in the field. Only fillet welds and complete joint penetration welds should be shown. The existing steel to be welded may require special preheat because of its chemistry. In many cases it is better to design bolted details.
When designing connections, interference with other members should be considered. This is also true when making spans continuous for live load or full dead load. Welding of stiffeners is not allowed to the splice plates. Lateral gusset plates may have to be moved.

19.4.3 Painted vs. Unpainted

Special consideration should be given to blast cleaning requirements and the specifications governing the painting or coating of the new structure. Often, because of the nature of the work, the existing and new structures will be painted using different items. The limits of each controlling item should be clearly shown on the plans.

19.4.4 Fracture-Critical Member (FCM) Work

When dealing with FCMs, such as large floorbeams in a truss or column connections, the process of structure reassembly must be considered. The structure must be erected such that there are no unaccounted for internal stresses induced by the assembly sequence. To ensure this “zero stress” state, the system may require erection shoring, or the system may be assembled in the shop and transported to the site.

Steel available at the time of original construction will most likely not have the strength, toughness and fatigue life of the steels used today. Special inspection may be needed for the determination to reuse the existing steel. The extent of deterioration should be carefully considered for the lead time of the contract plans. If the project is not anticipated to begin for two years and to be completed for four years, the additional amount of corrosion should be anticipated and compensated for in the design. Steels used in main members should be ordered to the correct level of strength and toughness. For main members, the material should specify Charpy V Notch (CVN) requirements for FCM Zone 2 and reference the direction of rolling (See SCM Section 507).

19.4.5 Rehabilitation of Riveted Structures

The following considerations should be addressed during design of riveted structures that will be rehabilitated:

- It is important to consider the original construction, and the need to bring the structure up to the current AASHTO code requirements for strength, service life, and fatigue resistance. Riveted connections in structures are classified as Category D for fatigue resistance per the AASHTO Specifications. In order to upgrade this classification, removal of all rivets, reaming all holes, and installation of oversized bolts is necessary. In lieu of retrofitting, remaining fatigue life may be calculated using the Section 7 of the AASHTO Manual for Bridge Evaluation. If the calculated remaining safe life exceeds the remaining expected service life of the structure, further work is not required if the component is in good condition.
• An in-depth inspection of the steel and riveted connections should be performed during preliminary engineering. The extent of deterioration that is documented in the in-depth inspection shall be clearly identified on the contract plans. Pack rust should be noted in the in-depth inspection, as it is a critical issue for riveted structures. Even a very small amount of pack rust can increase substantially in period of only a few years and will have a major impact on the serviceability of the bridge. It is essential that any pack rust, no matter how slight, be identified.

• Use of bolted repairs is preferred on most riveted bridge rehabilitation projects, because of the difficulty and cost associated with welding older steels.

• Types of Repairs:

  **Removal of Rivets and Replacement with High Strength Bolts:**

  The determination as to when to replace individual rivets in built-up structural elements is based mainly on the section loss of the rivet head. An estimate based on a field survey should be used to determine the quantity of rivets to be replaced. This shall be detailed on the contract plans. It is recommended that this estimate be increased to take into account unknown or unforeseen field conditions, as it is not uncommon for this percentage to go to 100% where rivets are concealed by the deck.

  Designers should contact the Metals Engineering Unit for rivet removal and replacement notes and details to be placed on the contract plans.

  Total quantities shall be confirmed by the E.I.C., and paid for under Item 586.05.

  **Coverplated Repairs of Riveted Members:**

  Cover-plating should be considered for the repair of localized areas of deterioration, such as the ends of stringers under joint systems, when the deck and bearings are being replaced, when the remainder of the structural element is in good condition, and/ or when the replacement of the entire element does not fall under the scope of the project. Since existing rivet holes are rarely available for these new connections, it is recommended that new cover-plates with full size shop drilled holes be provided for field use. After assembly and alignment, the holes in the new steel shall be used as a template to field drill new holes in the existing steel.

  It is important that designers clearly define all holes to be field drilled on the contract plans, as the Contractor will be paid for each designated hole location. Additionally, the following note should be placed on the associated contract drawings:

  “The Contractor shall be provided one payment for each hole location designated to be field drilled, regardless of the number of plies field drilled.”
Field drilling existing steel to be included under Item 586.10; and installation of new steel coverplates and bolts to be paid for under Item 564.51nnn.

