Steel Pin and Hanger Assembly Replacement Options

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January 2017
A number of steel beam bridges exist in the United States that contain pin and hanger assemblies. Pin and hanger assemblies are fracture critical members whose failure would result in collapse of the bridge or render it unable to perform its expected functions. As these bridges continue to age, many assemblies have deteriorated to a point where retrofit or replacement has to be considered and performed to maintain intended safety and performance. States have taken various approaches to address the pin and hanger assembly retrofit and replacement options. However, there is no single report that summarizes these approaches. This report documents steel pin and hanger assembly retrofit and replacement options via a literature review and synthesis that explores options that have been studied and implemented in the United States. In conjunction with the literature review, a survey was developed in conjunction with the Bureau of Sociological Research (BOSR) at the University of Nebraska-Lincoln to assist with identifying implemented strategies and evaluate best practices. Information was solicited from 50 states and was used in conjunction with the literature review to develop flowcharts that would assist NDOR personnel with assessing various options and their consequences when pin and hanger assembly retrofit or replacement options are being considered for bridges in the state.
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Abstract

A number of steel beam bridges exist in the United States that contain pin and hanger assemblies. Pin and hanger assemblies are fracture critical members whose failure would result in collapse of the bridge or render it unable to perform its expected functions. As these bridges continue to age, many assemblies have deteriorated to a point where retrofit or replacement has to be considered and performed to maintain intended safety and performance. States have taken various approaches to address the pin and hanger assembly retrofit and replacement options. However, there is no single report that summarizes these approaches. This report documents steel pin and hanger assembly retrofit and replacement options via a literature review and synthesis that explores options that have been studied and implemented in the United States. In conjunction with the literature review, a survey was developed in conjunction with the Bureau of Sociological Research (BOSR) at the University of Nebraska-Lincoln to assist with identifying implemented strategies and evaluate best practices. Information was solicited from 50 states and was used in conjunction with the literature review to develop flowcharts that would assist NDOR personnel with assessing various options and their consequences when pin and hanger assembly retrofit or replacement options are being considered for bridges in the state.
Chapter 1  Introduction

1.1 Background

Pin and hanger assemblies are structural components that have been used in many steel bridge systems around the United States (Mosavi et al. 2011). These assemblies are often used in steel girder systems and were traditionally implemented to reduce analysis, design, and construction complexity. The primary function of the pin and hanger assemblies is to mimic the rotational freedom provided by an idealized hinge in a continuous structural system, thereby reducing levels of indeterminacy and facilitating construction. The additional rotational degrees of freedom provided by the assemblies also help accommodate thermal movements of the bridge superstructure (Graybeal et al. 2000). As bridges continue to age, water, deicing chemicals, and debris that fall through the deck joint above the pin and hangers can accumulate on these assemblies and accelerate their degradation, possibly adversely affecting their performance and leading to a need for retrofit or replacement (Graybeal et al. 2000).

Pin and hanger assemblies are considered fracture critical members (FCMs), meaning they are non-redundant and their failure could cause partial or complete collapse. Non-redundant systems have traditionally contributed to major steel bridge collapses. The collapse of the Mianus River Bridge in Connecticut in 1983 is an example of a pin and hanger bridge that suffered a catastrophic failure (Connor et al. 2005).

The American Association of State Highway and Transportation Officials, Load and Resistance Factor Design Specifications (AASHTO LRFD) defines redundancy as “the quality of a bridge that enables it to perform its design function in a damaged state,” and redundant member
as “a member whose failure does not cause failure of the bridge” (AASHTO LRFD, 2014).

Different ways to enhance bridge redundancy include:

- Increasing the number of main supporting elements between points of structural support;
- Providing load redistribution mechanisms or providing continuity for main elements over interior supports elements; or
- Properly detailing structural elements using built-up cross sections, which provide division of elements to restrict increasing fracture propagation across the entire cross section.

States have taken various approaches to address the pin and hanger assembly retrofit and replacement, but there is no single report summarizing these approaches. This report documents a literature review that explores steel pin and hanger assembly replacement and retrofit options that have been studied and implemented in the United States. In addition to the literature review, a survey was developed in conjunction with the Bureau of Sociological Research at the University of Nebraska-Lincoln (BOSR) to assist with determining implemented strategies and evaluate best practices. In this survey, information was solicited from 50 states on current engineering practices related to addressing the steel pin and hanger assembly replacement options. Of these 50 solicitations, 38 (76%) were returned. Literature review and survey information was used to design an organized decision-making tool in the form of flowcharts that would assist NDOR personnel with assessing various options and their consequences when the pin and hanger assembly replacement and retrofit are being considered.
1.2 Objectives and Scope

The objectives of this project were to review and summarize research related to pin and hanger assembly behavior, repair and replacement while also determining and summarizing retrofit and replacement options being used by states in the U.S. The ultimate goal was the development of decision-making tools that would assist NDOR when considering pin and hanger assembly repair or replacement options in the future. These objectives were accomplished via the following steps:

1. Review relevant literature related to the pin and hanger assembly replacement options that have been studied and implemented in the United States;
2. Review relevant literature related to the design of steel web and flange splices one of the possible replacement options;
3. Survey U.S. State Departments of Transportation (DOTs) to investigate current practices for addressing pin and hanger assembly retrofit and replacement;
4. Synthesize and summarize information from Steps 1-3 to provide an initial summary of retrofit and replacement options;
5. Develop and present flowcharts that would assist engineers with assessing various options and their consequences when the pin and hanger assembly retrofit and replacements are being considered in the future.
Chapter 2 Literature Review

2.1 Introduction

A major element of this study consisted of an in-depth literature review. The purpose of this review was to collect and summarize information related to pin and hanger assembly retrofit and replacement options. The literature review also provides information successfully implemented options in different parts of the United States and served as a resource for other portions of this study.

In this chapter, Section 2.2 Literature, summarizes the review of literature related to pin and hanger assembly retrofit and replacement options. Section 2.3 State and Federal DOT Provisions, describes available state DOT design provisions and protocols for various retrofit and replacement options.

2.2 Literature

In 1983, the I-95 Mianus River Bridge in Greenwich, Connecticut collapsed (Figure 2.1). The collapse was determined to occur when one of the pin and hanger assemblies fractured. This assembly was subjected to excessive corrosion due to water leaking through the deck joints and from drainage modifications (NTSB, 1984).
As a result of the Mianus River Bridge collapse, the Pennsylvania Department of Transportation (PennDOT) instructed its districts to identify and establish the current condition of pin and hanger assemblies on all bridges in Pennsylvania (Britt, 1990). A subsequent condition inspection of twin structures carrying I-80 over the Susquehanna River at Mifflinville, Pennsylvania discovered multiple fractured lower pin retainer bolts in its pin and hanger assemblies (Christie & Kulicki, 1991). Further investigation determined that the major cause of the fractures was significant build-up of corrosion on the pin and hangers. PennDOT had identified additional problems in similar bridges, such as pin cracking on the Wysox Bridge in the northeastern part of the state. As a result of this discovery and in an attempt to ensure future safety of similar bridges in the state, Modjeski and Masters (M&M) developed and proposed cost-effective methods to provide a higher level of redundancy for these bridges. M&M proposed the following pin and hanger assembly retrofit and replacement options:
• Providing continuity by removing the pin and hanger assembly and splicing the flange and web at that location;
• Providing a secondary system under the floor beams at the pin and hanger assembly; or
• Providing a secondary system under girders at the pin and hanger assembly.

PennDOT engineers, after several major studies (Christie & Kulicki, 1991), decided that providing continuity was the most advantageous solution from both aesthetic and safety points of view. However, preliminary study shows that this approach would only be economical when re-decking was programmed. Continuity would be established by designing splices into the girders following provisions established in the AASHTO Standard Specifications for Highway Bridges.

In 1989, the Loma Prieta earthquake in California demonstrated that bridges designed following pre-1983 AASHTO seismic criteria were sensitive to strong earthquakes (Shirole & Malik, 1993). As a result of these findings it was determined that a considerable retrofitting program was needed to address this issue. The program included improving the strength of the existing bridges whenever practical to improve their seismic resistance and global efficiency. Pin and hanger assemblies were deemed to be seismically sensitive components and global structural efficiency would be improved via their removal, which would provide continuity and enhance the redundancy of the structure.

In response to work in California, the New York State Department of Transportation (NYSDOT) initiated part of study on seismically sensitive bridges in New York to evaluate their resiliency and to provide a cost data for various seismic retrofits (Shirole & Malik, 1993). The project included a case study of five-span, continuous, steel, multi-girder bridge having pin and hanger assemblies that produced drop-in spans. The study recommended removal of the pin and hanger assembly replacing it with top flange, bottom flange and web splices following AASHTO
Standard Specifications for Highway Bridges guidelines. It was also recommended that cumulative dead and live load stresses be checked in the vicinity of the replaced pin and hanger assembly locations.

Another possible retrofit option, termed a “link slab”, has also been discussed in the research (Caner & Zia, 1998). In this method, expansion joints are removed at the pin and hangers, the deck is debonded from the girders for a minimum of 5% of the span length on each side of the splice, and the joint is replaced with link slab, which renders the deck continuous while maintaining some level of rotational freedom for the girders beneath the link slab. Reducing the number of expansion joints via the placement of link slabs (Caner & Zia, 1998) would minimize or eliminate corrosion damage due to water leaking through the deck joints. Further discussion of this retrofit option can be found in Section 4.2.2.

A national effort to identify and synthesize inspections and repairs appropriate for FCMs was conducted in association with the National Cooperative Highway Research Program (NCHRP). The subsequent report provided a comprehensive investigation of bridges with fracture critical details and focused on inspection and maintenance of FCMs. One of the outcomes was identifying and briefly discussing prevailing pin and hanger assembly retrofit and replacement options in the U.S. The final report summarized two common techniques for the replacement and retrofit of pin and hanger assemblies (Connor et al. 2005):

- Complete removal of the pin and hanger assembly. In this method, the pin and hanger assembly is completely removed and replaced with a new section of the girder having bolted splices. The girders are made continuous for live load and a proportion of dead load given that these splices would be placed after the large part of the deck has been cast.
Continuity would be established by designing splices into the girders following AASHTO LRFD Bridge Design Specifications; and

- Placement of a catcher beam system. These systems are added below the location of the pin and hanger assembly to catch the suspended girder when the existing pin and hanger assembly fails.

In 2010, PennDOT further investigated pin and hanger assembly rehabilitation via a preservation program associated with the I-579 Crosstown Boulevard Bridge in Pittsburgh (Sirianni & Tricini, 2010). The program included complete replacement of pin and hanger assemblies with new stainless pins and high strength hangers. By replacing the existing assemblies with new, more durable components, the assemblies would be strengthened and maintenance requirements for the fracture critical bridges could be reduced.

In 2014, the Manitoba Infrastructure and Transportation Department conducted a detailed structural survey of the Pinawa Bridge, a bridge that contained pin and hanger assemblies. The study identified that steel girders near the existing pin and hanger assemblies had severe corrosion and deterioration due to deck expansion joint leakage (Banthia et al. 2014), which, subsequently, caused corrosion at the pin and hanger assembly that could possibly lead to catastrophic failure of the assembly. A number of possible failure mechanisms were identified, including:

- Reduction of pin cross section that could lead to crack initiation;
- Locking of the pin, which could produce considerable amount of torsional stresses on a reduced cross-section, stresses that, when combined with direct shear stresses, could provide an area for development and increases of cracks which leads to pin failure (Banthia et al. 2014); and
• Corrosion and packrust formation of hanger plates that could cause the pin to move out of the assembly and result in failure of the structure at the location of the assembly.

The study did not directly observe any cracks or loss in pin cross-sectional area or prevention of rotation. Despite these observations, it was recommended to replace all pin and hanger assemblies with bolted splices following guidelines provided in the *AASHTO Standard Specifications for Highway Bridges* and *Manual for Bridge Evaluation*.

### 2.3 State and Federal DOT Provisions

The Nebraska Department of Roads (NDOR) has implemented certain retrofit and replacement options for the pin and hanger assemblies on specific bridges. These options included implementing:

- Catcher beam systems;
- Bolted splices; and
- Replacement with new pin and hanger assembly.

Design drawings for the implemented assembly options are found in Appendix D1.

NDOR was interested in identifying other State and Federal agencies who have implemented retrofit and replacement options and developed design specifications and supporting documents. Identified DOTs and their implemented options and documentation are summarized below.

The 2002 edition of the Montana Department of Transportation’s “Montana Structural Manual” provides rehabilitation alternatives for pin and hanger assemblies (MDT, 2002). It was stated that pin and hangers are sensitive to corrosion because of leaking deck joints and subsequent
accumulation of debris on the assembly. This could result in the pin misplacements due to unseating of hangers and frozen pins and in initiation of fatigue cracks in the hangers. They recommended the following pin and hanger rehabilitation techniques (MDT, 2002):

- Unlocking the frozen pin and hanger assembly. Provide alternative support beam system to the suspended girder and remove the pin and hanger assembly. The elements of the assembly could be replaced or cleaned of corrosion before re-assembling the elements;
- Complete elimination of pin and hanger assembly. In this method, pin and hanger assemblies should be completely replaced with bolted splices. This approach requires a structural analysis of the continuous girder to show that revised load paths do not exceed the resistance of the superstructure. Continuity would be established by designing splices into girders following appropriate AASHTO Standard Specifications for Highway Bridges; and
- Providing a catcher beam system. In a catcher beam system, a supplemental support beam system is provided to catch the suspended girder ends if the pin and hanger assembly fails. Similar structural system could also be provided temporarily when frozen pin and hanger assemblies are slated to be unlocked.

