Steel Pin and Hanger Assembly Replacement Options

Daniel G. Linzell, Ph.D., P.E., F.ASCE.
Voelte-Keegan Professor and Chair
Department of Civil Engineering
University of Nebraska-Lincoln

Chandana C. Balakrishna
Graduate Research Assistant
Department of Civil Engineering
University of Nebraska-Lincoln

2017

Nebraska Transportation Center
262 Prem S. Paul Research Center at Whittier School
2200 Vine Street
Lincoln, NE 68583-0851
(402) 472-0141

“This report was funded in part through grant[s] from the Federal Highway Administration [and Federal Transit Administration], U.S. Department of Transportation. The views and opinions of the authors [or agency] expressed herein do not necessarily state or reflect those of the U.S. Department of Transportation.”
Steel Pin and Hanger Assembly Replacement Options

Daniel G. Linzell, Ph.D., P.E., F.ASCE.
Voelte-Keegan Professor and Chair
Department of Civil Engineering
University of Nebraska-Lincoln

Chandana C. Balakrishna
Graduate Research Assistant
Department of Civil Engineering
University of Nebraska-Lincoln

A Research Report Sponsored by

Mid-America Transportation Center
University of Nebraska-Lincoln
Nebraska Department of Roads

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.
Table of Contents

Chapter 1  Introduction .................................................................................................................. 1
  1.1 Background ............................................................................................................................ 1
  1.2 Objectives and Scope ............................................................................................................. 3

Chapter 2  Literature Review ...................................................................................................... 4
  2.1 Introduction ............................................................................................................................ 4
  2.2 Literature ................................................................................................................................ 4
  2.3 State and Federal DOT Provisions ....................................................................................... 9
  2.4 Summary ................................................................................................................................ 12

Chapter 3  U.S. State Departments of Transportation Survey ...................................................... 14
  3.1 Survey Objectives ................................................................................................................... 14
  3.2 Survey History and Timeline ............................................................................................... 15
  3.3 Findings of the Survey ........................................................................................................... 15
  3.4 Follow-Up Contact ............................................................................................................... 34
  3.5 Summary ................................................................................................................................ 36

Chapter 4  Flowcharts Summarizing Retrofit and/or Replacement Options ................................ 38
  4.1 Introduction ............................................................................................................................ 38
  4.2 Retrofit and/or Replacement Options Process Summaries ................................................... 39
    4.2.1 Replace with Bolted Splices .......................................................................................... 40
    4.2.2 Link Slab ....................................................................................................................... 42
    4.2.3 Catcher Beam System ................................................................................................. 45
    4.2.4 Replace with Ship Lap Joint ....................................................................................... 48
    4.2.5 Replace with Pin and Hanger Assembly .................................................................. 53
  4.3 Summary ................................................................................................................................ 55

Chapter 5  Recommendations for Future Research .................................................................... 56

References ....................................................................................................................................... 57

Appendix A .................................................................................................................................... 61

Appendix B ..................................................................................................................................... 65

Response to Survey of DOTs ....................................................................................................... 65
Additional Comments .......................................................................................................................................................... 69
Appendix C ....................................................................................................................................................................... 71
List of Abbreviations ......................................................................................................................................................... 71
Appendix D ............................................................................................................................................................................. 74
Table A.1 Summary ............................................................................................................................................................. 74
Appendix D1 ........................................................................................................................................................................... 75
List of Tables

Table 3.1 Types of bridges which has pin and hanger assembly................................. 20
Table 3.2 Other types of steel bridges with pin and hanger assemblies. ......................... 21
Table 3.3 Implemented and programmed retrofit and/or replacement options. .................. 25
Table 3.4 Other implemented and programmed retrofit and/or replacement options ............. 26
Table 3.5 Design Specifications. .................................................................................. 30
Table 3.6 Developed own criteria & procedures. .......................................................... 30
Table 3.7 Reasons for pin and hanger assembly non-action........................................... 33
Table 3.8 Summary of follow-up contacts ..................................................................... 35
Table A.1 Summary ....................................................................................................... 74
List of Figures

Figure 2.1 Mianus River Bridge collapse. ................................................................. 5

Figure 3.1 Geographic representation of states that responded to the survey. .............. 16

Figure 3.2 Visual representation of responses to question 1. ...................................... 17

Figure 3.3 Geographic representation of state responses to question 1 .......................... 18

Figure 3.4 Visual representation of state response to question 1(a). .............................. 19

Figure 3.5 Visual representation of state response to question 2 .................................. 22

Figure 3.6 Geographical representation of states responded to question 2 ..................... 23

Figure 3.7 Visual representation of state response to question 2 (a) ............................... 24

Figure 3.8 Geographical representation of federal design Specification usage ................ 27

Figure 3.9 Visual representation of state responses to question 3. ................................. 28

Figure 3.10 Visual representation of states response to question 4. ............................... 29

Figure 3.11 Geographical representation of states have developed own criteria and procedures. 29

Figure 3.12 Visual representation of states response to question 5. ............................... 31