**Replacement of Members, Member Components, and Member Connections:**

Based on the extent of deterioration, consideration should be given to replacing the existing member components and connections with new steel sections and high strength bolts.

Generally, new steel that will mate to existing steel shall be brought out to the field blank (without predrilled holes). Thereafter, rivet holes in the existing steel shall be used as a one time template to core drill full size holes in the new steel. This method is preferred by both Contractors and NYSDOT as it simplifies fabrication, expedites construction, and provides the hole quality required by the SCM.

Another less preferred and more time consuming approach is to use templates to fabricate the replacement element. This method requires the contractor to disassemble the connection, create a template of the existing rivet pattern, and then fabricate a replacement element. This method can only be used when the bridge can be closed to traffic and the use of temporary supports is possible.

Removal of existing steel and associated connections shall be paid for under Items 589.01nnnn or 589.52nnnn; drilling new steel to match existing holes shall be included under Item 564.xx; and installation of new steel and new bolts shall be paid under Item 564.xx.

A legend specifying payment items and sections showing the locations where existing holes are to be used for the repair shall be clearly defined on the contract plans.

**Additional notes to designer:**

1. Where deterioration is found in riveted primary members (multi-girder), designers should review the project scope. If the deck is being replaced as part of the same project, replacement of existing riveted members with new steel may be faster and more cost-effective.

2. For non-redundant two-girder structures with floor beams, replacement may not be an option.

3. As repairing riveted members tends to be very costly, an analysis shall be performed to determine the cost benefit of repairing rivet holes versus replacing the elements. Rivet replacement and field drilling both cost in the range of $50 per hole, and a fairly simple repair on a plate girder can have 100 holes.

4. Note that the cost of temporarily supporting a member during rivet removal may be higher than the cost of repairs.

5. Projects that involve riveted structures should have the required work determined after the In-depth Inspection is done. Biennial inspection data is usually not precise enough to accurately estimate the cost or scope of work on the rehabilitation of a riveted structure.
19.4.6 A7 Steel Retrofits or Replacement

It is recommended to replace existing A7 steel with ASTM A709 Grade 36 or Grade 50 whenever possible. FCM Zone 2 steel should be used for FCM members.

If A7 steel is to be retained and welding is to be considered, a chemical analysis should first be performed in order to determine the Carbon Equivalent (CE). This is because the ASTM A7 specification did not contain limits for carbon or other commonly used alloying elements and a higher CE negatively affects weldability. The CE shall be calculated using the following formula:

\[
CE = C + \frac{(Mn+Si)}{6} + \frac{(Cr+Mo+V)}{5} + \frac{(Ni+Cu)}{15}, \text{ where}
\]

- \(C\) = Carbon percentage
- \(Mn\) = Manganese percentage
- \(Si\) = Silicon percentage
- \(Cr\) = Chromium percentage
- \(Mo\) = Molybdenum percentage
- \(Mo\) = Molybdenum percentage
- \(V\) = Vanadium percentage
- \(Ni\) = Nickel percentage
- \(Cu\) = Copper percentage

(Source: AWS D1.5 Bridge Welding Code, 2010)

The CE value is used along with plate thickness to specify preheat and interpass temperatures for all welding onto A7 steel, including studs. Table 19-4 shall be used to specify the temperature values. For dissimilar plate thicknesses, the thicker value shall be used. If no chemical test is performed, a CE of 0.55 is to be assumed.