PennDOT further investigated pin and hanger assembly rehabilitation in 2010 and recommended installation of a catcher beam system when pin and hanger assembly failure is a concern so that bridge integrity and safety is maintained (PennDOT, 2010). They stated that the catcher beam system should be designed to be active only if the pin and hanger fails and must accommodate anticipated thermal movements. The gap between the girder and the catcher beam system must be kept as small as possible to limit impact loading if failure occurs. They
recommended use of auxiliary neoprene bearings on the catcher beam system to reduce any impact effects (PennDOT, 2010).

In 2011, the Illinois Department of Transportation published a report that recommended that steel girders with pin and hanger assemblies be examined for assembly elimination and to make the superstructure system continuous whenever feasible and economical (IDOT, 2011). Continuity would be established by designing splices into the girders following the AASHTO Standard Specifications for Highway Bridges.

In 2012, the Federal Highway Administration stated that pin and hanger assembly failure is caused by formation of corrosion between the hanger and the girder web due to deck expansion joint leakage. As steel corrodes, it can occupy up to 10 times its original volume and cause unwanted forces in a limited space (FHWA-BIRM, 2012), which results in packrust and possible failure of the assembly. Additional pin and hanger assembly defects that were identified in the report were corrosion, fatigue cracking and coating failures. Various retrofit and replacement options were discussed as summarized below:

- Catcher beam system. The catcher beam system is added to the structure to carry a load if the pin and hanger assembly fails. The gap between the girder and the catcher beam should be kept as small as possible to reduce impact. Auxiliary neoprene bearings on the catcher beam system could be provided to reduce impact effects should failure occur;

- Removal and replacement of pin and hanger assembly with bolted splices. This approach requires a structural analysis to determine if other members can support continuous girders instead of cantilevered and drop-in spans. Analyses should investigate both positive and negative moment regions in the superstructure; and
Replacing the pin and hanger assembly with a structural grade stainless steel pin and hanger, which results in reduction in corrosion mitigation.

In 2014, the Minnesota Department of Transportation published a study on a rehabilitation of the Kennedy Bridge over the Red River. This study focused on rehabilitation alternatives and showed that its pin and hanger assemblies had sufficient load carrying capacity. However, failure of multiple hangers could result in failure of the structure (MnDOT, 2014). Part of this study focused on increasing reliability of a bridge containing a pin and hanger assembly. It was reported that pin and hanger assembly retrofit and replacement options can include removing existing pins and hangers, re-machining pin holes to accommodate new pins as required to remove corrosion and pitting and the installation of new, higher strength pins and reinforced hangers. It was stated that each girder must be temporary supported while work is occurring and that temporary supports must be able to accommodate hanger fit up.

2.4 Summary

This chapter has documented the results of a literature search that focused on current practices implemented in the United States and research related to retrofit and replacement of pin and hanger assemblies. A summary of finding from the literature review are provided below.

Retrofit options:

Bolted Splices -

Provide continuity by removing the existing pin and hanger assembly and splicing the flange and web at that location following appropriate AASHTO Specifications (AASHTO Standard Specifications for Highway Bridges, and AASHTO LRFD Bridge Design Specifications) and/or relevant state specifications. Providing continuity was the most advantageous solution from both
aesthetic and safety points of view but would be economical only when re-decking was programmed.

**Rehabilitation options:**

**Link Slab -**

Providing a link slab is a rehabilitation option that would remove expansion joints by linking two adjacent girder sections together using a continuous slab design. This approach would render the deck continuous while maintaining some level of rotational freedom for the girders.

**Catcher Beam System -**

A secondary catcher beam system could be added below the location of the pin and hanger assembly. This system should provide to carry live loads if the existing pin and hanger fails. The use of auxiliary neoprene bearings on the catcher beam system was recommended to use, reduce any impact effects should failure occur.

**Removal and replacement option:**

**New Pin and Hanger Assembly -**

In this option existing pins and hangers are removed and replaced with new, higher strength pins and reinforced hangers. It was recommended to use stainless steel pins and hangers according to *AASHTO LRFD Bridge Design Specifications* (Article 6.4.7), this could result in reduction in corrosion failure. While work is under construction each girder must be temporary supported and that temporary supports must be modifiable to accommodate hanger fit up.
3.1 Survey Objectives

In December 2015 a survey was sent to 50 State Departments of Transportation (DOTs). The objective of the survey was to assemble additional information on variety of topics related to pin and hanger retrofit and replacement options. These topics included: a) types of steel bridges that contain pin and hanger assemblies; b) pin and hanger assemblies that need retrofitted and/or replacements; and c) designs, procedures, or criteria for retrofit and/or replacements. Of the 50 surveys, 38 were received as of March 2016. Results from these surveys were examined to: a) document current practices and level of success concerning pin and hanger assembly retrofit and replacement options; b) identify practical application of retrofit and replacement options documented in the literature; and c) identify new or innovative retrofit and replacement options that have not yet been recorded in the literature.

The survey was divided into three sections. Section 1 (General) collected general information related to types of steel bridges that contain pin and hanger assemblies. Section 2 (Options) intended to identify various options, criteria and procedures related to retrofit and replacement of pin and hanger assemblies in each of the states. In addition, data related to retrofit and replacement options that have been implemented and programmed for future was requested. Section 3 (Future Contact) requested that additional information related to pin and hanger assemblies be provided, information that included: to share the respective state DOTs that have developed their own criteria and procedures for retrofits and/or replacements. A copy of the survey is included in Appendix A and responses are provided in Appendix B.
3.2 Survey History and Timeline

The questionnaire was designed by BOSR with technical input being provided by UNL Civil Engineering personnel assigned to the project and NDOR. Prior to the initial mailing, NDOR notified and encouraged State Bridge Engineers to complete the survey. The initial mailing occurred in mid-December 2015. Non-responders were mailed survey packets a second time in early January 2016. Completed surveys were collected by BOSR through early March with findings summarized and provided to UNL Civil personnel.

3.3 Findings of the Survey

Surveys that were completed and returned were initially examined by BOSR, who performed data analysis, processing and filtering. BOSR’s used Statistical Package for the Social Sciences (SPSS) software for processing and documenting the dataset. BOSR personnel assigned to the project, in turn, analyzed each survey question in detail and prepared a report. As stated earlier, of the 50 State Bridge Engineers who were sent the survey, 38 were completed and returned (Figure 3.1), a 76% response rate based on the American Association for Public Opinion Research’s (AAPOR) standard definition for Response Rate 2 (RR2), which counts partial interviews as respondents (AAPOR, 2015). The following sections summarize survey responses to each question.
Figure 3.1 Geographic representation of states that responded to the survey.
3.3.1 Question 1

Do you have steel bridges that contain pin and hanger assemblies?

Figure 3.2 and Figure 3.3 show that, of the 38 states who answered the question, 35 have steel bridges that contain pin and hanger assemblies and 3 states have steel bridges without pin and hanger assemblies.

![Figure 3.2 Visual representation of responses to question 1.](image)
Figure 3.3 Geographic representation of state responses to question 1.

Question 1 (a)

If yes, please provide the number of steel bridge types for each category that have pin and hanger assemblies.

Figure 3.4 reports on the superstructure types that contain pin and hanger assemblies in their states. Eighteen states (67%) reported having two or three girder bridges with pin and hanger assemblies, 25 (86%) have at least one bridge with four or more girders having a pin and hanger assemblies, and 19 states (68%) contain at least one truss bridge with a pin and hanger assembly (Figure 3.4). Additional bridges reported as having pin and hanger assemblies included tied
through arches, suspension bridges, and pinned arches. Additional details are found in Table 3.1, Table 3.2 and Appendix B.

**Figure 3.4** Visual representation of state response to question 1(a).
Table 3.1 Types of bridges which has pin and hanger assembly.

<table>
<thead>
<tr>
<th>Types of bridges (number of pin and hanger assemblies)</th>
<th>DOTs</th>
<th>Two or three girder bridges</th>
<th>Four or more girder bridges</th>
<th>Truss bridges</th>
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<tr>
<td>New Hampshire DOT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Mexico DOT</td>
<td>0</td>
<td>17</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>North Carolina DOT</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>North Dakota DOT</td>
<td>0</td>
<td>14</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ohio DOT</td>
<td>9</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oklahoma DOT</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Oregon DOT</td>
<td>5</td>
<td>73</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Pennsylvania DOT</td>
<td>45</td>
<td>15</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>South Dakota DOT</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tennessee DOT</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Utah DOT</td>
<td>2</td>
<td>33</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Virginia DOT</td>
<td>1</td>
<td>18</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Washington State DOT</td>
<td>51</td>
<td>306</td>
<td>488</td>
<td></td>
</tr>
<tr>
<td>West Virginia DOT</td>
<td>6</td>
<td>26</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Wyoming DOT</td>
<td>12</td>
<td>90</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

*Acronym definitions in Appendix C.
Table 3.2 Other types of steel bridges with pin and hanger assemblies.

<table>
<thead>
<tr>
<th>DOTs</th>
<th>Other types of bridges</th>
<th>Number of P &amp; H assemblies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska Department of Transportation and Public Facilities</td>
<td>Box girders</td>
<td></td>
</tr>
<tr>
<td>Arkansas State Highway and Transportation Department</td>
<td>Arch deck</td>
<td>2</td>
</tr>
<tr>
<td>Colorado DOT</td>
<td>Tie down</td>
<td></td>
</tr>
<tr>
<td>Illinois DOT</td>
<td>Truss with eye bars &amp; pins</td>
<td>1</td>
</tr>
<tr>
<td>Iowa DOT</td>
<td>Secondary highway steel girders</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Secondary highway truss</td>
<td></td>
</tr>
<tr>
<td>Michigan DOT</td>
<td>All girder bridges</td>
<td>1099</td>
</tr>
<tr>
<td>Minnesota DOT</td>
<td>Arch</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Suspension</td>
<td>1</td>
</tr>
<tr>
<td>Ohio DOT</td>
<td>Riveted steel arches</td>
<td>2</td>
</tr>
<tr>
<td>Oregon DOT</td>
<td>RGDG</td>
<td>9</td>
</tr>
<tr>
<td>Utah DOT</td>
<td>Pinned arches</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Suspension arches</td>
<td>1</td>
</tr>
<tr>
<td>Washington State DOT</td>
<td>Concrete box (2)</td>
<td>132</td>
</tr>
<tr>
<td></td>
<td>Steel box (3)</td>
<td>90</td>
</tr>
<tr>
<td>West Virginia DOT</td>
<td>Tied thru arch</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Suspension Bridge</td>
<td>1</td>
</tr>
</tbody>
</table>

*Acronym definitions in Appendix C.
3.3.2 Question 2

*Does your agency view the pin and hanger assemblies as components that need to be retrofitted and/or replaced?*

Figure 3.5 and Figure 3.6 show state agencies were nearly evenly split between viewing pin and hanger assemblies as components that need to be retrofitted and/or replaced and feeling that these assemblies do not need retrofitted and/or replaced. A complete list of reasons for non-action can be found in Appendix B.

![Pie chart showing 53% do not need retrofitted and 47% need retrofitted](image)

**Figure 3.5** Visual representation of state response to question 2
Figure 3.6 Geographical representation of states responded to question 2

Question 2(a)

If yes, please provide the number of retrofit and/or replacement options that you have implemented or programmed for each category below. If you have implemented or scheduled retrofit and/or replacement options other than those listed below, please describe and provide the number for each option in the additional table rows.

Figure 3.7 shows that, for those that view retrofitting and/or replacement as necessary, most states have implemented a secondary system, such as a catcher beam (79%). Few responses indicated that replacements had taken place using new pin and hanger assemblies (43%) or bolted splices (33%). Despite fewer states implementing replacement using new pin and hanger
assemblies or bolted splices, nearly one-quarter of states who responded to the question have new pin and hanger replacement projects planned for the future (21%), while 8% have replacements with bolted splice repairs planned. Details are found in Table 3.3.

Other retrofit and/or replacement options implemented or planned by survey respondents included: (a) replacing the bridge or entire superstructure with concrete girders; (b) supporting the assembly using an “under-running bearing beam,” which is akin to a catcher beam; and replacing the assembly with a “ship lap joint”. Complete detail on these retrofit and replacement options can be found in Table 3.4 and Appendix B.

![Figure 3.7](image)

**Figure 3.7** Visual representation of state response to question 2 (a)
Table 3.3 Implemented and programmed retrofit and/or replacement options.