Figure 3.13 Geographical representation of states need or not need for further action ....... 32

Figure 3.14 Geographical representation of states contacted for additional details. .......... 36

Figure 4.1 Flowchart demonstrates decision – making process. ................................. 39

Figure 4.2 Bolted splice design process ........................................................................ 41

Figure 4.3 Link slab detail ............................................................................................ 43

Figure 4.4 Link slab design process .............................................................................. 44

Figure 4.5 Catcher beam system .................................................................................. 46

Figure 4.6 Catcher beam system representative detail .................................................. 46

Figure 4.7 Catcher beam design process ...................................................................... 47
Figure 4.8 Ship lap joint at bearing at joint locations. ................................................................. 49
Figure 4.9 Ship lap joint detail ........................................................................................................ 50
Figure 4.10 Ship lap joint design process. ....................................................................................... 51
Figure 4.11 New pin and hanger assembly design process. ............................................................... 54
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 provided 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 results 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.
Chapter 3  U.S. State Departments of Transportation Survey

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.

![Pie chart showing 92% of states with steel bridges containing pin and hanger assemblies and 8% without](image)

**Figure 3.2** Visual representation of responses to question 1.
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.

![Bar chart showing types of bridges](chart.png)

**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>DOTs</th>
<th>Two or three girder bridges</th>
<th>Four or more girder bridges</th>
<th>Truss bridges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama DOT</td>
<td>1</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Alaska DOT &amp; PF</td>
<td>0</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Arizona DOT</td>
<td>12</td>
<td>157</td>
<td>84</td>
</tr>
<tr>
<td>Arkansas State Highway and Transportation Department</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Delaware DOT</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Illinois DOT</td>
<td>1</td>
<td>92</td>
<td>14</td>
</tr>
<tr>
<td>Indiana NDOT</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Iowa DOT</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Maine DOT</td>
<td>0</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Massachusetts DOT</td>
<td>1</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Minnesota DOT</td>
<td>4</td>
<td>29</td>
<td>7</td>
</tr>
<tr>
<td>Mississippi DOT</td>
<td></td>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>Missouri DOT</td>
<td>26</td>
<td>750</td>
<td>10</td>
</tr>
<tr>
<td>Montana DT</td>
<td>4</td>
<td>150</td>
<td>0</td>
</tr>
<tr>
<td>New Hampshire DOT</td>
<td></td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>New Mexico DOT</td>
<td>0</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>North Carolina DOT</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>North Dakota DOT</td>
<td>0</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Ohio DOT</td>
<td>9</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Oklahoma DOT</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Oregon DOT</td>
<td>5</td>
<td>73</td>
<td>12</td>
</tr>
<tr>
<td>Pennsylvania DOT</td>
<td>45</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>South Dakota DOT</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Tennesseem DOT</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Utah DOT</td>
<td>2</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>Virginia DOT</td>
<td>1</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>Washington State DOT</td>
<td>51</td>
<td>306</td>
<td>488</td>
</tr>
<tr>
<td>West Virginia DOT</td>
<td>6</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>Wyoming DOT</td>
<td>12</td>
<td>90</td>
<td>4</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 that 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.

**Figure 3.5** Visual representation of state response to question 2

*Does not need retrofitted and/or replaced* 53%

*Need retrofitted and/or replaced* 47%
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** 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>Missouri 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>2</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>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. Five states reported using their own developed criteria and procedures.

![United States Map](Image)

**Figure 3.8** Geographical representation of federal design Specification usage.

27
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](image)

**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 DOT</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 &quot;good&quot;.</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.

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.
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 waterproofing 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 4.10 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</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.
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>
<td>New Hampshire Department of Transportation</td>
<td>Electronically</td>
</tr>
<tr>
<td>Tim Schwaglor</td>
<td><a href="mailto:tschwaglor@nd.gov">tschwaglor@nd.gov</a></td>
<td>North Dakota Department of Transportation</td>
<td>Electronically</td>
</tr>
<tr>
<td>Walter Peters</td>
<td><a href="mailto:wpeters@odot.org">wpeters@odot.org</a></td>
<td>Oklahoma Department of Transportation</td>
<td>Electronically</td>
</tr>
<tr>
<td>Tom Macioce</td>
<td><a href="mailto:tmacioce@pa.gov">tmacioce@pa.gov</a></td>
<td>Pennsylvania Department of Transportation</td>
<td>Electronically</td>
</tr>
<tr>
<td>Graham Bettis</td>
<td><a href="mailto:graham.bettis@txdot.gov">graham.bettis@txdot.gov</a></td>
<td>Texas Department of Transportation</td>
<td>Electronically</td>
</tr>
<tr>
<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 A.1: Summary of DOT Options

<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>Bolted splices</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>Link slab</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>MassDOT. MassDOT, MnDOT, NHDOT, Oklahoma DOT, TDOT, WVDOT.</td>
</tr>
<tr>
<td>Catcher beam system</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 MassDOT.</td>
</tr>
<tr>
<td>Ship lap joint</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>New pin and hanger assembly</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>
Appendix D1

Nebraska Department of Roads Design Plans


- PLATTSMOUTH NORTH BRIDGES -

- NOTES -

The existing structure was built under project 178321-1, dated 1987. Plans are available from the Bridge Division upon request.