<table>
<thead>
<tr>
<th>CE, %</th>
<th>Plate Thickness, inches</th>
<th>Preheat and interpass Actual Temperature F°</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.40 max</td>
<td>Any</td>
<td>50</td>
</tr>
<tr>
<td>0.41 to 0.45 inclusive</td>
<td>To 1 ¼ inclusive</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Over 1 ¼</td>
<td>100</td>
</tr>
<tr>
<td>0.46 to 0.55 inclusive</td>
<td>To 1 ¼ inclusive</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>1 ¼ - 3</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>Over 3</td>
<td>300</td>
</tr>
<tr>
<td>Over 0.75</td>
<td>Any</td>
<td>No Welding Permitted</td>
</tr>
</tbody>
</table>

Table 19-4
Preheat and Interpass Temperatures for A7 Steel

If A7 steel is to be retained and welded, the following note shall be added to the plans with the appropriate temperature from Table 9-4:

BEFORE AND DURING ANY WELDING OPERATION TO A7 (INCLUDING SHEAR STUDS), THE STEEL SHALL BE HEATED TO A TEMPERATURE OF XXX DEGREES FAHRENHEIT.
19.4.7 Fatigue

If fatigue sensitive details (AASHTO category D, E, or E’) fall within the scope of the work, they shall be analyzed for remaining life using accepted methods. Notch effects, such as rivet holes and nonradius cuts, cause stress increases. The designer should consider removing or retrofitting all poor details, fatigue sensitive details and stress risers of all types. Lateral connection plates should not be welded to tension flanges. Rivet holes should be made round by reaming to eliminate crack initiation sites. Often when widening or connecting two new structures, new load paths are created. The designer should carefully consider the stiffness of the new members and how the older adjacent members should be strengthened in order to carry the new loadings.

19.4.8 Partial Length Coverplate Retrofits

There are many existing highway bridges with steel beams constructed prior to the recognition of the low fatigue resistance of partial length cover plates.

When rehabilitating structures with partial length coverplates calculate the remaining fatigue life in accordance the Section 7 of the AASHTO Manual for Bridge Evaluation. If the remaining fatigue life is inadequate, the beam coverplates should be retrofitted using the end bolted detail shown in Fig. 10.3.1C in the NYSDOT Standard Specifications for Highway Bridges or Fig. 6.6.1.2.3-1 in the NYSDOT LRFD Bridge Design Specifications or use Ultrasonic Impact Treatment. When adding cover plate retrofits designers need to verify that the minimum allowable vertical clearance is not violated.

Designers can contact the Metals Engineering Unit for the cost information associated with this retrofit

19.5 Continuity Retrofit

19.5.1 Feasibility

Continuity retrofits require DCES approval and should not be considered for structures with skews greater than 30 degrees.

During a rehabilitation project, the expansion joint at a pier can be eliminated by splicing the simple spans together to form a continuous girder. Benefits include reducing the possibility of deterioration of the girder and substructure due to a leaky joint, increasing resistance to seismic displacements, and slightly improving the load carrying capacity of the superstructure.

However, continuity retrofit can result in undesirable structural performance characteristics that must be addressed in the design. Increased vulnerability to fatigue may result due to areas of the existing beams being subjected to stress reversals and higher stress ranges compared to simple span behavior. The end regions of retrofitted girders originally designed for simple span positive moments of small magnitude are subjected to larger magnitude negative moments. While the deck joints over the interior supports are eliminated, the deck in this area is subjected to tension under service loads and crack control measures must be considered. Continuity can also increase seismic loads on individual piers depending on bearing fixity configurations.
The scope of a project may help determine when it is appropriate to retrofit two or more simple spans into one continuous span. For a rehabilitation that involves a deck overlay only, the extra cost of concrete removal required to retrofit the simple span may be beyond the project scope. However, if deck scarification, deep removal and joint replacement are also scheduled as part of the rehabilitation, a cost assessment should be done to determine if retrofitting the simple span girders to be continuous is reasonable. Complete deck replacement projects provide excellent opportunities to include girder retrofit since the girders will be readily accessible and the future costs of maintaining the joints will be eliminated. The cost of providing continuity retrofits for full deck replacement projects should be compared to the cost of replacing the girders. This is particularly relevant when the cost of cleaning and painting the existing steel is required for the retrofit alternate.

19.5.2 General Design Considerations

19.5.2.1 Full Continuity vs. Continuous for Live Load

When considering using a continuity retrofit, a decision must be made whether the girders will be made fully continuous or continuous for live load only. Representative details of a fully continuous and a continuous for live load retrofit splice are shown in Figure 19.1.