<table>
<thead>
<tr>
<th>DOTs</th>
<th>Catcher beam system</th>
<th>Replace with P &amp; H assembly</th>
<th>Replace with bolted splice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number implemented</td>
<td>Number programmed</td>
<td>Number implemented</td>
</tr>
<tr>
<td>Arkansas State Highway and Transportation Department</td>
<td>1</td>
<td></td>
<td>92</td>
</tr>
<tr>
<td>Delaware DOT</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illinois DOT</td>
<td>0</td>
<td>0</td>
<td>92</td>
</tr>
<tr>
<td>Indiana DOT</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maine DOT</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Massachusetts DOT</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Minnesota DOT</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Mississippi DOT</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Missouri DOT</td>
<td>20</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>New Hampshire DOT</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Carolina DOT</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Oklahoma DOT</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tennessee DOT</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Utah DOT</td>
<td>0</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>West Virginia DOT</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wyoming DOT</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

*Acronym definitions in Appendix C
Table 3.4 Other implemented and programmed retrofit and/or replacement options.

<table>
<thead>
<tr>
<th>DOTs</th>
<th>Other options</th>
<th>Number implemented</th>
<th>Number programmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maine DOT</td>
<td>Superstructure replace</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Massachusetts DOT</td>
<td>Ship lap joint. Replace P &amp; H assembly with under running beam</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Mississippi DOT</td>
<td>Replace bridge</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Nebraska Department of Roads</td>
<td>Replace bridge or superstructure</td>
<td></td>
<td>50/102</td>
</tr>
<tr>
<td>North Carolina DOT</td>
<td>Replace with concrete girder</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Virginia DOT</td>
<td>Replace bridge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wyoming YDOT</td>
<td>Suspension hanger/seismic</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

*Acronym definitions in Appendix C.*
3.3.3 Question 3

For the retrofits and/or replacements you indicated above as implemented or programmed, did you follow any of the designs, procedures, or criteria below?

The survey indicated that multiple designs, procedures, and/or criteria are used to complete pin and hanger assembly retrofit or replacement. Nearly all state bridge engineers who answered the inventory question reported using *AASHTO Standard Specifications for Highway Bridges* criteria and procedures, while some states use *AASHTO LRFD Bridge Design Specifications* criteria and procedures as shown in Figure 3.8 Figure 3.9. Five states reported using their own developed criteria and procedures.

![United States map](image)

**Figure 3.8** Geographical representation of federal design Specification usage.
3.3.4 Question 4

*Have you developed your own criteria and procedures for retrofits and/or replacements?*

One-quarter of states in the (24%) reported developing their own criteria and procedures for retrofits and/or replacements (Figure 3.10 and Figure 3.11). More states use their own procedures in conjunction with the *AASHTO Standard Specifications for Highway Bridges*. Additional details are found in Table 3.5, Table 3.6 and Appendix B.
Figure 3.10 Visual representation of states response to question 4.

Figure 3.11 Geographical representation of states that have developed own criteria and procedures.
Table 3.5 Design Specifications.

<table>
<thead>
<tr>
<th>Design Specifications</th>
<th>Total number of States</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO LRFD criteria and procedures</td>
<td>11</td>
</tr>
<tr>
<td>AASHTO Standard Specification criteria and procedures</td>
<td>16</td>
</tr>
<tr>
<td>Developed own criteria and procedures</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 3.6 Developed own criteria & procedures.

<table>
<thead>
<tr>
<th>DOTs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas State Highway and Transportation Department</td>
<td>Internally developed.</td>
</tr>
<tr>
<td>Illinois DOT</td>
<td>It is part of our structural services manual. Bureau of Bridges and Structures.</td>
</tr>
<tr>
<td>Mississippi DOT</td>
<td>Our bridge replacement program prioritizes bridges with pins &amp; hanger high enough to systematically replace the bridge with another (usually concrete) bridges.</td>
</tr>
<tr>
<td>Missouri DOT</td>
<td>No set criteria. Details are case-by-case.</td>
</tr>
<tr>
<td>Utah DOT</td>
<td>Is not documented.</td>
</tr>
</tbody>
</table>

*Acronym definitions in Appendix C.
3.3.5 Question 5

Does your agency view the pin and hanger assemblies as components that need no further action at this time?

Of the 32 state bridge engineers who answered the question, half reported that their agency views pin and hanger assemblies as not needing further action at this time as shown in Figure 3.12 and Figure 3.13. Reasons for non-action included: a) bridges being in good condition and functioning properly; b) routine inspections and adequate maintenance; and c) a lack of concern about these assemblies. A complete list of reasons for non-action can be found in Table 3.7 and Appendix B.

Figure 3.12 Visual representation of states response to question 5.
Figure 3.13 Geographical representation of states need or not need for further action.
### Table 3.7 Reasons for pin and hanger assembly non-action.

<table>
<thead>
<tr>
<th>DOTs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alaska DOT &amp; PF</td>
<td>Pin &amp; hangers are functioning properly. No pack rust present.</td>
</tr>
<tr>
<td>Colorado DOT</td>
<td>No section loss due to corrosion &amp; no crack on hanger.</td>
</tr>
<tr>
<td>Delaware DOT</td>
<td>We are not as concerned with pin &amp; hanger assemblies for multi-beam bridges. Pin &amp; hanger assemblies on truss bridges are treated as a fracture critical member and are scrutinized more.</td>
</tr>
<tr>
<td>Iowa DOT</td>
<td>Proper inspection should identify deficiencies in time to address them without impacts to public safety.</td>
</tr>
<tr>
<td>Louisiana DOT</td>
<td>Bridges are in good condition.</td>
</tr>
<tr>
<td>Montana DT</td>
<td>Pins and hangers are usually inspected every 2 years and UT inspected every 4 years. With our relatively dry climate and large temperature swings the p &amp; h assemblies usually stay moving as designed with little rust impact.</td>
</tr>
<tr>
<td>Minnesota DOT</td>
<td>We will include repairs or improvements to pin and hanger elements as conditions warrant. We have not developed projects solely on pin and hanger detail unless condition justifies.</td>
</tr>
<tr>
<td>North Carolina DOT</td>
<td>Inspection reports indicate the condition of the pin and hanger is “good”.</td>
</tr>
<tr>
<td>Nebraska Department of Transportation</td>
<td>All bridges are inspected by certified inspectors at least every 2 years and all bridges that this agency manages directly have redundant secondary systems should failure occur.</td>
</tr>
<tr>
<td>Nevada DOT</td>
<td>We haven't identified problems with the hangers, aside from minor corrosion.</td>
</tr>
<tr>
<td>Ohio DOT</td>
<td>We retrofit when they are deteriorated.</td>
</tr>
<tr>
<td>Oklahoma DOT</td>
<td>We used ultrasonic inspection on our pins. No problems were found.</td>
</tr>
<tr>
<td>Oregon DOT</td>
<td>We inspect &amp; monitor p &amp; h's and only r &amp; r or provide supplemental support when their condition indicates a need.</td>
</tr>
<tr>
<td>Pennsylvania DOT</td>
<td>We have retrofitted the inventory of 2 girder and truss bridges with suspended assemblies.</td>
</tr>
<tr>
<td>South Dakota DOT</td>
<td>These assemblies are part of annual NBIS inspections and the pins get a periodic NDT inspection as well.</td>
</tr>
<tr>
<td>Virginia DOT</td>
<td>We evaluate each one individually.</td>
</tr>
<tr>
<td>Washington State DOT</td>
<td>Routine inspections and painting when needed.</td>
</tr>
<tr>
<td>West Virginia DOT</td>
<td>We monitor during routine inspections and provide action as needed</td>
</tr>
</tbody>
</table>

*Acronym definitions in Appendix C.*
3.3.6 Question 6

*If you developed your own criteria and procedures for retrofit and/or replacements, would you be willing to share those with us?*

Of the 30 state bridge engineers who answered the question, 10 states were willing to share their criteria and procedures electronically.

3.3.7 Question 7

*Would you like to receive results of this study?*

Of the 38 states bridge engineers who answered the question, 33 states would like to receive the results from this study.

3.4 Follow-Up Contact

States that indicated they would provide additional information in response to question 6, based on the response to question 6, follow up for the fourteen states (Figure 3.14). The plans, drawings and photos are found in Appendix D1. Additional details of the retrofit and/or replacement options are discussed in Chapter 4. Summary of contact information found in Table 3.8.
Table 3.8 Summary of follow-up contacts

<table>
<thead>
<tr>
<th>DOTs</th>
<th>Contacted for the information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas State Highway and Transportation Department</td>
<td>Not responded</td>
</tr>
<tr>
<td>Colorado DOT</td>
<td>Not responded</td>
</tr>
<tr>
<td>Georgia DOT</td>
<td>Not responded</td>
</tr>
<tr>
<td>Illinois DOT</td>
<td>Provided repair drawings found in Appendix D1</td>
</tr>
<tr>
<td>Indiana DOT</td>
<td>Not responded</td>
</tr>
<tr>
<td>MassDOT</td>
<td>Provided information on ship lap joints with plan and pictures found in Appendix D1</td>
</tr>
<tr>
<td>Michigan DOT</td>
<td>Provided pin and hanger assembly drawings found in Appendix D1</td>
</tr>
<tr>
<td>North Dakota DOT</td>
<td>Not responded</td>
</tr>
<tr>
<td>New Hampshire DOT</td>
<td>Not responded</td>
</tr>
<tr>
<td>Oklahoma DOT</td>
<td>Provided catcher beam system drawing found in Appendix D1</td>
</tr>
<tr>
<td>Pennsylvania DOT</td>
<td>Provided catcher beam system drawing found in Appendix D1</td>
</tr>
<tr>
<td>South Carolina DOT</td>
<td>Not responded</td>
</tr>
<tr>
<td>Texas DOT</td>
<td>Not responded</td>
</tr>
<tr>
<td>Utah DOT</td>
<td>Not responded</td>
</tr>
</tbody>
</table>

*Acronym definitions in Appendix C.
3.5 Summary

The State DOT survey produced the following information:

- States who responded were roughly split between seeing such retrofits and replacements as necessary and unnecessary;

- Pin and hanger assemblies are most commonly found bridges having four and more girders (86%);

- Implementing a secondary system, such as a catcher beam (79%), is a more widely used retrofit and/or replacement option than replacing with either a new pin or hanger assembly.
(43%) or with bolted splices (33%), although at the time of the inventory study no future secondary system retrofits were programmed;

- Nearly all of the states utilize AASHTO Standard Specifications for Highway Bridges (94%), while fewer states use the AASHTO LRFD Bridge Design Specifications (65%), and some states developed their own criteria and procedures; and

- Additional retrofit and/or replacement options that were revealed by the survey included replacing with a “ship lap joint,” providing an “under-running bearing beam,” and, as expected, replacing the entire bridge or superstructure.
Chapter 4 Flowcharts Summarizing Retrofit and/or Replacement Options

4.1 Introduction

The objectives of this chapter are to provide flowcharts that describe steps associated with completing feasible options associated with addressing pin and hanger assembly retrofit and/or replacement. Approaches for which flowcharts are provided are categorized as retrofit, rehabilitation, or removal and replacement options as shown in Figure 4.1. The intention is that these flowcharts will provide an organized decision-making tool that would assist NDOR personnel with assessing options and their consequences when pin and hanger assembly retrofit and/or replacement are being considered. As appropriate, each cell in the flowcharts refers to corresponding articles in appropriate state and federal design specifications. These include the AASHTO Standard Specifications for Highway Bridges, the AASHTO LRFD Bridge Design Specifications and NDOR’s Bridge Office Policies and Procedures (BOPP) manual.
Figure 4.1 Flowchart demonstrates decision – making process.

4.2 Retrofit and/or Replacement Options Process Summaries

This section summaries retrofit, rehabilitation and, removal and replacement options based on the literature review and survey of DOTs and provided along with pros and cons of each respective options. Each section organized into brief summary followed with pros, cons and flowcharts with description.
4.2.1 Replace with Bolted Splices

This section summarizes the option that involves removing pin and hanger assemblies and replacing them with bolted splices. Items that are discussed and presented in the corresponding flowchart incorporate relevant information from the literature search, DOT survey and appropriate federal and state specifications.

When a major retrofit of a bridge structure is programmed, pin and hanger assemblies should be examined for elimination. The pin and hanger assembly would be replaced with continuity web and flange splices and existing deck expansion joints at the hinges would be removed and replaced to make these locations continuous. By making the drop-in section spans locations to continuity support the demand of the girder changes, so demand should be recalculated. While the pin and hanger assembly is being replaced with bolted splices, the girders should be temporarily supported from below or above the deck.

The state DOT survey produced a comment related to replacing pin and hanger assemblies with bolted splices. For drop-in section spans, the method implemented to eliminate the assemblies completely and replace with bolted splices involved installation of counterweights at the ends of the span. A flow-chart detailing general steps involved in the process is located in Figure 4.2.

Pros:

- Pin and hanger assembly is removed and continuity is provided through splices, possibly eliminating non-redundancy and making the structure more efficient; and
- Expansion joints eliminated to reduce and mitigate superstructure corrosion.
Cons:

- Changing the structural system from containing a drop-in span to being completely continuous necessitates a re-evaluation of superstructure behavior and capacity; and
- Higher construction cost.