The concrete bridge deck is designed by the structural design method in accordance with AS1570/LAP 84

The contractor may incorporate any of the alternate designs shown on the plans for the original design. All specifications are based on the original design and no additions or modifications will be allowed for the use of any alternate design.

- 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 4#5-8#6 CONCRETE FOR BRIDGES CLASS 4#5-8#6 CONCRETE FOR BRIDGES GLAUB ________________ 28.4 CU. YD.
HUNTING ________________ 1.3 CU. YD. CONCRETE RAILS ________________ 38.4 CU. YD.
CLASS 4#5-8#6 CONCRETE FOR BRIDGES CLASS 4#5-8#6 CONCRETE FOR BRIDGES GLAUB ________________ 28.4 CU. YD.
HUNTING ________________ 1.3 CU. YD. CONCRETE RAILS ________________ 38.4 CU. YD.
STRUCTURAL STEEL FOR SUPERSTRUCTURE ________________ 400 LBS.
EXPLOSION REINFORCING STEEL ________________ 515 LBS.
SLAB ________________ 365 LBS.
CONCRETE RAILS ________________ 365 LBS.
EXPANSION BEARING, TYPE ________________ 10 EACH
BEARING DEVICE REPLACEMENT ________________ 10 EACH
GRANULAR BACKFILL ________________ 85 CU. YD.
SUBGRADE DRAINAGE MATTE ________________ 76 CU. YD.
BROKEN CONCRETE RISER ________________ 500 LBS.
CONCRETE FOR PAVERS APPROACHES ________________ 465.5 CU. YD.
CLASS 4#5-8#6 CONCRETE FOR BRIDGES CLASS 4#5-8#6 CONCRETE FOR BRIDGES GLAUB ________________ 103.5 CU. YD.
CONCRETE RAILS ________________ 203.5 CU. YD.
GRADE BEAM ________________ 420 CU. YD.
EXPLOSION REINFORCING STEEL FOR PAVERS APPROACHES ________________ 3,177 LBS.
SLAB ________________ 707 LBS.
CONCRETE RAILS ________________ 3,025 LBS.
GRADE BEAM ________________ 4,535 LBS.
PRECOMPRESSED POLYURETHANE FOAM JOINT, TYPE 8 ________________ 85.5 LIN. FT.
19.5 CONDUIT IN BRIDGE ________________ 201 LIN. FT.

- INDEX -

GENERAL NOTES, QUANTITIES & INDEX ________________ 1
GENERAL PLAN & ELEVATION ________________ 2
PHASING PLAN ________________ 3
PLAN & ELEVATION OF ABUTMENT NO. 1 ________________ 4
PLAN & ELEVATION OF ABUTMENT NO. 2 ________________ 5
GRADE BEAM BILL OF BARS ________________ 6
GROUT LAYOUT & FIELD SPACING DETAILS ________________ 7
CROSS SECTION OF ROADSIDE ________________ 8
PLAN BEAM OF SLAB & TURNBOW ________________ 8
SLAB BILL OF BARS ________________ 10
APPROACH SLAB ________________ 11
APPROACH SLAB SECTION & DETAILS ________________ 12
RAIL ON APPROACH SLAB ________________ 13
BILL OF BARS - APPROACH SLAB ________________ 14
RAILROAD NOTES

THE PROPOSED URBAN SEPARATION PROJECT SHALL NOT INCREASE THE QUANTITY AND/OR CHARACTERISTICS OF THE FLOW IN THE RAILROAD'S DITCHES AND/OR DRAINAGE STRUCTURES.

THE ELEVATION OF THE EXISTING TOP-OF-RAIL LEVELS 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 PROPOSED METHOD OF EROSION AND SEDIMENT CONTROL AND HAVE THE METHOD APPROVED BY THE RAILROAD.

ALL DRAINAGE SYSTEMS THAT IMPACT THE RAILROAD'S OPERATIONS AND/OR SUPPORTS THE RAILROAD'S EMBANKMENT SHALL BE DESIGNED AND CONSTRUCTED IN COMPLIANCE WITH CURRENT RAILROAD GUIDELINES FOR TEMPORARY EROSION.

ALL EROSION CONTROL SYSTEMS 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 OVER THE RAILROAD'S RIGHT-OF-WAY SHALL BE DESIGNED TO CAUSE NO INTERRUPTION TO THE RAILROAD OPERATIONS. EROSION ON THE TRACKS TO REMAIN OPEN TO TRAFFIC PER THE RAILROAD'S REQUIREMENTS.