Compared to continuous for live load only designs, fully continuous retrofits require more complex splice and retrofit details. However, a retrofit that provides full continuity for both dead and live loads is advantageous because the combined girder should behave like a conventional continuous girder. Since this retrofit requires so much more of the girder to be exposed in the area of the splice, a fully continuous retrofit should only be done in conjunction with a full deck replacement. Another benefit is that the existing two lines of bearings at the pier can be replaced by a single bearing line.
Figure 19.1
Typical Retrofit Details
On the negative side, the existing beam sections adjacent to the pier may not be able to adequately resist the increased moments and shears associated with a continuous beam without supplemental cover plating. If a fully continuous retrofit proves to be structurally difficult or uneconomical, an alternative is to make the span continuous for live load only (see Design Guideline No.16, below).

Continuous for live load retrofits adapt well structurally to situations where the deck is being retained. Although the splice details are simpler than those for fully continuous retrofit, two lines of bearings must be retained at each splice.

Continuous for live load designs in conjunction with complete deck replacements require a deck placement sequence consistent with the design assumptions. All such design assumptions, including a construction sequence, shall be clearly documented in the contract plans as well as reflected in the design load, moment and shear, and haunch tables. In some cases, the continuity splice for continuous for live load designs may not accommodate a future continuous deck replacement unless the deck removal and replacement follows the original continuous for live load design assumptions. Such sequences could require loosening and reinstalling the splice. Alternatively, continuous for live load retrofits can be designed to accommodate unrestricted full deck replacements. (See Design Guideline No. 17, below).

19.5.2.2 Fatigue Considerations

Continuity retrofits often put fatigue sensitive details originally intended to only be in compression into tension and/or stress reversal. All connection details in areas of tension or stress reversal should be analyzed for the stress ranges induced by the retrofit. Details of particular importance to check are butt welded splices, partial length cover plate ends, welded lateral gusset plate connections, connection plate/stiffener welds and shear connector welds in tension or reversal zones. Nondestructive testing should be performed on butt welded top flange splices to ensure weld soundness. Upgrading of fatigue sensitive details using bolted over-splicing of partial length cover plate ends should also be considered to meet the allowable fatigue stresses as per Article 10.3 of the *Standard Specifications for Highway Bridges*. Excessive fatigue stresses or unreasonable costs to upgrade fatigue sensitive details may dictate that a continuity retrofit not be performed. Riveted girders should not be retrofitted for continuity due to their uncertain fatigue performance and difficult splice detail requirements.

19.5.2.3 Detail Verification

As-built plans and/or shop drawings should be reviewed followed by a thorough site inspection making note of material condition, fatigue prone details, utilities, geometry, girder alignment, and possible paint removal and containment considerations.
19.5.3 Design Guidelines

1. The retrofitted span should be analyzed as fully continuous or continuous for live load to determine the new moments and increased shears induced over the interior support. The bolted flange splices shall be designed to carry the new moments, while the web splice shall be designed to carry the increased shear. The existing piers and bearings (if being retained) shall be analyzed for the increased reactions due to continuity. As a minimum, the splice is made the same section size as the beams.

2. Continuity retrofits should be designed for an HS 20 live load. Upgrading the superstructure to an HS 25 design is not required.

3. One method of increasing the design moment capacity of the continuous girder is to increase the girder's section properties by adding bolted cover plates to the flanges of the existing girders.

4. The negative moment capacity of the girder may be enhanced by considering the girder over the pier as a composite section. Using this method, the longitudinal reinforcing steel in the deck is included in computing the composite section properties. If not damaged, the stud shear connectors for the simple span beams may be left in place during deck removal operations. In most cases, the existing shear connectors are adequate to provide composite action in the negative moment region between the girder and the longitudinal reinforcing steel in the deck. Spiral shear connectors should be replaced with stud shear connectors because of the difficulty of removing concrete around the spirals.