**Figure 4.2** Bolted splice design process.
As shown in Figure 4.2, when considering replacing the assemblies with bolted splices, the process starts with following steps. While replacing the pin and hanger assemblies with bolted splices, the girder should be supported by temporary support beam and this support should be provided according to Standard Specifications, Division II-Construction (Article 3). The portion of the deck along the expansion joints are removed as per the design dimensions of the splices according to Standard Specifications, Division II-Construction (Article 2.3.3). The portion of the girder section near the pin and hanger location, pin and hanger assembly, and the expansion joints are removed according to Standard Specifications, Division II-Construction (Article 2). The drop-in span is completely converted into continuity support which is provided through bolted splices connection according to Standard Specifications, Division I-Design (Article 10.18) and BOPP Specifications (Article 3.4.2). Here demand of the girder changes, so demand should be recalculated. Provide shear connectors along the newly constructed girder, shear connectors are designed to provide a composite action between the slab and the girders according to Standard Specifications, Division I-Design (Article 10.38.2) and BOPP Specifications (Article 3.4). Place the deck according to BOPP Specifications (Article 3.1.1). Finally, after construction temporary support should be removed according to Standard Specifications, Division II-Construction (Article 2).

4.2.2 Link Slab

This section summarizes the option that involves removing expansion joints and replacing them with link slab. Items that are discussed and presented in the corresponding flowchart incorporate relevant information from the literature search.
The deck expansion joint is one of the significant components in the functioning of bridge structures (Chang & Lee, 2002). Deck expansion joints accompany the pin and hanger assemblies. The elimination or reduction of expansion joints reduces costs. One identified option that would help eliminate deck joints is via providing “link slabs” at joint locations. Figure 4.3 referred from (Caner & Zia, 1998). A flow-chart detailing general steps involved in the process is located in Figure 4.4.

![Link slab detail](image)

**Figure 4.3** Link slab detail.

**Pros:**

- Reduced construction and maintenance of bridge via reduction of joints, moisture intrusion and subsequent corrosion control.

**Cons:**

- Continuity achieved by providing link slab influences shrinkage, creep and thermal stress which causes structural damages; and
- Continuous slab has high stresses developed due to repeated load will lead to fracture and cracking of the structures along the slab.
Figure 4.4 Link slab design process.

As shown in Figure 4.4, when considering rehabilitation with link slab, the process starts with following steps according to (Caner & Zia, 1998). While replacing the pin and hanger assembly with a link slab, the girder should be supported by temporary support beam and this support should be provided according to Standard Specifications, Division II-Construction (Article
3). Expansion joints and a portion of the concrete deck along the expansion joints are removed according to Standard Specifications, Division II-Construction (Article 2). Debond the concrete deck on each side of the beam at least 5% of the span length according to AASHTO LRFD Specifications, (Article 5.11.4.3) along the debonded region, the shear connectors are removed to prevent composite action. Further, the top flange of the girder is provided with debonding mechanism in the form of standard roofing tar paper which acts as a water proofing material. Provide reinforcement steel lap splice for continuity of deck reinforcement according to Standard Specifications, Division I-Design (Article 8.32.1). Join the adjacent beams with a continuous concrete deck according to AASHTO LRFD Specifications (Article 9) and BOPP Specifications (3.1.1). Finally, after construction temporary support should be removed according to Standard Specifications, Division II -Construction (Article 2).

4.2.3 Catcher Beam System

This section summarizes the option that involves rehabilitation of pin and hanger assemblies with catcher beam system. Items that are discussed and presented in the corresponding flowchart incorporate relevant information from the literature search, DOT survey and appropriate federal and state specifications. A Secondary catcher beam system is provided to carry live loads across the expansion joint when the existing pin and hanger fails at the location of the pin and hanger assembly. The retrofit should be detailed to resist applied live load and the gap between the girder and the catcher beam must be kept as small as possible to the limit impact loading. To reduce impact, the use of auxiliary neoprene bearings on the catcher beam is also recommended (PennDOT, 2010). A flow-chart detailing general steps involved in the process is located in Figure 4.7.
**Figure 4.5** Catcher beam system. (Connor et al. 2005)

**Figure 4.6** Catcher beam system representative detail.
**Pros:**

- When pin and hanger assembly fails to carry the live load then catcher beam system should be installed to carry the live load, which is an immediate option to replace and control the sudden bridge collapse.

**Cons:**

- This is a temporary system, which works for very less number of years due to fatigue related problems in catcher beam system, and replacement needs to be considered.

**Figure 4.7** Catcher beam design process.
As shown in Figure 4.7, when considering retrofit of pin and hanger assemblies with catcher beam, the design process is explained below. Catcher beam system design consists of two components: design of the beam and connecting elements.

- Design of beam: The web and flanges of the beam is designed according to Standard Specifications, Division I-Design (Article 10.34.2 & 10.34.3). Stiffeners are designed according to Standard Specifications, Division I-Design (Article 10.34) and BOPP Specifications (Article 3.4).

- Connecting elements: For connecting the catcher beam and the supported girder, bearing systems are used and this bearing system is designed according to Standard Specifications, Division I-Design (Article 14). For connecting the catcher beam and the supporting girder, bearing systems and tension systems like bolts are designed according to Standard Specifications, Division I-Design (Article 14 & 10.24) and BOPP Specifications (Article 3.5 & 2.2.3).

### 4.2.4 Replace with Ship Lap Joint.

This section summarizes the option that involves rehabilitation of pin and hanger assemblies with ship lap joint. Items that are discussed and presented in the corresponding flowchart incorporate relevant information from the DOT survey and state specifications.

The Massachusetts DOT has utilized a different type of pin and hanger replacement option they refer to as a “ship lap joint.” In this option, which performs in similar fashion to the original pin and hanger assembly, bearings are used to carry loads at the joint location, with girder sections being modified to act as short “cantilevers” that transfer loads across the joint in shear and bending. This detail is depicted for a specific project, the I-91 viaduct in Springfield, Massachusetts, in
Figure 4.8, Figure 4.9 and in Appendix D1. A flow-chart detailing general steps involved in the process is located in Figure 4.10.

**Figure 4.8** Ship lap joint at bearing at joint locations (Mass DOT, 2014).
Pros:

- In the ship lap joint, support beam is carried by bearings, which improves rotational degree of freedom.

Cons:

- Still need to maintain joint which results in accumulation of debris and moisture and causes corrosion;
- Design and retrofit required for ship lap joint appears tedious compared to pin and hanger assemblies; and
- Fabrication and construction cost are more compare to pin and hanger assemblies.

**Figure 4.9** Ship lap joint detail (Mass DOT, 2014).
Figure 4.10 Ship lap joint design process.
As shown in Figure 4.10, when considering replacing the assemblies with ship lap joint, the process starts with following steps. While replacing the pin and hanger assemblies with a ship lap joint, the girder should be supported by a temporary support beam and this support should be provided according to Standard Specifications, Division II-Construction (Article 3). Then remove the deck according to Standard Specifications, Division II-Construction (Article 2.3.3). The portion of the girder length and the pin and hanger assembly are removed according to Standard Specifications, Division II-Construction (Article 2). Then provide new girders and shear connectors according to Standard Specifications, Division I-Design Standard Specifications (Article 10.34 & 10.38.2) and BOPP Specifications (Article 3.4). Then provide the new girder ends with bolted splices connection and stiffeners according to Standard Specifications, Division I-Design (Article 10.18 & 10.34) and BOPP Specifications (Article 3.4.2 & 3.4). Provide diaphragms or cross frames at new fabricated girders according to Standard Specifications, Division I-Design (Article 10.20). The support beam is carried by bearings which carries the loads at the joint locations and bearing systems are designed according to Standard Specifications, Division I-Design (Article 14) and BOPP Specifications (Article 3.5) which improves rotational degree of freedom. Further, place the deck according to BOPP Specifications (Article 3.1.1). Finally, after construction, temporary support beam should be removed according to Standard Specifications, Division II-Construction (Article 2).
4.2.5 Replace with Pin and Hanger Assembly.

This section summarizes the option that involves removing pin and hanger assemblies and replacing them with new similar pin and hanger assembly. Items that are discussed and presented in the corresponding flowchart incorporate relevant information from the literature search, DOT survey and appropriate federal and state specifications.

When pin and hanger assembly is found to be frozen, they should be considered for examination and should be replaced with new pin and hanger assembly. The hanger plates and pins should be designed according to *AASHTO Standard Specifications for Highway Bridges*. While replacing the new pin and hanger assembly, the suspended span should be temporarily supported from below or above the deck. FHWA recommended to use new stainless steel pins and hangers according to *AASHTO LRFD Bridge Design Specifications* (Article 6.4.7), which reduces corrosion damage. Higher strength pins and larger hanger cross sections are also recommended to use so that by replacing existing assemblies with new, more durable components the assembly would be strengthened and maintenance requirements could be reduced. (Sirianni & Tricini, 2010).

From the DOTs survey, the approach of replacing new pins and hangers is programmed in more states than any other approaches. A flow-chart detailing general steps involved in the process is located in Figure 4.11.

**Pros:**

- Replacement with similar design can be cost efficient and cause minimal disruption to traffic; and
- By using stainless pins and hangers, corrosion could be controlled.
Cons:

- Still provides non-redundant system; and
- Pin and hanger assembly needs regular ultrasonic inspection every two years. So there is a higher inspection and maintenance cost.

Figure 4.11 New pin and hanger assembly design process.
As shown in Figure 4.11, when considering replacing the assemblies with new assemblies, the process starts with following steps. When replacing the pin and hanger assemblies with new similar design section, the girder should be temporary supported and this support should be provided according to Standard Specifications, Division II-Construction (Article 3). Removal of the pin and hanger assembly is carried out according to Standard Specifications, Division II-Construction (Article 2). Then provide a new pin and new hanger according to Standard Specifications, Division I-Design (Article 10.25). Providing stainless steel pins and hangers are recommended to use and these are designed according to AASHTO LRFD Specifications (Article 6.4.7), which reduces corrosion damage. Finally, after construction, temporary support beam should be removed according to Standard Specifications, Division II-Construction (Article 2).

4.3 Summary

This chapter summarized and provided flowcharts that describes steps associated with completing feasible options associated with addressing pin and hanger assembly retrofit and/or replacement. The intention was that the described flowcharts will provide an organized decision-making tool that would assist NDOR personnel with assessing options and their consequences when pin and hanger assembly retrofit and/or replacement are being considered. The respective flowcharts in this chapter are designed based on the relevant information from the literature search, DOT survey and appropriate federal and state Specifications. These included the AASHTO Standard Specifications for Highway Bridges, the AASHTO LRFD Bridge Design Specifications and NDOR’s Bridge Office Policies and Procedures (BOPP) manual.
**Chapter 5 Recommendations for Future Research**

- In the present study, research work was related to the synthesis part of finding the different types of pin and hanger assembly retrofit and replacement options.

- The future research should focus on the analysis part of the different types of pin and hanger assembly retrofit and replacement options.

- The analysis part includes finding the behavior of the various retrofit and/or replacement option of steel pin and hanger assembly, and its effects on the behavior of the bridge with different retrofit and/or replacement options.

- The research mainly focuses on retrofit and replacement options and their effect on bridges due to distortion induced fatigue cracking at the connections between the girders, one of the severe problem of steel bridges. Fatigue analysis should be carried out by modelling and analyzing using finite element analysis.

- The development of a finite element models and analysis are planned for the bridges located in the Nebraska State.
References


*Bridge Office Policies and Procedures (BOPP).* (2014). Nebraska Department of Roads, Bridge Division.


Appendix A

Survey

Steel Pin and Hanger Assembly Replacement Options
Inventory Survey

A number of steel beam bridges exist in the United States that contain steel pin and hanger assemblies. These assemblies were used to facilitate construction and to reduce the level of indeterminacy along a given beam line when the bridges were originally built. As the bridges continue to age, these assemblies have collected debris and moisture and, in certain instances, have deteriorated to a point where their retrofit or removal has been completed or is being considered. We are facilitating this survey on behalf of the Nebraska Department of Roads (NDOR) to explore how other agencies address pin and hanger assemblies that are aging and becoming deteriorated. Results from the survey can be provided to you upon request.

Section 1. General

1. Do you have steel bridges that contain pin and hanger assemblies?
   - Yes
   - No → Go to Question 7 on page 3

1a. If yes, please provide the number of steel bridge types for each category below that have pin and hanger assemblies. If you do not have a pin and hanger assembly for the steel bridge type, please write in ‘0’.

<table>
<thead>
<tr>
<th>Type of bridge</th>
<th>Number of pin and hanger assemblies</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Two or three girder bridges</td>
<td></td>
</tr>
<tr>
<td>b. Four and more girder bridges</td>
<td></td>
</tr>
<tr>
<td>c. Truss bridges</td>
<td></td>
</tr>
<tr>
<td>d. Other, specify</td>
<td></td>
</tr>
<tr>
<td>e. Other, specify</td>
<td></td>
</tr>
</tbody>
</table>
Section 2. Options

2. Does your agency view the pin and hanger assemblies as components that need retrofitted and/or replaced?
   - Yes
   - No  Go to question 5 on page 3

2a. If yes, please provide the number of retrofit and/or replacement options that you have implemented or programmed for each category below. If you have implemented or scheduled retrofit and/or replacement options other than those listed below, please describe and provide the number for each option in the additional table rows. If you have not implemented or programmed the retrofit and/or replacement option listed, please write in '0'.