RAILROAD REQUIREMENTS DO NOT ALLOW WORK WITHIN 68 FEET OF TRACK CENTERLINE WHEN A TRAIN PASSES THE WORK SITE AND ALL PERSONNEL MUST CLEAR THE AREA WITHIN 20 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>BAR</th>
<th>NUMBER OF BARS</th>
<th>LENGTH</th>
<th>TYPE</th>
<th>&quot;A&quot;</th>
<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>&quot;G&quot;</th>
<th>PB</th>
<th>INCH</th>
<th>WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>421</td>
<td>16</td>
<td>36' 0&quot;</td>
<td>STRAIGHT</td>
<td>2&quot;</td>
<td>4&quot;</td>
<td>6&quot;</td>
<td>7&quot;</td>
<td>4&quot;</td>
<td>6&quot;</td>
<td>8&quot;</td>
<td>2&quot;</td>
<td>642</td>
<td>144</td>
</tr>
<tr>
<td>6401</td>
<td>16</td>
<td>36' 0&quot;</td>
<td>STRAIGHT</td>
<td>2&quot;</td>
<td>6&quot;</td>
<td>10&quot;</td>
<td>12&quot;</td>
<td>7&quot;</td>
<td>10&quot;</td>
<td>12&quot;</td>
<td>2&quot;</td>
<td>642</td>
<td>241</td>
</tr>
<tr>
<td>4401</td>
<td>16</td>
<td>36' 0&quot;</td>
<td>STRAIGHT</td>
<td>2&quot;</td>
<td>6&quot;</td>
<td>10&quot;</td>
<td>12&quot;</td>
<td>7&quot;</td>
<td>10&quot;</td>
<td>12&quot;</td>
<td>2&quot;</td>
<td>642</td>
<td>241</td>
</tr>
<tr>
<td>4402</td>
<td>2</td>
<td>12' 0&quot;</td>
<td>STRAIGHT</td>
<td>2&quot;</td>
<td>6&quot;</td>
<td>10&quot;</td>
<td>12&quot;</td>
<td>7&quot;</td>
<td>10&quot;</td>
<td>12&quot;</td>
<td>2&quot;</td>
<td>492</td>
<td>26</td>
</tr>
<tr>
<td>4403</td>
<td>2</td>
<td>12' 0&quot;</td>
<td>STRAIGHT</td>
<td>2&quot;</td>
<td>6&quot;</td>
<td>10&quot;</td>
<td>12&quot;</td>
<td>7&quot;</td>
<td>10&quot;</td>
<td>12&quot;</td>
<td>2&quot;</td>
<td>492</td>
<td>26</td>
</tr>
</tbody>
</table>

**Subtotal =** 2,064 105

| 4201| 16             | 36' 0" | STRAIGHT | 2" | 4"  | 6"  | 7"  | 4"  | 6"  | 8"  | 2" | 642  | 144    |
| 6402| 16             | 36' 0" | STRAIGHT | 2" | 6"  | 10" | 12" | 7"  | 10" | 12" | 2" | 642  | 241    |
| 4402| 2              | 12' 0" | STRAIGHT | 2" | 6"  | 10" | 12" | 7"  | 10" | 12" | 2" | 492  | 26     |
| 4403| 2              | 12' 0" | STRAIGHT | 2" | 6"  | 10" | 12" | 7"  | 10" | 12" | 2" | 492  | 26     |

**Subtotal =** 2,064 105

**Total =** 4,128 210

---

**Note for Building Drawings:** For lengths & diameters, see Sheet 18 of 44.

---

**Drainage Detail and Granular Backfill:**

- Fill fabric side of subgrade
- Drainage meeting toward backfill
### Bill of Bars

<table>
<thead>
<tr>
<th>Note</th>
<th>Number of Bars</th>
<th>Length</th>
<th>Type</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>Pin</th>
<th>Hook</th>
<th>Weight</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>NWB2</td>
<td>28</td>
<td>18'-5&quot;</td>
<td>Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>390</td>
<td>250</td>
<td>365</td>
<td></td>
</tr>
<tr>
<td>NWB3</td>
<td>3</td>
<td>14'-4&quot;</td>
<td>Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>66</td>
<td>66</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>NWB4</td>
<td>30</td>
<td>11'-9&quot;</td>
<td>Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>585</td>
<td>585</td>
<td>585</td>
<td></td>
</tr>
<tr>
<td>NWB5</td>
<td>28</td>
<td>Avg. 19'-7.7&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWB6</td>
<td>3</td>
<td>16'-4&quot;</td>
<td>Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>106</td>
<td>106</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>NWB7</td>
<td>2</td>
<td>14'-8&quot;</td>
<td>Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72</td>
<td>72</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>NWB8</td>
<td>2</td>
<td>14'-8&quot;</td>
<td>Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72</td>
<td>72</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>NWB9</td>
<td>10</td>
<td>Avg. 13'-3.5&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWB10</td>
<td>16</td>
<td>Avg. 13'-6.5&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWB11</td>
<td>12</td>
<td>10'-11&quot;</td>
<td>Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>509</td>
<td>509</td>
<td>509</td>
<td></td>
</tr>
<tr>
<td>NWB12</td>
<td>28</td>
<td>8'-11&quot;</td>
<td>Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>365</td>
<td>365</td>
<td>365</td>
<td></td>
</tr>
<tr>
<td>NWB13</td>
<td>28</td>
<td>Avg. 8'-5&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWB14</td>
<td>28</td>
<td>Avg. 8'-6&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWB15</td>
<td>28</td>
<td>Avg. 8'-7&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWB16</td>
<td>20</td>
<td>Avg. 6'-11&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWB17</td>
<td>20</td>
<td>Avg. 6'-11&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWB18</td>
<td>30</td>
<td>6'-6&quot;</td>
<td>Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>105</td>
<td>105</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>NWB19</td>
<td>28</td>
<td>Avg. 6'-7&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWB20</td>
<td>28</td>
<td>Avg. 6'-8&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NWB21</td>
<td>28</td>
<td>Avg. 6'-9&quot; Str.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Standard Hook Length