5. For both fully continuous and continuous for live load retrofits, additional longitudinal reinforcing steel must be installed in the tension regions of the continuous deck. If the full deck is not being replaced, a portion of the existing deck concrete over the interior supports shall be removed to install the additional reinforcement. The deck concrete shall then be replaced as a continuous placement after the girder continuity splices are installed. For fully continuous retrofits, the provisions of the Standard Specifications for Highway Bridges (Art. 10.38.4.3) should be applied. This negative moment deck reinforcement should extend to the points of dead load contraflexure plus the development length. For continuous for live load retrofits, the reinforcement needs only to extend to where the combined dead load plus the negative live load moments equal zero, plus the development length. The minimum continuous for live load reinforcement provided may be per Standard Specifications for Highway Bridges (Art. 10.38.4.3) or be based on concrete crack control requirements.

6. Filler plates may be used to make up differences in thickness between flanges or between webs to be spliced. The minimum filler plate thickness allowed is \( \frac{1}{8} \)" (Note: This allowance of filler plates for continuity retrofit splices is an exception to the NYSDOT general prohibition of their use in girder bolted splices). Machined splice plates have been used to make up thickness differences, however, these plates are more expensive than filler plates and generally not necessary.
7. Bolts through the bottom flanges must be arranged to avoid interfering with the bearing(s). The use of countersunk bolts through the bottom splice plates in the area over the bearing may reduce this interference, as well as reduce the length of the splice.

8. Installing the splice may require removing the existing end diaphragms and bearing stiffeners. A new line of diaphragms and bearing stiffeners should be placed over the centerline of the new bearings. Rolled beams may not have bearing stiffeners. In this case, new bearing stiffeners should be designed and installed to provide support and stiffness. New bearing stiffeners shall be bolted to the web splice assembly.

9. The remaining expansion joints on the structure, if there are any, should be checked to verify that they can handle the thermal expansion of the continuous girders. If it is determined that new joints are required, they should be designed with the current design procedure for expansion joints.

10. The existing pier shall be analyzed for any increased longitudinal or seismic loading caused by the continuity retrofit. Current seismic retrofit criteria should be reviewed. Pedestals and capbeam repair or replacement may be required due to deterioration of pier concrete below the joint connecting the simple spans or due to new bearing and pedestal requirements.

11. The designer shall consider the constructability, variations in girder alignment and end gap differences between adjoining girders. The designer should consider larger splice plates to provide extra edge distance for field fit-up. Field confirmation of dimensions and steel condition is essential.

12. Caution is advised when using continuity retrofits with stage construction. The design must carefully consider construction sequencing. Each stage shall be structurally independent during the retrofitting process. In no case shall two simple spans be attached to a deck continuous over a pier. Diaphragms in the bay between the staging need to be temporarily disconnected.

13. Continuity retrofits have been installed on a few bridges with horizontally curved decks and straight girders set on chords. Such retrofitting should be considered only when the angle between beams to be spliced is small (i.e., less than 4°). Flange splice plates must be cut to fit the splice geometry or oversized plates may be used if dimensions permit. Bent plates are used for the web splice. Lateral force effects from the angled continuous beams must be considered in investigating the retrofit details and bearings.

14. For a retrofit made in conjunction with a full deck replacement, a new deck haunch table using continuous concrete dead load and super-imposed dead load deflections shall be provided. The haunch table shall be developed in conformance with the design assumptions (fully continuous or continuous for live load) and proposed deck placement sequence. Corresponding moment and shear tables shall also be provided.
15. A fully continuous retrofit includes replacing the existing two lines of simple-span bearings with one line of bearings for the continuous girder. When replacing the bearings, care must be taken to insure that the elevation of the superstructure remains the same. Tapered sole plates may be required to maintain proper grade and elevations. The pedestals may also have to be modified or replaced. If space constraints hamper work on the existing pedestals, height adjustments may have to be made in the bearing plates. A construction sequence for lifting girders and installing bearings shall be provided on the plans.

16. For continuous for live load retrofits, the two lines of bearings from the existing simple span configuration are retained. Only the girder flanges need to be spliced. The top flange splice shall be made using conventional bolted splice plates. The bottom (live load compression) flange splice may be bolted, or be achieved using a compression block fitted and welded between the flange ends. Continuous for live load retrofits require that the deck be in place, except for the areas over the piers, prior to installing the splice. Continuity closure pours over the pier are then placed after splicing the girders.