<table>
<thead>
<tr>
<th>Retrofit option</th>
<th>Number implemented</th>
<th>Number programmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Use a secondary system such as a &quot;catcher beam&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Replace with new pin and hanger assembly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Replace with bolted splice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Other, specify:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Other, specify:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. For the retrofits and/or replacements you indicated above as implemented or programmed, did you follow any of the designs, procedures, or criteria below?

<table>
<thead>
<tr>
<th>Criteria and procedures</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. AASHTO LRFD criteria and procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. AASHTO standard specification criteria and procedures</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Have you developed your own criteria and procedures for retrofits and/or replacements?
   - Yes
   - No  Go to question 5 on page 3

4a. If yes, please provide references.
5. Does your agency view the pin and hanger assemblies as components that need **no further action** at this time?
   - Yes
   - No → Go to Question 6
5a. If yes, please briefly explain why no action was taken.

Section 3. Future Contact

6. If you developed your own criteria and procedures for retrofits and replacements, would you be willing to share those with us?
   - Yes
   - No → Go to Question 10
   - Not applicable
6a. If yes, which format would you prefer to share those in?
   - Electronically
   - Hard copy

7. Would you like to receive the results of this study?
   - Yes
   - No

8. If you answered yes to Question 6 or 7, please provide your information below for us to contact you to either request your criteria and procedures, or to provide you the results of this study.

   Name
   First: ______________________ Last: ______________________
   Email: ______________________ @ ______________________
9. Please use the space below to provide any additional comments.

Thank you!
That completes our questions. We greatly appreciate the time you have taken to complete this inventory survey. For your convenience, please use the postage-paid return envelope included in your survey packet to return your questionnaire to the Bureau of Sociological Research.

Questions or requests from this survey can be directed to:
Bureau of Sociological Research
University of Nebraska-Lincoln
PO Box 886102
Lincoln, NE 68588-6102
Phone: 1-800-480-4549 (toll free)
E-mail: bosr@unl.edu
Appendix B
Response to Survey of DOTs

Question 1

Other types of steel bridges that have pin and hanger assemblies other than listed are:

- Arizona DOT: Arch Bridge (85).
- Arkansas State Highway and Transportation Department: Arch deck (2).
- Alaska Department of Transportation and Public Facilities: Box girders (1).
- Colorado DOT: Tie down.
- Illinois DOT: Truss with eye bars & pins (1).
- Iowa DOT: Secondary highway steel girders, secondary highway truss.
- Michigan DOT: All girder bridges (1099).
- Minnesota DOT: Arch (1), Suspension (1).
- Ohio DOT: Riveted steel arch (2).
- Oregon DOT: RGDG (9).
- Utah DOT: Pinned arches (7), Suspension arch (1).
- Washington State DOT: Concrete box -2 (132).
- West Virginia DOT: Tied thru arch (1), Suspension bridge (1).

Question 2

- Maine DOT: Superstructure replace (number implemented-1, number programmed -1).
- Massachusetts DOT: Ship lap joint (number programmed -1), replace p & h assembly with under running bearing beam (number implemented-1).
- Michigan DOT: Replace bridge (number implemented-1, number programmed -3).
• North Carolina DOT: Replace w/ concrete girder (number programmed -1).
• Nebraska Department of Roads: replace bridge or superstructure- (of the 102 pin and hanger bridges on the state system 50 are scheduled for replacement of either the entire bridge or the entire superstructure).
• Virginia DOT: replace Bridge.
• Wyoming DOT: suspension hanger/seismic (number implemented-1).

**Question 4**
• Arkansas State Highway and Transportation Department: Internally developed.
• Illinois DOT: It is part of our structural services manual. Bureau of bridges and structures IDOT.
• Michigan MDOT: Our bridge replacement program prioritizes bridges with pins & hanger high enough to systematically replace the bridge with another (usually concrete) bridge.
• Missouri DOT: No set criteria. Details are case-by-case.
• Utah DOT: Is not documented.

**Question 5**
• Alaska Department of Transportation and Public Facilities: Pin & hangers are functioning properly. No pack rust present.
• Colorado DOT: No section loss due to corrosion & no crack on hanger.
• Delaware DOT: We are not as concerned with pin & hanger assemblies for multi-beam bridges. Pin & hanger assemblies on truss bridges are treated as a fracture critical member and are scrutinized more.
• Iowa DOT: Proper inspection should identify deficiencies in time to address them without impacts to public safety.

• Louisiana Department of Transportation and Development: Bridges are in good condition.

• Montana DOT: Pins and hangers are usually inspected every 2 years and UT inspected every 4 years. With our relatively dry climate and large temperature swings the p & h assemblies usually stay moving as designed with little rust impact.

• Minnesota DOT: We will include repairs or improvements to pin and hanger elements as conditions warrant. We have not developed projects solely on pin and hanger detail unless condition justifies.

• North Carolina DOT: Inspection reports indicate the condition of the pin and hanger is “good”.

• Nebraska Department of Roads: All bridges are inspected by certified inspectors at least every 2 years and all bridges that this agency manages directly have redundant secondary systems should failure occur.

• Nevada DOT: We haven't identified problems with the hangers, aside from minor corrosion.

• New Hampshire DOT: Framing plan varies from 10 to 7 girder lines, condition is satisfactory.

• Ohio DOT: We retrofit when they are deteriorated.

• Oklahoma DOT: We used ultrasonic inspection on our pins. No problems were found.

• Oregon DOT: We inspect & monitor p & h's and only r & r or provide supplemental support when their condition indicates a need.
- Pennsylvania DOT: We have retrofitted the inventory of 2 girder and truss bridges with suspended assemblies.
- South Dakota DOT: These assemblies are part of annual NBIS inspections and the pins get a periodic NDT inspection as well.
- Virginia DOT: We evaluate each one individually.
- Washington State DOT: Routine inspections and painting when needed.
- West Virginia DOT: We monitor during routine inspections and provide action as needed

**Question 6**

- 10 states willing to share their own criteria and procedures for retrofit and or/replacements are:

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>DOT</th>
<th>Preference for sharing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michael Hill</td>
<td><a href="mailto:mike.hill@ahtd.ar.go">mike.hill@ahtd.ar.go</a></td>
<td>Arkansas State Highway and Transportation Department</td>
<td>Electronically</td>
</tr>
<tr>
<td>Behrooz Far</td>
<td><a href="mailto:behrooz.far@state.co.us">behrooz.far@state.co.us</a></td>
<td>Colorado Department of Transportation</td>
<td>Electronically</td>
</tr>
<tr>
<td>Victor Veliz</td>
<td><a href="mailto:victor.veliz@illinois.gov">victor.veliz@illinois.gov</a></td>
<td>Illinois Department of Transportation</td>
<td>Electronically</td>
</tr>
<tr>
<td>Anne Rearick</td>
<td><a href="mailto:arearick@indot.in.gov">arearick@indot.in.gov</a></td>
<td>Indiana Department of Transportation</td>
<td>Electronically</td>
</tr>
<tr>
<td>Dave Powelson</td>
<td><a href="mailto:dpowelson@dot.state.nh.us">dpowelson@dot.state.nh.us</a></td>
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<td>Electronically</td>
</tr>
<tr>
<td>Tim Schwaglor</td>
<td><a href="mailto:tschwaglor@nd.gov">tschwaglor@nd.gov</a></td>
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<td>Electronically</td>
</tr>
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<td>Walter Peters</td>
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<td>Electronically</td>
</tr>
<tr>
<td>Tom Macioce</td>
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<td>Pennsylvania Department of Transportation</td>
<td>Electronically</td>
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</tr>
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<td>Joshua Sletten</td>
<td><a href="mailto:jsletten@utah.gov">jsletten@utah.gov</a></td>
<td>Utah Department of Transportation</td>
<td>Electronically</td>
</tr>
</tbody>
</table>
Additional Comments

- Arkansas State Highway and Transportation Department: We usually have 1 or 2 bridges a year that have pin/hanger issues. Our fix is normally to replace pin and hanger. Sometimes we keep the hanger and just flip it around. When we have wear we will bore and replace with bigger pins.

- Illinois DOT: As a result of a fractured pin is one of our structures in the mid 1990's the Illinois Department of Transportation developed an aggressive program for the replacement of pins and link assemblies. Between 1995 and 1997 over 90 structures on our primary system were retrofitted. Over 2000 pins and corresponding links or plate assemblies were replaced throughout the state. In general the retrofit replaced the old style “shoulder” pin (with no bushings) with a constant diameter solid pin made of a stronger material (Nitronic 60) using Teflon bushings. The intent was to provide a better pin assembly as well as one that was easier to inspect in the future.

- Iowa DOT: We have replaced bushings in pin & hanger assemblies due to corrosion/wear.

- Massachusetts DOT :For the replacement of the p & h assembly with the under running bearing beam, the detail looks just like a catcher beam except that the suspended span sits on a bearing on that beam and the p & h assembly was removed in its entirely.

- Michigan DOT: MDOT does not automatically view pin & hangers as needing replacement. We replace them on a case-by case basis based on condition and load capacity. Although pin & hangers are not utilized on new bridges, we do not have any focused efforts to remove them from our inventory.
• Mississippi DOT: We have replace pins & links on our large scale MS River crossing bridges in Watchez, MS. It is the only bridge we intend to remain in service with these details. The replacements were very large scale. These are long span truss bridges.

• Montana DOT: Our pin and hanger assemblies tend to work well. We have replaced pins over the years due to wear and also a few assemblies when they were ruined by impacts to girders from overweight loads.

• Minnesota DOT: MnDOT stopped building bridges w/ pin and hanger details in 1960's. We have not rehabilitated that many as the bridge width is typically too narrow therefore we have done mostly bridge replacements for those vintage. It has been over 10 years since last pin and hanger rehab and that one was caused by no cotter pin on pin and there was a condition concern the hanger may come off of pin. Call w/ questions.

• Missouri DOT: We only replace or repair them after they deteriorate. We don't have a program to do so.

• New Mexico DOT: Performs ultrasonic testing on all pins every 60 months. We have found and replaced compromised/broken pins.

• Ohio DOT: Number of retrofits performed - you did not give a time frame for this work. This makes it difficult to answer. This type of work has gone on for many years. We do not track this work so there is no way to answer that question beyond the memory of current group.

• Utah DOT: Please contact me for additional details on the bridge retrofit projects we have completed or programmed. I would like a copy of the results.

• Wyoming DOT: The pin & hanger we replaced was due to damage from gunshot.
Appendix C

List of Abbreviations

Alabama Department of Transportation (ALDOT)
Alaska Department of Transportation and Public Facilities (Alaska DOT & PF)
American Association for Public Opinion Research (AAPOR)
American Association of State Highway and Transportation Officials, Load and Resistance Factor Design (AASHTO LRFD)
Arizona Department of Transportation (ADOT)
Arkansas State Highway and Transportation Department (AHTD)
Average Daily Truck Traffic (ADTT)
Bridge Office Policies and Procedures (BOPP)
Bureau of Sociological Research (BOSR)
Colorado Department of Transportation (CDOT)
Delaware Department of Transportation (DelDOT)
Federal Highway Administration (FHWA)
Florida Department of Transportation (FDOT)
Fracture Critical Members (FCMs)
Georgia Department of Transportation (GDOT)
Hawaii Department of Transportation (Hawaii DOT)
Illinois Department of Transportation (IDOT)
Indiana Department of Transportation (INDOT)
Iowa Department of Transportation (IOWADOT)
Louisiana Department of Transportation and Development (LADOTD)
Maine Department of Transportation (Maine DOT)
Massachusetts Department of Transportation (Mass DOT)
Michigan Department of Transportation (MDOT)
Minnesota Department of Transportation (MnDOT)
Mississippi Department of Transportation (Mississippi DOT)
Missouri Department of Transportation (MoDOT)
Montana Department of Transportation (MDT)
National Bridge Inspection Standards (NBIS)
National Cooperative Highway Research Program (NCHRP)
National Transportation Safety Board (NTSB)
Nebraska Department of Roads (NDOR)
Nevada Department of Transportation (NDOT)
New Hampshire Department of Transportation (NHDOT)
New Mexico Department of Transportation (NMDOT)
New York State Department of Transportation (NYSDOT)
Non-destructive Testing (NDT)
North Carolina Department of Transportation (NCDOT)
North Dakota Department of Transportation (NDDOT)
Ohio Department of Transportation (ODOT)
Oklahoma Department of Transportation (OklahomaDOT)
Oregon Department of Transportation (OregonDOT)
Pennsylvania Department of Transportation (PennDOT)
Rhode Island Department of Transportation (RIDOT)
South Dakota Department of Transportation (SDDOT)
South Carolina Department of Transportation (SCDOT)
Tennessee Department of Transportation (TDOT)
Texas Department of Transportation (TxDOT)
Transportation Research Board (TRB)
Utah Department of Transportation (UDOT)
Virginia Department of Transportation, Central Office (VDOT)
Washington State Department of Transportation (WSDOT)
West Virginia Department of Transportation (WVDOT)
Wyoming Department of Transportation (WYDOT)
Appendix D