<table>
<thead>
<tr>
<th>Note</th>
<th>Length</th>
<th>Primary Stress Bars</th>
<th>Strut 1 &amp; Ties</th>
<th>Primary Stress Bars</th>
<th>Strut 1 &amp; Ties</th>
</tr>
</thead>
<tbody>
<tr>
<td>NWB22</td>
<td>10'-2&quot;</td>
<td>87' x 7&quot; x 7&quot;</td>
<td>10'-2&quot; x 7&quot; x 7&quot;</td>
<td>87' x 7&quot; x 7&quot;</td>
<td>10'-2&quot; x 7&quot; x 7&quot;</td>
</tr>
</tbody>
</table>

### Bending Diagrams

All dimensions are to the nearest inch. All reinforcing steel shall be epoxy coated.
NOTES

The existing structure was built under project N-023-L-I, dated 1950, and was widened under project 3069626 & 26 (1961-54), dated 1972. Plans are available from the Bridge Division upon request.

The contractor may substitute any one of the alternate designs shown on the plans for the original design. All specifications are based on the original design and no additions or deductions will be allowed for the use of an alternate design.

All reinforcing steel for Superstructure shall conform to the requirements of ASTM A615/A615M, Grade 60.

Concrete for slab, approach slabs and rails shall be class "A-160", with a minimum 28-day strength of 4000 psi.

All other cast-in-place concrete shall be class "G-75" concrete with a 28-day strength of 3300 psi.

An reinforcing steel shall be epoxy coated and conform to the requirements of ASTM A929/A929M, Grade 60.

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

An existing concrete coating in contact with the new work shall be thoroughly cleaned and roughened before shooting new concrete.

An reinforcing steel encased in encasing having existing concrete shall be thoroughly cleaned, unstressed and extended into the new work a minimum of 24 in.

All dimensions shown are horizontal plane only. All allowances have been made for settling curve or any structural stress.

The girders for this bridge are not designed to resist any inclination or lateral forces due to temporary construction loads. The Contractor must provide any necessary tie-backs necessary to support the girder web and flanges against all transverse or lateral forces resulting from construction loads.

Before ordering any materials, the contractor shall make a detailed field inspection of the project site, verifying all dimensions and inspecting the project in the field to ensure any discrepancies between site measurements and those shown on the plans.

All materials received shall become the property of the contractor and shall be removed from the project site.

All excavations, materials, equipment, tools, labor and incidentals necessary to complete the work and are not paid for by the Engineer shall be considered the property of the Owner for which payments may be made.

All concrete surfaces to be in contact with the new work shall be thoroughly cleaned before placing any new concrete.

Contractor shall determine the locations of all Class II Repair, with the approval of the Engineer.

The Contractor shall place a 1" deep saw cut at the limits of pavement removal to facilitate a clean smooth line when breaking back existing concrete.

When opening existing concrete, the use of a maximum 1/4 hammer shall be at a 45° angle is required.

INDEX

NOTES, QUANTITIES, A INDEX 1
GENERAL PLAN & ELEVATION STA. 6447+60 2
CONSTRUCTION DRAWING 3
GRANITE ELAVATION 4
GRANITE CEMENT & REBAR 5
PIN REPLACEMENT DIAGRAM 6
SLAB REFINISHING 7
CROSS SECTION OF ROADWAY AND JOINT DETAILS 8
9'-0" RAIL ON BRIDGE 9
9'-0" RAIL ON BRIDGE 10
11'-0" RAIL ON BRIDGE 11
SLAB REFINISHING 12
APPROACH SLAB PLAN VIEW 13
CLOSED RAIL ON APPROACH SLAB 14
APPROACH SLAB PLAN VIEW 15

CLASS I, II AND III REPAIR LOCATION AND SIZE LOCATED IN FALCON PROJECT No. 023-L-1 Lewallen, see perspective.

ELEVATION NORTHWEST ALUMINUM CAP IN BRIDGE RAIL EXISTING ELEVATION SOUTHEAST ALUMINUM CAP IN BRIDGE RAIL 5502.09

The location of all aerial and underground utility facilities may not be indicated on these plans. Underground utilities, whether indicated or not will be located and marked at the request of the Contractor.