17. It is advisable to check the behavior of continuous for live load retrofits for a future full deck removal and replacement. Removing a continuous for live load deck will impart a positive moment into a continuity splice that was primarily designed for negative live load plus superimposed dead load moments only. Uplift at the pier bearings is also theoretically possible upon removing the deck. Normally, this load case should not be a problem since the reduced stiffness of a continuous for live load splice relative to the girders as a whole should minimize the magnitude of this moment redistribution. This behavior would only occur during a temporary construction condition, therefore some overstress allowance is reasonable. Similar behavior during a future deck replacement could also occur with fully continuous retrofits that were installed while the existing deck was retained.

19.6 Truss Rehabilitation

Early involvement with the Metals Engineering Unit is highly recommended on all truss rehabilitation projects. The following should be addressed during design:

- It is important to consider the original construction, and the need to bring the structure up to current AASHTO code requirements for strength, service life, and fatigue resistance.

- An in-depth inspection of the steel needs to be performed during the scoping phase and the extent of deterioration must be clearly identified on the contract plans.

- The steel used on many trusses fabricated before the advent of modern carbon steel does not have the weldability or the resistance to fatigue that the replacement steel adds to the structure. In some instances it is important to consider the retrofit or reconfiguration of the design connections because of the level of stress that the stronger steel will introduce. This may require the replacement of more steel in order to have a fatigue resistant load path.
Welded repairs for older steels are cost prohibitive due to the very rigorous controls required on the welding processes. Therefore, bolted repairs should generally be specified on most truss rehabilitation projects.

When trusses have pre-existing welded repairs to tension members, or other welded attachments to tension members, these welds shall be removed and ground flush. In the case of I-bar structures, these details can introduce serious defects in the fracture critical members. For these cases, repair procedures should be requested from the Metals Engineering Unit.

Contract plans shall identify all main members in tension.

Fracture critical truss members shall be called out in a separate listing. This callout requires the contractor to follow the fracture critical control plan during fabrication. Fracture critical members include the bottom chord of the truss (in tension areas), the vertical and diagonals in tension, and in some truss configurations may include the end portals. Additionally, floorbeams shall be considered fracture critical when the center-to-center spacing exceeds 12 feet.

### 19.7 Seismic Rehabilitation

All bridges that are scheduled for rehabilitation shall be evaluated with regard to seismic failure vulnerability. The purpose of this evaluation is to assess seismic retrofit measures and to incorporate into the rehabilitation plans those measures deemed warranted to eliminate or mitigate such failure vulnerability. (See the *Bridge Safety Assurance Seismic Vulnerability Manual*.) Policy and specifications for seismic design and rehabilitation are contained in the *Standard Specifications for Highway Bridges*. 
Appendix 19A
Rehabilitation Preliminary Checklist

A. Plan

Show rehabilitation generally. However, existing conditions may be shown if needed for clarity.

☐ Bridge HCL and stationing, increasing left to right
☐ Centerline of feature crossed
☐ North Arrow
☐ Station equality (over/under)
☐ Approach Slab, indicate length
☐ Pressure relief joints with concrete approach pavement
☐ Light Poles and signs
☐ Slope lines, toe of slope
☐ Names of roads
☐ Scuppers and or Catch Basins
☐ Utilities (overhead and underground)
☐ Skew
☐ Bridge Joints, show type
☐ Adjacent topography
☐ Theoretical grade line locations
☐ Bridge begin and end stations
☐ Abutments - ℄ Bearings
☐ Piers - ℄ Bearings
☐ Bridge curbs (identify type)
☐ Bridge pavement lanes and traffic directions
☐ Superstructure
☐ Bridge railing
☐ Approach railing
☐ Approach shoulders
☐ Ditches
☐ Direction of channel flow (could be tidal)
☐ Dolphins and fender systems
☐ Navigation lights (location, type, color and size)
☐ Scour Protection (limits, type and size)
☐ Channel Alignment
☐ Locate point of minimum vertical clearance in plan
B. Elevation
Show directly under and projected down from the plan, unless a larger scale is required.