Table A.1 Summary

Summary of various retrofit and replacement options are briefly presented in the Table A1.
<table>
<thead>
<tr>
<th>Retrofit/replacement options</th>
<th>Pros</th>
<th>Cons</th>
<th>States that uses retrofit/replacement options</th>
<th>States that have drawings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bolted splices</strong></td>
<td>Eliminates non-redundant system, make structure more efficient. Reduces and mitigate superstructure corrosion.</td>
<td>Need to re-evaluate superstructure behavior and capacity. Higher construction cost.</td>
<td>MaineDOT, MnDOT, NHDOT, UDOT.</td>
<td></td>
</tr>
<tr>
<td><strong>Link slab</strong></td>
<td>Reduction of joints controls corrosion and moisture intrusion.</td>
<td>Structural damages-(thermal stress, shrinkage &amp; creep). Higher stress lead to fracture &amp; cracking along the slab.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Catcher beam system</strong></td>
<td>Immediate option, controls sudden failure of bridge.</td>
<td>Temporary system. Fatigue related problem replacement need to be considered.</td>
<td>AHTD, DelDOT, INDOT, MaineDOT, MassDOT, MnDOT, MoDOT, NCDOT, Oklahoma DOT, TDOT, WVDOT.</td>
<td>OklahomaDOT, PennDOT</td>
</tr>
<tr>
<td><strong>Ship lap joint</strong></td>
<td>Support beam carried by bearings, improves rotational degree of freedom.</td>
<td>Need to maintain joints. Higher maintenance and initial construction cost. Design, retrofit required are tedious compare to pin and hanger assembly.</td>
<td>MassDOT.</td>
<td>MassDOT</td>
</tr>
<tr>
<td><strong>New pin and hanger assembly</strong></td>
<td>Similar design can be cost-effective and minimal traffic disruption.</td>
<td>Regular ultrasonic inspection. Still provides non-redundant system.</td>
<td>IDOT, MnDOT, Mississippi DOT, MoDOT, UDOT, WYDOT.</td>
<td>IDOT, MichiganDOT</td>
</tr>
</tbody>
</table>

**Table A 1: Summary of DOT Options**
Appenidix D1

Nebraska Department of Roads Design Plans


PLATTSMOUTH NORTH BRIDGES

NOTES

The existing structure was built under project 4182-07, dated 1957. Plans are available from the Bridge Division upon request.

The concrete bridge deck is designed by the empirical design method in accordance with AASHTO LRF fourth edition.

The contractor may substitute any of the alternate designs shown on the plans for the original design. All specifications are based on the original design and all substitutions or deviations will be allowed for the use of any alternate design.

All structural steel for stiffeners and all plate material, sealants to the requirements of ASTM A709/A709M, Grade 50W weathering steel, nuts, bolts and washers used in the assembly of weathering steel shall be Type 3.

All fasteners shall be 316 high-strength bolts, ASTM A325.

Fillet welds of all form hangers or miscellaneous hardware to any part of the steel girder shall be prestressed.

The grinders for this bridge are not designed to remove any portion of the steel girder or other grades due to excessive construction loads. The contractor shall provide any necessary bracing necessary to support the girder and fasteners against all temporary forces resulting from construction loads.

Concrete for slab, approach slab and rail shall be class "K8C", with a minimum 28-day strength of 4000 psi.

All reinforcing steel shall be epoxy coated and conform to the requirements of ASTM A615/A615M, Grade 60 steel.

The minimum clearance, measured from the face of the concrete to the surface of any reinforcing bar, shall be 2", except where otherwise noted.

All dimensions shown are in horizontal plane only, the dimensions have been made for vertical walls or roadway cross slope.

Amenities show may be provided on the roadway for visual and noise control due to the weight of the slab and rail only. The contractor is responsible for selecting the necessary modifications for the particular roadway system used to achieve the slab grades and elevations shown on the plans.

PREPARING CONSTRUCTION AS FINISHED:

New Slab, Treadway and Rails
New Approach Slabs and Guard Rails
New Launches or Approach

INDEX

- QUANTITIES -

| Preparation of Bridge at STA 95+00.50 | 1 EACH |
| Abutment No. 1 Excavation | 1 Lump Sum |
| Abutment No. 2 Excavation | 1 Lump Sum |
| Class: 40D-400 Concrete for Bridges: Slab | 376.4 CU. YD. |
| Hanger | 1.3 CU. YD. |
| Concrete Rails | 38.4 CU. YD. |
| Structural Steel for Superstructure: | 4150 LBS |
| Expansion Bearing, Type | 4115 LBS |
| Bearing Device | 100 LBS |
| Gravel Backfill | 85 CU. YD. |
| Subgrade Drains/Mattings | 500 TONS |
| Concrete for Pavement Approaches: | 216.5 CU. YD. |
| Slab | 105.3 CU. YD. |
| Concrete Rails | 29.3 CU. YD. |
| Grade Beam | 42.0 CU. YD. |
| epoxy coated reinforcing steel | 2075 LBS |
| Slab | 2075 LBS |
| Concrete Rails | 42.0 CU. YD. |
| Grade Beam | 42.0 CU. YD. |
| Precompressed Polyurethane Foam Joint, Type B | 15.5 LIN. FT. |
| 102 Conduct on Bridge | 281 LIN. FT. |

GENERAL NOTES, QUANTITIES & INDEX

- GENERAL PLAN & ELEVATION -
- PHASING PLAN -
- PLAN & ELEVATION OF ABUTMENT NO. 1 -
- PLAN & ELEVATION OF ABUTMENT NO. 2 -
- GRADE BEAM BILL OF BARS -
- GUIDER MOUNT & FIELD SPACE DETAILS -
- CROSS SECTION OF ROADWAY -
- PLAN VIEW OF SLAB AND TURNBOW -
- SLAB BILL OF BARS -
- APPROACH SLAB -
- APPROACH SLAB SECTION AND DETAILS -
- RAIL ON APPROACH SLAB -
- BILL OF BARS - APPROACH SLAB -
RAILROAD NOTES

The proposed grade separation project shall not increase the quantity and/or characteristics of the flow in the road's diverting and/or drainage structures. The elevation of the existing grade shall be verified before beginning construction. All disagreements shall be brought to the attention of the railroad prior to construction.

The contractor must submit a proposal method of erosion and sediment control and have the method approved by the railroad.

All drainage systems that impact the railroad's operations and support the railroad's embankment shall be designed and constructed per current railroad guidelines for temporary erosion.

All construction within the railroad's right-of-way and/or demolition that may impact the railroad's tracks or operations shall be in compliance with the railroad's demolition guidelines.

Erosion at the railroad's right-of-way shall be designed to cause no interruption to the railroad's operation, enabling the tracks to remain open to traffic for the railroad's requirements.

Railroad requirements do not allow work within 50 feet of track centerline when a train passes the work site and all personnel must clear the area within 25 feet of the track centerline and secure all equipment.

False-work clearances shall comply with minimum construction clearances.

All permanent clearances shall be verified before project closing.

For railroad coordination please refer to the railroad minimum requirements as part of special provisions.
## Bill of Bars

<table>
<thead>
<tr>
<th>Material</th>
<th>Number of Bars</th>
<th>Length</th>
<th>Type</th>
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<th>&quot;D&quot;</th>
<th>&quot;E&quot;</th>
<th>&quot;F&quot;</th>
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<td></td>
<td>26</td>
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**Total:** 2068.00

---

### Drainage Detail and Granular Backfill

- Please fabric side of subsurface drainage meeting toward backfill.

---

*Notes: For building drawings, Nora lengths & PMD diameters see Sheet H of H.*
1. Replace bearings at Abutments.
2. Place a Full System (Top and Bottom Flange) at Pin and Hanger Systems.
3. Place 2-1 5/8" wide spaced at 3'-6" c/c at maximum section of web.

**SECTION AT EXPANSION BEARING (TFE TYPE)**

Tapped holes are to be removed before new shear plates can be attached to existing Girders.

**FIELD SPICE DATA**

<table>
<thead>
<tr>
<th>PIN AND HANGER SYSTEM NO. 1 AND NO. 2</th>
<th>Thickness</th>
<th>Width</th>
<th>Length</th>
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<tr>
<td>Plate A</td>
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<td>3'-4&quot;</td>
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<tr>
<td>Plate B</td>
<td>3/4</td>
<td>11&quot;</td>
<td>3'-4&quot;</td>
</tr>
<tr>
<td>Plate C</td>
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<td>3'-4&quot;</td>
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<td>Plate D</td>
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</tr>
<tr>
<td>Plate E</td>
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<td>3'-4&quot;</td>
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</table>

**ELEVATION**

**PLAN OF BOTTOM FLANGE**

**DIMENSIONS FOR BEARING DEVICES**

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<tr>
<th>LOCATION</th>
<th>NO. PLATE</th>
<th>FABRIC PADS</th>
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<tr>
<td>Sheeting Plate</td>
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<td>A</td>
</tr>
<tr>
<td>Abutment No. 1</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Abutment No. 2</td>
<td>C</td>
<td>B</td>
</tr>
<tr>
<td>Abutment No. 3</td>
<td>C</td>
<td>B</td>
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**FIELD SPICE DETAILS**
CROSS SECTION OF ROADWAY

PLAN VIEW OF SLAB
SHOWING TOP BARS ONLY
# BILL OF BARS

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<thead>
<tr>
<th>MARK</th>
<th>NUMBER OF BARS</th>
<th>LENGTH</th>
<th>TYPE</th>
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<th>&quot;B&quot;</th>
<th>&quot;C&quot;</th>
<th>&quot;D&quot;</th>
<th>&quot;E&quot;</th>
<th>&quot;F&quot;</th>
<th>PIN NO.</th>
<th>HEIGHT</th>
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<td>8</td>
<td>25'</td>
<td>BAR</td>
<td>5&quot;</td>
<td>5&quot;</td>
<td>5&quot;</td>
<td>5&quot;</td>
<td>5&quot;</td>
<td>5&quot;</td>
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<td>100</td>
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<tr>
<td>5402</td>
<td>12</td>
<td>25'</td>
<td>BAR</td>
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<td>4&quot;</td>
<td>4&quot;</td>
<td>3&quot;</td>
<td>5&quot;</td>
<td>5&quot;</td>
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<td>76</td>
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<tr>
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<td>3&quot;</td>
<td>4&quot;</td>
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<td>2&quot;</td>
<td>3&quot;</td>
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<td>1.5&quot;</td>
<td>1.5&quot;</td>
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<td>4&quot;</td>
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<td>5407</td>
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**Total:** 300 bars

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<th>TYPE</th>
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<th>&quot;B&quot;</th>
<th>&quot;C&quot;</th>
<th>&quot;D&quot;</th>
<th>&quot;E&quot;</th>
<th>&quot;F&quot;</th>
<th>PIN NO.</th>
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<td>BAR</td>
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<td>5402</td>
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<td>10'</td>
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<td>1.5&quot;</td>
<td>1.5&quot;</td>
<td>2&quot;</td>
<td>3&quot;</td>
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<tr>
<td>5403</td>
<td>80</td>
<td>6'</td>
<td>BAR</td>
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<td>1&quot;</td>
<td>1&quot;</td>
<td>1.5&quot;</td>
<td>2&quot;</td>
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<td>4&quot;</td>
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<tr>
<td>5404</td>
<td>80</td>
<td>6'</td>
<td>BAR</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>1&quot;</td>
<td>1.5&quot;</td>
<td>2&quot;</td>
<td>3&quot;</td>
<td>4&quot;</td>
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</table>

**Total:** 240 bars

---

### NOTES

- For bending diagrams, hook lengths & pin diameters see sheet W of TL.
LONGITUDINAL SECTION

SECTION A-A

SECTION B-B

SECTION C-C

APPROACH SLAB NOTES:
Concrete slab width = 14'-6". See sheet 13 or 14 for placement of rail reinforcement.
See Standard Specifications for timing and finishing of approach slabs.

SSS MODIFIED ASPHALT base sheets and all other bituminous sheets shall be considered subsidiary to the slab base. CONCRETE FOR PLACEMENT APPROACHED CLASS 480-400.

The expansion gap between approach sections and saving section shall be covered at all foreign edges before the completion of the expansion joint or the finishing material.