No deduction will be permitted for the area of underground utility facilities unless such facilities have been located and marked to the satisfaction of the Owner. The Contractor must be accompanied with extreme care in order to avoid any possibility of damage to the utility facility.
The granular backfill in this area shall be placed in 8 inch lifts and compacted by a single pass of a 10-ton pneumatic vibratory (approx. 1500 lb.) vibratory roller, after 6 hours of curing. There is no density requirement. Heavy compaction equipment shall be used to 80% of the maximum density for highway construction.

Granular Backfill

General Plan
Not to Scale

Notes:
- Pin shall be ASTM A-307 or ASTM A-325
- Class 2 or Apparent Equal. Rebar shall be either forged or cast steel.
- Structural steel for Live Loads shall be ASTM A36.
- For the purpose of shapes, all Live Loads shall be considered main motion member.

SECTION A-A

PIN REPLACEMENT

This work shall consist of supporting the suspended grader at the expansion joint, removing the existing link plates and pins, and installing the new live plates and pins.

Prior to beginning any work, a step-by-step procedure for supporting the grader and replacing the link plates and pins shall be submitted by the Contractor to the Engineer's approval. A possible method of supporting the grader 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 installing of live plates and pins shall be a part of this item. Any damage to the structure due to negligence by the Contractor shall be repaired by the Contractor or as directed by the Engineer. 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 link plates and pins replaced and approved by the Engineer.

Payment for this work shall be measured in linear feet, to be paid by the contract with price per each (EA) for the item this replacement. This price shall include, but not be limited to, labor, equipment, tools, materials and any incidentals necessary to complete the work.
<table>
<thead>
<tr>
<th>BILLOF BARS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAKE</strong></td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>S101</td>
</tr>
<tr>
<td>S200</td>
</tr>
<tr>
<td>S500</td>
</tr>
<tr>
<td>S501</td>
</tr>
<tr>
<td>5A100</td>
</tr>
<tr>
<td>5A101</td>
</tr>
<tr>
<td>5A102</td>
</tr>
<tr>
<td>S300</td>
</tr>
<tr>
<td>S400</td>
</tr>
<tr>
<td>S502</td>
</tr>
<tr>
<td>S600</td>
</tr>
</tbody>
</table>

**NOTE FOR PIN CHAMBERS, HOOK LENGTHS & Bending drawings, see sheet 15 of IS.**

Example shown for Adjustment repair: (See picture)

All damaged concrete or grout should be removed to sound concrete and then patch in with new concrete. Pay them for this repair.

Emerald Bridge Division with any questions.
THREE BEAM TERMINAL CONNECTION DETAIL

A. As an alternative method, the connector shall be formed and cast into the concrete as approved herein. All assembly consisting of threaded inserts, and so forth, shall be in accordance with the instructions of the manufacturer. Stress bars shall be in accordance with the plate washers and the 7/8" cap screws. The stress bars shall be a standard product of a reputable manufacturer and be capable of resisting a shear load of 10,000 lbs.

NOTES

1. Drilled bars indicate placement in the top layer of slab reinforcement. Concrete rail will be built parallel.
2. Measured at front face of rail.
3. For use of bars see sheet 16 of 14.

Steel forms are required when using the 1920 rail channels.

SECTION B-B

ALTERNATE CHAMFER DETAIL

SECTION C-C

CONCRETE BARRIER
### B I L L O F B A R S

<table>
<thead>
<tr>
<th>MARK</th>
<th>NUMBER OF BARS</th>
<th>TYPE OF BARS</th>
<th>LENGTH</th>
<th>&quot;A&quot;</th>
<th>&quot;B&quot;</th>
<th>&quot;C&quot;</th>
<th>&quot;D&quot;</th>
<th>PIN</th>
<th>HOE</th>
<th>PIN COUNT</th>
<th>MOLD</th>
<th>MOLD MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>40</td>
<td>13&quot;</td>
<td>38&quot;-3&quot;</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
</tr>
<tr>
<td>2002</td>
<td>47</td>
<td>13&quot;</td>
<td>38&quot;-3&quot;</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
</tr>
<tr>
<td>2003</td>
<td>22</td>
<td>13&quot;</td>
<td>38&quot;-3&quot;</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
</tr>
<tr>
<td>2004</td>
<td>20</td>
<td>13&quot;</td>
<td>38&quot;-3&quot;</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
</tr>
<tr>
<td>2005</td>
<td>12</td>
<td>13&quot;</td>
<td>38&quot;-3&quot;</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
</tr>
<tr>
<td>2006</td>
<td>4</td>
<td>13&quot;</td>
<td>38&quot;-3&quot;</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
<td>2/32</td>
<td>1/16</td>
</tr>
</tbody>
</table>

**BAR MARKS**

- **A** = Size of Bar
- **B** = Type of Bar
- **C** = Length of Bar
- **D** = Pin Size
- **E** = Hoe Size

**BENDING DIAGRAMS**

- All dimensions are cut to fit & not to scale.
- All reinforcing steel shall be epoxy coated.
- All sizes are bars, not reinforcing bars.
- Type of bridge Alicia = 24-foot.
- Sizes 8" = 24" BS = 24" NWB = 24" (Redrawn Size)