- Bridge railing type
- Approach railing
- Railing transition
- Superstructure
- Abutments
- Dolphins & fender systems
- Piers
- Scour protection (location, type, and size)
- Slope protection key detail
- Light poles (only if on structure)
- Bearings, fixed and expansion (indicate type)
- Road section beneath bridge
- Minimum vertical clearance
- Minimum horizontal clearance
- Navigation lights (location, type, color & size)
- Contract limits (may be shown on profile)
- Substructure foundations (piles, spread footing, etc.)

C. Bridge Section
Show a section for each different bridge section. (Existing, Stage(s), Final)

- Orient looking up station
- Removal item numbers
- New item numbers
- Cross slope
- Curb type and curb height
- â€¢ of strs., TGL, point of rotation (p.o.r.), station line, and H.C.L.
- Sidewalk dimensions
- Lane dimension, shoulders and medians
- Out-to-Out dimension
- Stringer spacing and type
- Type of railing or parapet and fencing
- Pavement type and thickness - (Membrane and Type)
Rehabilitation Preliminary Checklist

☐ Deck thickness
☐ Identify utilities and conduits carried on bridge
☐ Limits of sawcut grooving of slab and penetrating sealer
☐ Pier type: solid, column, aesthetic treatment, fender system
☐ Longitudinal deck joints and closure pours
☐ Temporary support systems

D. Bridge Approach Section:

☐ Orient looking up station
☐ Removal item numbers
☐ New item numbers
☐ HCL
☐ Lane dimensions
☐ Shoulder and sidewalk dimensions
☐ Guide rail and type
☐ Cross slope
☐ Side slope
☐ Theoretical grade line
☐ Pavement type
☐ Subsurface layers
☐ Curb type and dimensions
☐ Limits of sawcut grooving of approach slab and penetrating sealer
☐ Shoulder type and approach slab width

E. Highway Section:

The highway section shall be beyond the approach section; the highway designer shall indicate all items in the highway plans. Do not show item numbers here.

☐ Orient looking upstation
☐ ✴, T.G.L., station line, and P.O.R, H.C.L...
☐ Lane dimensions
☐ Shoulder and sidewalk dimensions
☐ Curb dimensions
☐ Mall dimensions
☐ Pavement slope
☐ Shoulder slope and sidewalk slope
☐ Side slope
☐ Slope protection
☐ Curb and guide rail type
F. **Under Section:**
   Usually shown in elevation (Existing, Proposed)

Road Under:
- Centerline, station line and T.G.L.
- Lane dimensions
- Shoulder dimensions
- Curb dimensions
- Mall dimensions
- Pavement slope
- Shoulder slope
- Side slope
- Slope protection
- Guide rail protection
- Horizontal offsets to piers, abutments and/or ditch lines

Channel Section:
- Centerline & TGL Location
- Scour protection (location, type and size)
- Slope protection (geotextile bedding, stone fill type and key)
- Side slope
- Channel dimensions, fish dish if applicable

Railroads:
- All pertinent track dimensions, if applicable
- Minimum vertical clearance over RR clearance point
- Minimum horizontal clearances to Piers and Abutments
- Indicate crash wall if needed (unless railroad has waived)

**NOTE:** For C, D, E and F, the following shall apply:

1. If symmetrical, show existing left of t, and proposed right of t, for D, E, and F.
2. If unsymmetrical, show complete existing and complete proposed sections for D, E, and F.
3. Show complete existing, each stage, and proposed section for C.

G. **Flag Profile of Bridge:**
   No scale, no datum, exaggerate at one or two PVIs in vicinity of bridge. Show existing and proposed flag profiles if they differ.
Rehabilitation Preliminary Checklist

☐ Station PVI
☐ Elevation PVI
☐ Vertical curve length
☐ Grades
☐ Middle ordinate
☐ Sight distance (SSD and HSD)
☐ Banking diagram
☐ Limits of work
☐ Equality stations

H. **Flag Profile of Road Under or Channel:**

No scale, no datum, flag at one PVI.