1. Expansion joints shall be created at the intersection of the edge of clear roadway and clear slabs.
2. Expansion joints shall be created at edges of clear roadways.
### Bill of Bars

<table>
<thead>
<tr>
<th>Steel Type</th>
<th>Length</th>
<th>Bars</th>
<th>Quantity</th>
<th>Total Length</th>
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<tbody>
<tr>
<td>A36</td>
<td>12'</td>
<td>4</td>
<td>12'</td>
<td>48'</td>
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<tr>
<td>A572</td>
<td>12'</td>
<td>3</td>
<td>12'</td>
<td>36'</td>
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### Standard Hook Length

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<th>Hook Length</th>
<th>Pin Diameter</th>
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<td>8'</td>
<td>12&quot;</td>
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<tr>
<td>10'</td>
<td>14&quot;</td>
</tr>
</tbody>
</table>

### Bar Mark

- **A36**: 12' 4 bars
- **A572**: 12' 3 bars

### Bending Diagrams

- **Bar Number**: 12
- **Bar Size**: 8" 12" 14" 16" 18" 20"
- **Bar Quantity**: 6 8 10 12 14 16
- **Bar Length**: 12' 10' 8' 6' 4' 2'

#### Bar Sets - Phase 1

<table>
<thead>
<tr>
<th>Steel Type</th>
<th>Bars</th>
<th>Hook Length</th>
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<tr>
<td>A572</td>
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#### Bar Sets - Phase 2

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<tbody>
<tr>
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<td>8&quot; 12&quot;</td>
<td>12&quot;</td>
</tr>
<tr>
<td>A572</td>
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<td>8&quot; 12&quot;</td>
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#### Bar Sets - Phase 3

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<thead>
<tr>
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<th>Pin Diameter</th>
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<td>8&quot; 12&quot;</td>
<td>12&quot;</td>
</tr>
<tr>
<td>A572</td>
<td>3</td>
<td>8&quot; 12&quot;</td>
<td>12&quot;</td>
</tr>
</tbody>
</table>
PHASE I TRAFFIC & REMOVAL

- Remove or deck = 2'-6"
- Edge of Ha
- Saw cut and break jack back 2' of Ha
- Existing Asphal Overlay
- Start Asphal overlay removal from this point
- New Overlay

PHASE I CONSTRUCTION & PHASE II TRAFFIC & REMOVAL

- New Overlay
- Phase Line
- For overlay
- Start Asphal overlay removal from this point
- Existing Asphal Overlay
- Saw cut and break jack back 2' of Ha

PHASE II CONSTRUCTION & TRAFFIC

- New Overlay
- Phase Line
- For overlay
- New Overlay
The plan view quantity for Granular Backfill per Abutment, has been established using the following equation:

\[ \text{Quantity (yd}^3\) = \text{Area A} (3' x 3') \times \text{Depth} \]

- The Granular Backfill in this area shall be placed to 8 inch lift and compacted to a single lift of a stacked weigh train (approx. 100 lbs.) mechanical tamper, roller, or vibratory compactor.
- There is no density requirement; heavy compaction equipment shall not be used in this area filling the granular backfill with water is not allowed.

**SECTION A-A**

**GENERAL PLAN**

Not to Scale

---

- **NOTES**

  "PIN REPLACEMENT". This work shall consist of supporting the suspended girders at the expansion joint, removing the existing pin plates and pins, and installing the new pin plates and pins.

  Prior to beginning any field work a shop-fit trial procedure shall be completed by the Contractor for the Engineer’s approval. A possible method of supporting the girders is shown in the plan. The Contractor is not required to use this method of support, it is only shown as a possible method. The furnishing and installation of the new temporary girders clamping plates or other material shall be a part of this item. Any damage to the structure due to negligence by the Contractor shall be repaired by the Contractor at no expense to the State. Approval of any procedure submitted by the Contractor shall not release him of any responsibility.

  The term "Pin Replacement" shall be measured for payment as a single unit for each set of pin plates and pins replaced and approved by the Engineer.

  Payment for this work measured in square feet, shall be made at the contract unit price per each $1.00 for the item "Pin Replacement". This price shall include, furnishing, removing, installing new pin plates, equipment, tools, materials and any incidental necessary to complete the work.
PLAN OF OPEN CONCRETE RAIL ON BRIDGE (SPANS NO. 1 & NO. 9)

Open Concrete Rail on Bridge Deck - 65'-0" L.O.G.

ELEVATION OF OPEN CONCRETE RAIL ON BRIDGE (SPANS NO. 1 & NO. 9)

NOTES:

- Notes must be shown.
- Transition near Abutment No. 2 only.
- Measured at front face of rail.

For Bill of Rail see sheet 12 of 15.

4" = Each Face
3/4" = Deck Face

ALTERNATE CHAMFER DETAIL

"H" = Zero

LAP DETAIL

RAIL SECTION
See 142-Spec
## BILL OF BARS

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<th>NUMBER OF SETS</th>
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<th>HOE</th>
<th>&quot;C.D.&quot;</th>
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<td>2-1/2</td>
<td>600</td>
<td>450</td>
<td>180</td>
<td>180</td>
</tr>
</tbody>
</table>

**SUBTOTAL =** | 2050 | 2050 |

| S905 | 64             | 64     | 5-1/2 | 104 | 5-1/2 | 104 | 5-1/2 | 104 | 5-1/2 | 104 | 450 | 200 | 200 |
| S906 | 64             | 64     | 5-1/2 | 104 | 5-1/2 | 104 | 5-1/2 | 104 | 5-1/2 | 104 | 450 | 200 | 200 |
|      |                |        |      |     |     |     |     |     |     |     |     |       |       |
|      |                |        |      |     |     |     |     |     |     |     |     |       |       |
|      |                |        |      |     |     |     |     |     |     |     |     |       |       |
|      |                |        |      |     |     |     |     |     |     |     |     |       |       |

**SUBTOTAL =** | 2050 | 2050 |

| S910 | 60              | 60     | 4-1/2 | 130 | 4-1/2 | 130 | 4-1/2 | 130 | 4-1/2 | 130 | 450 | 200 | 200 |
| S911 | 64              | 64     | 4-1/2 | 130 | 4-1/2 | 130 | 4-1/2 | 130 | 4-1/2 | 130 | 450 | 200 | 200 |
|      |                |        |      |     |     |     |     |     |     |     |     |       |       |
|      |                |        |      |     |     |     |     |     |     |     |     |       |       |

**SUBTOTAL =** | 2050 | 2050 |

| S915 | 88              | 88     | 3-3/4 | 130 | 3-3/4 | 130 | 3-3/4 | 130 | 3-3/4 | 130 | 450 | 200 | 200 |
| S916 | 88              | 88     | 3-3/4 | 130 | 3-3/4 | 130 | 3-3/4 | 130 | 3-3/4 | 130 | 450 | 200 | 200 |
|      |                |        |      |     |     |     |     |     |     |     |     |       |       |
|      |                |        |      |     |     |     |     |     |     |     |     |       |       |

**SUBTOTAL =** | 2050 | 2050 |

**TOTAL =** | 15000 | 15000 |

---

**NOTE:** For pin diameters, hook lengths & bending diagrams see sheet 23 of 23.

---

Example shown for Abatement report: (See picture)

All damaged concrete or asphalt should be removed to sound concrete and then patch with new concrete. Pay Item for this repair.

"Abatement Report"

Contact Bridge Division with any questions.
**APPENDIX SLAB NO. 1**

**APPENDIX SLAB NO. 2**

**GENERAL PLAN OF APPROACH SLABS**

**LONGITUDINAL SECTION**

**LONGITUDINAL JOINT**

**ALTERNATE JOINT DETAIL**

**AT END OF FLOOR**

To be used at approach slab steps, connected with edge beam.

**OPTIONAL GRADE BEAM JOINT DETAIL**

**SECTION A-A**

**SECTION B-B**

**APPENDIX SLAB NOTES:**

Concrete flat wash = 3/8". See sheet 13 or 14 for placement of rail reinforcement.

**LSBS MODIFIED ASPHALT** base sheet and all other Bitumenous items shall be accompanied by the plan detail. For Pavement Approaches CLS-1000, 30-800, 30-600.

**LSBS MODIFIED ASPHALT** base sheet shall be accompanied by reinforcement materials. A minimum thickness of 3/4" and a minimum weight of 900 lbs per 100 sq ft.

**LONGITUDINAL JOINTS** shall be 3/8" deep and sealed in the gaps as shown in the full plan and any other plans. The expansion joint between the approach and the bridge shall be at least 3/4" deep and sealed in the gaps as shown on the full plan and any other plans. The expansion joint between the approach and the bridge shall be at least 3/4" deep and sealed in the gaps as shown on the full plan and any other plans.

**CONCRETE FOR PAVEMENT APPROACHES CLASS 4000-4500**
THREE BEAM TERMINAL CONNECTION DETAIL

As an alternative method, the contractor shall furnish and set into the concrete an approved bolted assembly consisting of threaded inserts, held in place by the placement of the two angle plates and fastened with nuts. The threaded inserts shall be a standard product of a reputable manufacturer of both nuts and washers capable of resisting a shear load of 10,000 lbs.

NOTES

- Drilled areas indicate placement for the top layer of slab reinforcement. Concrete Rail will be built in place.
- Measured at front face of rail.

For Bill of Bars see Sheet 14 of 16.
Steel plates are required when using the R52 rail connector.

FRONT FACE (FP) = Front Face
BP = Back Face

SECTION B-B
ALTERNATE CHAMFER DETAIL

FRONT FACE (FP) = Front Face
BP = Back Face

SECTION A-A
SECTION B-B
SECTION C-C

CONCRETE BARRIER

PLAN OF 2'-6" POST
PLAN OF 4'-0" POST
### B I L L  O F  B A R S

| MARK | NUMBER OF BARS | LENGTH | TYPE | "B" | "C" | "D" | "E" | PIN | HOOK | REBAR | S H | P L A U S | P L A U S |
|------|----------------|--------|------|-----|-----|-----|-----|-----|-----|------|------|-----|---------|---------|
| N001 | 48             | 44     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N002 | 47             | 47     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N003 | 47             | 47     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N004 | 40             | 40     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N005 | 38             | 38     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N006 | 38             | 38     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N007 | 34             | 34     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N008 | 40             | 40     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N009 | 40             | 40     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N010 | 38             | 38     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N011 | 36             | 36     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N012 | 34             | 34     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N013 | 32             | 32     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N014 | 30             | 30     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
| N015 | 30             | 30     | "D"  | 1 4" |     | 8 11"|     | 2 10"| 10" | 10" | 10" | 10" |        |          |
|      |                |        |      |     |     |     |     |     |     |     |     |     |        |          |

### B A R  M A R K

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### B E N D I N G  D I A G R A M S

All dimensions are cut to fit a not to scale. All reinforcement shall be omit cutoff.

- "R" = reaction bar (to resist) a = anchor bar, s = stay, s = support, a = approach slab

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<th>&quot;C&quot;</th>
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### S T A N D A R D  H O O K  L E N G T H

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### P I N  D I A M E T E R

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NOTES
Alkaline Concrete used on approach sides are full width of the bridge and 3'11" from the end of the bridge floor.

QUANTITIES

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<td>25 ft</td>
<td>120 lb Ft</td>
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<td>Reinforcement</td>
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<td>25 ft</td>
<td>120 lb Ft</td>
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<td>Reinforcement, Plt.</td>
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<td>25 ft</td>
<td>120 lb Ft</td>
</tr>
<tr>
<td>Plank</td>
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<td>25 ft</td>
<td>120 lb Ft</td>
</tr>
<tr>
<td>Steel</td>
<td>7</td>
<td>25 ft</td>
<td>120 lb Ft</td>
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Alkaline Concrete, Type "A" | 100 cu ft |

STATE OF NEBRASKA
DEPARTMENT OF HIGHWAYS - BRIDGE DIVISION

STATE ROAD | SHREW | PEP. NO. | REP. NO. | COUNTY

NOTES

- Structural Steel for Girder Planks
- Reinforcement
- Reinforcement, Plt.
- Plank
- Steel
- Alkaline Concrete, Type "A"

TABLE OF CONTENTS

- General Elevation
- Bridge No. 1
- Bridge No. 2
- Bridge No. 3
Illinois Department of Transportation

Standard drawings - pin and hanger assembly replacement.
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION
*
D-2 BRIDGE PIN REPLACE 297-1

ELEVATION AT EXISTING PIN ASSEMBLY
FOR INTERIOR BEAMS

Any pins that can be easily removed without damage to the pin shall be
removed and the Bridge Engineer shall be advised for disposition.
Cost of replacements is included in "Pin and Link Plate Replacement".

ELEVATION AT EXISTING PIN ASSEMBLY
FOR EXTERIOR BEAMS

If the existing deck between the new link plates, concrete
shall be removed to provide clearance for the new pin and link plates.

ELEVATION AT NEW PIN ASSEMBLY
FOR INTERIOR BEAMS

ELEVATION AT NEW PIN ASSEMBLY
FOR EXTERIOR BEAMS

MAXIMUM REACTIONS AT PIN

Note A:
Existing plates shall be inspected for cracks using liquid dye
detectors or magnetic particle testing. Any cracks that are found
shall be identified and reported to the Bureau of Bridges and
Structures for further disposition. Clean and paint before installing
new link plates.

Note B:
Bore diameter for bolting in this zone, existing plate
and link reinforcing plates shall correspond to building
manufacturer's allowable tolerances for proper function. Bolt
head diameter may be adjusted to allow use of standard bolts.

Note C:
Installing face of new link plates shall receive first field coat in
shop. The primer coat shall be the NEI's Red Phenol followed by the first
hard coat as specified.

Note D:
Actual bending moments per manufacturer's specifications,
\( M \) is a parameter that shall be used to determine
whether the bridge will require additional reinforcement. It shall be
the Contractor's responsibility to verify such dimensions and details.

Note E:
Tighten inside nuts to bring all link plates into firm contact.

Note F:
Apply a 1\( \frac{1}{2} \) to 2\( \frac{1}{2} \) coat of black to face of the reinforcing plates approximately
1\( \frac{1}{2} \) from the top edge of new link plates.