---

### STANDARD HOOK LENGTH

- **Primary Stress Bars**: 15" hook
- **Primary Stress Bars**: 15" hook
- **Secondary Stress Bars**: 10" hook
- **Secondary Stress Bars**: 10" hook

### PIN DIAMETER

- **Primary Stress Bars**: 1/8" hole
- **Primary Stress Bars**: 1/8" hole
- **Secondary Stress Bars**: 1/16" hole
- **Secondary Stress Bars**: 1/16" hole

---

**NOTES**

- All dimensions are cut to fit & not to scale.
- All reinforcing steel shall be epoxy coated.
- All sizes are bars, not reinforcing bars.
- Type of bridge Alicia = 24-foot.
- Sizes 8" = 24" BS = 24" NWB = 24" (Redrawn Size)
NOTES

Acrylic Concrete used in approach area is full width of the bridge and 5'10' from the end of the bridge floor.

QUANTITIES

<table>
<thead>
<tr>
<th>BRIDGE NO. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Steel for Beam Plates</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>Acrylic Concrete, Type C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BRIDGE NO. 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Steel for Beam Plates</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>1/16&quot; x 12&quot;</td>
</tr>
<tr>
<td>Acrylic Concrete, Type C</td>
</tr>
</tbody>
</table>
The tail of the Roadway Expansion Devices shall conform to the crown of the roadway. The bottom of the devices shall be straight between devices or flanges, over grinders they shall be straight to the tail of the girder.

**DETAiL OF SHIM PLATES**

Note: Compression steel shall not be paid for directly, but shall be considered subsidiary to item "Structural Steel for Superstructure."

**ELEVATION**

- Note: Bond reinforcing steel to clear deck min. of 1'. Guaranteed after fabrication.

**PLAN**

- Floor Drain Details
- Details of Diagonal Separator Connection at Existing Exterior Girders

**SECTION**

- Bearing Plate Details
- Details of Bearing Plates

**SECTION D-D**

- For grinders and edge of flanges, 
- 30" x 30" x 0.30" Deck Steel Girder
- SPANS BRIDGE WIDENING
- SPANS BRIDGE WIDENING
- STATE ROAD VENDEO FALL CITY
- HWY. NO. 1573
- COUNTY RICHMOND
- CONCRETE FLOOR
- DESIGN CLASSE 12-24-44
- DATE: JUNE 1973
- BRIDGE DESIGN SECTION, LINCOLN, NEBRASKA

**DETAiL OF SHiM PLATES**

- To be measured for each girder connection.

**CIP PLATE**

- CIP Plate Shim Plate

**FLOOR DRAIN DETAILS**

- Details of Diagonal Separator Connection at Existing Exterior Girders

**CONNECTION AT EXISTING EXTERIOR GIRDERS**

- Details of Bearing Plates

**DETAiLS OF BEARING PLATES**

- Details of Bearing Plates

**RiGHT SLOP**

- To 8"/8" for 1' to 2" of concrete.
### TYPICAL DETAIL OF PLATE SEPARATOR

**ORIGINAL DESIGN**

- **DETAILS OF COPPER DRAIN**
- **CAPACITY PLATE CONNECTION**
- **SECTION A-A**
- **SECTION B**
- **BARS 5-7**
- **BARS 5-9**
- **BARS 5-1**
- **PART ELEVATION**
- **DETAILS OF EXPANSION DEVICE TYPE II**
- **SHELL PLATE FOR EXPANSION DEVICES**

### UNIT QUANTITIES

**SHIM PLATE**

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>10</td>
</tr>
</tbody>
</table>

### NOTES

- The dimensions may vary as per the actual construction.
- The details of the expansion devices are designed to accommodate future changes.
Illinois Department of Transportation

Standard drawings - pin and hanger assembly replacement.
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

* D-2 BRIDGE PIN REPLACEMENT 1997-1

ELEVATION AT EXISTING PIN ASSEMBLY

FOR INTERIOR BEAMS

Any Pins that can be easily removed without damage to the pin shall be slugged out and the Bridge Engineer shall be notified for disposition. Cost of salvage is included in "Pin and Link Plate Replacement".

If the existing deck interface with the new link plates, concrete shall be removed to provide clearance for the new pins and old plates. Cost shall be included in the cost of "Pin and Link Plate Replacement".

For EXTERIOR BEAMS

Existing "I" x 8 Web Reinforcing
Pins shall remain in place
Each Side (See Note A)

Existing "I" x 8 Web Reinforcing
Pins shall remain in place
Each Side (See Note A)

Existing "I" x 8 Web Reinforcing
Existing 2" x 2" Pin

Existing "I" x 8 Web Reinforcing
Existing 2" x 2" Pin

Making existing 2" x 2" Pin

Existing "I" x 8 Web Reinforcing
Making existing 2" x 2" Pin

Existing "I" x 8 Web Reinforcing
Making existing 2" x 2" Pin

Existing "I" x 8 Web Reinforcing
Existing 2" x 2" Pin

NUT DETAIL

(To be Required)

LINK PLATE DETAIL

(To be Required)

SECTION THRU PIN

(To be Required)

GENERAL NOTES:

All new structural steel welding to ASABE Classification in 0.75 Gr. 36, unless otherwise noted.