☐ Station PVI
☐ Elevation PVI
☐ Middle ordinate
☐ Vertical curve length
☐ Grades
☐ Sight distance (SSD or HSD)
☐ Banking diagram
☐ Equality stations

I. **Profile of Railroad**

☐ Profile of control rail (specify)
☐ Top of existing or proposed rail
☐ Track number
☐ Equality stations

J. **Vacant**
K. Horizontal Curve Data:

☐

<table>
<thead>
<tr>
<th>SIMPLE CURVE DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC or PT Station</td>
</tr>
<tr>
<td>Radius</td>
</tr>
<tr>
<td>Length of Curve, Lc</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SPIRAL CURVE DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS Station</td>
</tr>
<tr>
<td>Radius</td>
</tr>
<tr>
<td>Length of Curve, Lc</td>
</tr>
<tr>
<td>Length of Spiral, Lc</td>
</tr>
</tbody>
</table>

L. Hydraulic Data:

☐ Include the table whenever data is available. When a hydraulic analysis is not required, include a statement indicating that the Regional Hydraulics Engineer has done a hydraulic evaluation and has addressed hydraulic adequacy of the existing structure and its vulnerability to scour, ice, and debris.

<table>
<thead>
<tr>
<th>HYDRAULIC DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage Area = (sq. miles)</td>
</tr>
<tr>
<td>Recurrency Interval (yrs.)</td>
</tr>
<tr>
<td>Peak discharge (ft³/s)</td>
</tr>
<tr>
<td>High Water Elevation @ Pt. of Max Backwater</td>
</tr>
<tr>
<td>Avg. Velocity Thru Structure @ Design Flood = (ft/s)</td>
</tr>
<tr>
<td>Temporary Structure Note............ ...... ....Area: Loading:</td>
</tr>
</tbody>
</table>
M. Load Rating:

☐ □

<table>
<thead>
<tr>
<th>LOAD RATING (LOAD FACTOR DESIGN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inventory</strong></td>
</tr>
<tr>
<td>HSXX</td>
</tr>
<tr>
<td><strong>XX.X Ton</strong></td>
</tr>
<tr>
<td><strong>Operating</strong></td>
</tr>
<tr>
<td>HSXX</td>
</tr>
<tr>
<td><strong>XX.X Ton</strong></td>
</tr>
</tbody>
</table>

N. Tear Sheet Notes:

General Notes:

☐ Design Specifications: Current New York State Department of Transportation Standard Specifications for Highway Bridges. (For design purposes, f'c shall be 3000 psi for reinforced concrete unless otherwise approved by DCE(S).


☐ Live Loading: __________

☐ Functional Classification: __________

☐ This project will be progressed under (identify funding source and/or procedure).

☐ Indicate Railing Design Service Level (TL-2, TL-4, or TL-5; formerly PL-1, PL-2, or PL-3).

Bridge Estimate

☐ Bridge Rehabilitation Cost = $__________

☐ Cost of MP&T = $__________

☐ Utilities (Bridge Share) = $__________

☐ Channel Work (Bridge Share) = $__________

Total Bridge Share = $__________

Temporary Structure = $__________

Removal of Superstructure = $__________

Removal of Substructure = $__________

January 2008 19A-7
**Vulnerability Assessment**

If vulnerability ratings have not been done, they should be completed now.

☐

<table>
<thead>
<tr>
<th>Mode</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic</td>
<td>X</td>
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<tr>
<td>Overload</td>
<td>X</td>
</tr>
<tr>
<td>Collision</td>
<td>X</td>
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<tr>
<td>Seismic</td>
<td>X</td>
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<tr>
<td>Steel Details</td>
<td>X</td>
</tr>
<tr>
<td>Concrete Details</td>
<td>X</td>
</tr>
</tbody>
</table>

☐ **Work To Be Done:** (List in sequence the bridge work to be done, show payment items, and at least once on the preliminary, give the title of each payment item.

**Regional Office or Consultant Notes:**

☐ ___________ will prepare plans, specifications and estimate for the Maintenance and Protection of traffic including detour layout, signing and signal devices.

☐ ___________ will indicate any surplus materials to be salvaged.

☐ ___________ will indicate whether they will perform the project survey or whether Item 625.01, Survey and Stakeout will be included in the contract.

☐ ___________ will indicate any water channel work to be done.

☐ Design Approval Date: ___________

PS&E Date: ___________

Design/Detailed by: ________________ Date: ______

Checked by: ______________________ Date ___________