TOTAL BILL OF MATERIAL

TR ROUTE 148 SEC. 06-3IR
BUREAU COUNTY
STA. 640 + 74.86
STL No. 005-0823
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

ELEVATION AT EXISTING PIN ASSEMBLY
FOR INTERIOR BEAMS

Existing 8" Line Plate
Each Side (See Note A)
Existing 6" Line Plate
Each Side (See Note A)
Existing 4" Tie Plate
Each Side (See Note A)
Existing 4" Tie Plate
Existing 8" Tie Plate
Existing 6" Tie Plate
Existing 5° Web Reinforcing
Existing 5° Web Reinforcing
Plate shall remain in place
Plate shall remain in place
Each Side (See Note A)
Each Side (See Note A)

The hole in the existing webs, web reinforcing plates and pin plates shall be 2 1/4" bored to 2 5/8" or 196 (See Note B)

ELEVATION AT EXISTING PIN ASSEMBLY
FOR EXTERIOR BEAMS

Existing 8" Line Plate
Each Side (See Note A)
Existing 6" Line Plate
Each Side (See Note A)
Existing 4" Tie Plate
Each Side (See Note A)
Existing 4" Tie Plate
Existing 8" Tie Plate
Existing 6" Tie Plate
Existing 5° Web Reinforcing
Existing 5° Web Reinforcing
Plate shall remain in place
Plate shall remain in place
Each Side (See Note A)
Each Side (See Note A)

The hole in the existing webs, web reinforcing plates and pin plates shall be 2 1/4" bored to 2 5/8" or 196 (See Note B)

ELEVATION AT NEW PIN ASSEMBLY
FOR INTERIOR BEAMS

Existing 8" Tie Plate
Existing 6" Tie Plate
Existing 5° Web Reinforcing
Existing 5° Web Reinforcing
Plate shall remain in place
Plate shall remain in place

ELEVATION AT NEW PIN ASSEMBLY
FOR EXTERIOR BEAMS

Existing 8" Tie Plate
Existing 6" Tie Plate
Existing 5° Web Reinforcing
Existing 5° Web Reinforcing
Plate shall remain in place
Plate shall remain in place

GENERAL NOTES:

All new structural steel shall conform to ASTM A572 Grade 50. All other materials shall be in accordance with the applicable specs.

The Contractor will provide support and/or shoring systems for the beams in the area of existing pin replacement. See Special Provision "Temporary Support Systems".

Elevations shown are not necessarily to scale or to final dimensions. E or W alignment is assumed.

MAXIMUM REACTIONS AT PIN

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TOTAL BILL OF MATERIAL

PIN REPLACEMENT
FAS 1248 SEC. 06-219B
BUREAU COUNTY
STA. 342+38.40
STA. NO. 006-017
Massachusetts Department of Transportation

Design drawings – ship lap joint assembly.
Michigan Department of Transportation

Design drawings - Pin and hanger assembly replacement.
**Suspender Details for Cantilevered Plate Girders**

**Elevation**
- **Expansion Joint**
- **Fixed Joint**

**Section A-A**
- **Anchor Span**
- **Suspended Span**

**Details:**
- **Pin (Typ)**
- **Link Plate**
- **Bevel for Pin Plate (Typ)**

**Stays:**
- **Stay Plate for Fixed Joint Only**
- **1" Min. (Typ)**
- **1/2" (Typ)**
- **1/2" Stainless Steel Washer (Typ)**
- **1/2" Non-Metallic Bushing (Typ)**
- **1/2" Nylon Washer**
- **1/2" Stainless Steel Cotter Pin (Typ)**
- **1/4" Radius (Typ)**

*For Detail, see Guide 8.15.01A*

---

**Drawn By:** BLT  
**Checked By:** VZ  
**Approved By:** DAJ  
**Issued:** 06/25/12  
**Supercedes:** 05/04/06  
**Issued:** 06/25/12  
**Prepared By:**  
**Design Division:**  
**Prepared By:**  
**8.15.01**
$\frac{1}{2}''$ NYLON WASHER (TYP)

$\frac{1}{4}''$ STAINLESS STEEL WASHER (TYP)

$\frac{1}{4}''$ RADIUS (TYP)

$\frac{1}{4}''$ NON-METALLIC BUSHING (TYP)

STAINLESS STEEL PIN

LINK PLATE (TYP)

NOTE:
SEE GUIDE 8.16.02 FOR WASHER DETAILS.
1/4" STAINLESS STEEL WASHER

1/2" NYLON WASHER

INCLUDED IN THE BID ITEM "STRUCTURAL STEEL, ....... FURN AND FAB."

LINK PLATE

WELDED PIN PLATES

SECTION A-A

*FOR DETAIL SEE 8.15.01A

NOTE:
SPACING OF THE H.S. STEEL BOLTS SHALL BE ACCORDING TO THE CURRENT AASHTO SPECIFICATIONS.
Oklahoma Department of Transportation

Design drawings - catcher beam system.
procedure confirms that the bolts have been
shall be
of bearing
Indicators"
be applied for optimum
concrete
LP/EPOXY
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accordance
concrete
is poured. the
Provis~ons
SPECIFICATIONS: intact
material
AA
Surface Pre
AA
(mm)
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**PAY QUANTITIES**

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**PAY QUANTITIES**

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Plan for Pier "Jacking Sequence" see note on SHT.

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Notes:
- For Pier No 8 jacking sequence see note on SHT.
- Plan for Pier "Jacking Sequence" see note on SHT.
- Details of bracket, gussets, and bearing assembly typical at all interior columns.
- Window cutout for bridge beam to pier cap.
- Column heads centered at column 1, 27 3/4" from end of beam (10 miles north).
JACKING STIFFENER

JACKING BEAM STIFFENER DETAIL

The plans in the jackin beam shall be as shown on Sheet 1. The crossframes shall be jacki on the jackin beam as follows:

The jackin beam shall only be jacki when the temperature is between 50°F and 70°F. Jacking shall be restricted to off-peak traffic hours, such as Sunday mornings.

The contractor shall temporarily remove the existing crossframes except for the top member. The jackin beam shall be bolted to the 72" plate girder as shown on the plans using the bolt holes from the crossframes and all new A-490 bolts. The jackin beam shall be bolted to the 72" plate girder as shown on the plans to take the load off the existing expansion assembly.

On the ramp, all three girders shall be jackin simultaneously. The reaction is approximately 70 tons per girder.

GALVANIZED ANCHOR BOLT DETAIL

It is recommended that the contractor torch the sole plate on four sides and remove the existing bearing assembly. It may be necessary to torch the pintle. The anchor bolts should be cut off flush with the top of the pedestal as directed.

The contractor shall slide in the new bearing assembly, release the jacks, remove the jackin assembly, drill 3" holes for the 1 1/2" anchor bolts, and drop in the new anchor bolts. The anchor plate extensions shall be welded to the anchor plate.

The anchor plates, anchor plate extensions, 3 1/4" dia A325 bolts & nuts, shall be painted in accordance with the Standard Specifications. If it is necessary to jack more than one inch, the contractor shall be required to jack the girders on both sides of the pier. In this situation, the jacking beam shall be jacked in place and the jackin beam shall be bolted to the girder. The jackin beam shall be disassembled and reassembled in place.

The existing bearing assembly shall become the property of the contractor and shall be removed from the project site in accordance with the Standard Specifications.

All structural steel shall be A-36. Used steel shall not be allowed except for the jackin beam.

QUANTITIES

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TYPICAL INTERIOR}

NOTE: For Construction Sequence at Pier 7B refer to Sheet no. 2.
ALL 3-UNIT CONCRETE ANCHORS SHALL BE 3/4" DIA X 9" LONG, EMBEDDED 6" INTO EXISTING CONCRETE.

BEVELED ANCHOR R

PIER NO. 7 RAMP 22
MODIFICATION

BEARING PAD DESIGN
3" COIR CORK LAYERS
2" 60 LBS. LAYERS
5 - 9 U. L. LAYERS
Top View of Section A-A

Adjustable Height Bearing Assembly

Section A-A

29" x 8" Slots (typ.)

Section C-C

Adjustable Height Bearing Assembly

2.5" x 1.5" Flange

Flange B 1.25" x 1.25"

Top View of Section C-C

Miscellaneous Details
CHANGE IN PLANS

CROSSFRAME CONNECTION DETAIL

SECTION A-A

EXISTING STRUCTURE

SECTION B-B FOR W1

SECTION B-B FOR W2

CROSSFRAME COLUMN CONNECTION DETAIL

CROSSFRAME COLUMN CONNECTION DETAIL

COLUMN CONNECTION DETAIL

NOTE: In locating the center line of the column, the pipe shall be at least 1 in. (25 mm) from the pipe edge of the component. The 5/16" x 5/8" connection pipe shall change to a length of sufficient amount to connect directly to the angle at the column.
PLAN VIEW

SECTION C-C

COLLAPSED FLOOD in to be used for changes or notes. See Bridge only at site no. 14.

JACKING ASSEMBLY

Note: Scales omitted for clarity.

SECTION A-A

Continuous falsework panels may be replaced by intermittent panels at the discretion of the engineer.

SECTION B-B

CHANGE OF PLANS NO.

ELEVATION VIEW OF DAMAGED PIER BEAM

DETAILS OF FALSEWORK AND JACKING LOCATIONS

STATE OF OKLAHOMA DEPARTMENT OF TRANSPORTATION PROJ. 278-78-68, 1993
Pennsylvania Department of Transportation

Design drawings – catcher beam system.
GENERAL NOTES

The work of this contract includes installation of auxiliary support beams located beneath the girder at the main supports in spans 3 and 6 of the westbound structure and spans 2 and 5 of the eastbound structure.

Details and dimensions shown on these drawings to resemble the existing structure must take into account form and finish of the structure and original built and may not reflect present conditions. Specify all corrosion and injury to the existing structure in the field, as necessary, for proper fit of the proposed construction.

Contact plans and shop drawings for the existing bridge are available from the Pennsylvania Department of Transportation, at a normal fee, for the purpose of aiding in future construction. Contact those of the existing structure which are of lesser importance for detailed construction. For details on contact plans, and for selecting those shop drawings required, do not assume that all the shop drawings relating to the proposed new work are available. Do not consider any of the data on the existing structure supplied by the original design drawings on those available by the department or its authorized agents. As positive representations by any of the conditions that will be encountered in the construction of the proposed new work, is not to be considered a basis for computation of the unit price for bidding purposes. These are to be considered as implied agreements that information is correctly shown. Assume the possibility that conditions affecting the cost and quantity of work to be performed may differ from those indicated.

Provide all materials and equipment in accordance with Pennsylvania Department of Transportation Specifications, publication 446-B, current supplement, and meeting bridge welding code SI 5.88 and contract special provisions.

Provide structural steel, conforming to ASTM A36, grade 50, or higher, except where noted otherwise. Provide structural steel, conforming to ASTM A572 grade 50, or higher, for steel lined with 11.3% of the total weight of the structure, and conforming to ASTM A572, where steel is identified.

Fabricate auxiliary support beam flange plates, web plates, and stiffeners and bearing plates. Assemble using ASTM A36 structural steel. To conform to the requirements of shop fabrication guide specifications for fabrication critical components. Provide material conforming to the base metal, namely, the requirements listed in the special provisions.

Fabricate all precast concrete segments at an AISI category 2 fabrication shop with precast concrete certification.

Design specifications and design 1.15 of 1986 ASABE standard specifications for highway bridges, including pinning through the 1.15 design specifications, and as supplemented by the Pennsylvania Department of Transportation.

LIVE LOAD DISTRIBUTION TO BE BASED ON THE AXIAL METHOD.

DEAD LOAD INCLUDES THE ORIGINAL WEIGHT OF THE STRUCTURE AND 30 POUNDS PER SQUARE FOOT FOR FUTURE BEARING SURFACE ON THE DECK SLAB.

LIVE LOAD IS MULTIPLIED BY THE LOAD FACTOR METHOD. A LIVE LOAD OF THE PENNSYLVANIA DEPARTMENT AS SET (LOAD POUND AND 125 PERCENT OF THE ALTERNATE MILITARY LOADS ARE ALSO APPLIED BY THE LOAD FACTOR METHOD.

IN ADDITION TO THE NORMAL REQUIREMENTS OF PENNSYLVANIA, THE DESIGN OF PORTION OF THE PROPOSED CONSTRUCTION IS CONTROLLED BY 1.15 STRESSES OCCURRING AT THE INSTANT THE AUXILIARY SUPPORT SYSTEM BECOMES ACTIVE. WHEN A PORTION OF THE STRUCTURE WILL CARRY A SHORT DISTANCE, FOR THIS CASE, A DYNAMIC IMPACT FACTOR IS APPLIED TO ALL LOADS AND THE FOLLOWING LOAD COMBINATIONS ARE USED:

DEAD LOAD: 1.20 L1 + L2 (ECONOMIC FACTOR)
HDX LOAD: 1.20 L1 + L2 (ECONOMIC FACTOR)

HDX LOADS SUBJECT TO THESE LOADINGS ARE EVALUATED AT LOAD OPERATING WITHIN STRESS LEVELS, THE "STRENGTH"-MINUS-"MINIMUM"-TENSILE CAPACITY IS NOT USED. THE OVERALL PROPORTIONS OF AXIS 3 DO NOT APPLY.

Fatigue design is based on an ADT of 5000 with 5,000,000 CYCLES OF AXIS 3 AT 1 PER YEAR.