The Contractor shall provide support and/or shores Assembly for the beam in the area of existing pin and link plate replacement. See Special Provision "Temporary Support System".

The "I" section shall have a minimum of 10.000 psi to be used for the base plate and field welding of new structural steel elements where otherwise needed. The "I" shall have a minimum of 3.600 psi. See Special Provision "Cleaning and Painted Weld Metal Structure".

Cost shall be included in the cost of "Pin and Link Plate Replacement".

Existing structural steel shall be cleaned and painted as required by the Special Provision "Cleaning and Painting the Existing Steel Structure". Paint shall be included in the cost of "Pin and Link Plate Replacement".

All existing steel surfaces painted link plates shall be cleaned and painted before installation of new link plates. Cost shall be included in the cost of "Pin and Link Plate Replacement".

Span dimensions and relative location to existing structure have been obtained from existing plans and are subject to removal and/or relocation.

It shall be the Contractor's responsibility to verify such dimensions and details in the field, and the pin diameters, and make necessary adjustments prior to construction or ordering of materials. Such modifications shall not be cause for additional compensation for any change in the scope of the work. The Contractor will be paid for the quantity actually furnished at the unit prices.

The "I" section shall be grouted to the minimum 

Cure 7 days after the first week. The pin and link plate replacement shall be included in the "Pin and Link Plate Replacement".

TOTAL BILL OF MATERIAL

TOTAL BILL OF MATERIAL

PIN REPLACEMENT

FAS 309  SEC. 06-71R-1
BUREAU COUNTY
STA. 1729+38
STA. NO. 062-0133

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin and Link Plate Replacement</td>
<td>Unit</td>
<td>300</td>
</tr>
<tr>
<td>Structural Steel</td>
<td>Unit</td>
<td>500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Unit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin and Link Plate Replacement</td>
<td>Unit</td>
<td>300</td>
</tr>
<tr>
<td>Structural Steel</td>
<td>Unit</td>
<td>500</td>
</tr>
</tbody>
</table>

ELEVATION AT NEW PIN ASSEMBLY

FOR INTERIOR BEAMS

MAXIMUM REACTIONS AT PIN

P = 80 224
L = 80 224
136 350
12 32 61
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

ELEVATION AT EXISTING PIN ASSEMBLY
FOR INTERIOR BEAMS:

ELEVATION AT EXISTING PIN ASSEMBLY
FOR EXTERIOR BEAMS:

ELEVATION AT NEW PIN ASSEMBLY
FOR INTERIOR BEAMS:

ELEVATION AT NEW PIN ASSEMBLY
FOR EXTERIOR BEAMS:

NUT DETAIL

LINK PLATE DETAIL

SECTION THRU PIN

MAXIMUM REACTIONS AT PIN

TOTAL BILL OF MATERIAL

PIN REPLACEMENT
TR ROUTE 14B, SEC. 06-39B
BUREAU COUNTY
STA. 640+74.60
STN. No. 006-023

006 - 0123
ELEVATION AT EXISTING PIN ASSEMBLY
FOR INTERIOR BEAMS

Any Pin that can be easily removed without damage to the pin shall be
removed and the bridge Engineer shall be contacted for disposition.
Cost of removal is included in "Pin Replacement".

ELEVATION AT EXISTING PIN ASSEMBLY
FOR EXTERIOR BEAMS

GENERAL NOTES:

All new structural elements shall conform to AASHTO Specifications in 270 Gr. 36
unless otherwise noted.
The Contractor shall provide support and/or shoring systems for the beams in
the area of existing pin replacement. See Special Provision "Temporary
Support Systems".
The closure joint rich primer/sealer/epoxy primer system shall be used for
painting, and painting of new structural steel elements where otherwise noted.
The color of the coating system used shall be "Ultracote" (see Note 5).
Coating shall be included in the cost of "Pin Replacement".
Existing structural steel shall be cleaned and painted as required by the
contract. Existing pin replacement shall be subject to the requirements of "Existing
Steel Structures". Cost shall be included in the cost of "Pin Replacement".
The details and materials of the new pin shall be as specified from existing pins,
subject to normal fabrication tolerances. It shall be the Contractor's responsibility
to notify the Engineer of any variations in the field, except for pin diameters, and
make necessary approval adjustments prior to construction to warranty of warranty. Such variations shall not be cause for
additional compensation for the change in the scope of the work. However, the
Contractor will be paid for the necessary work incurred at the unit price bid
for the work.
The new pin shall conform to the minimum Cherry V-notch
Toughness of 25 ft-lb. or 40°F.
The pin, bushings, nuts and silicone sealant are the items
included in "Pin Replacement".

MAXIMUM REACTIONS AT PIN

<table>
<thead>
<tr>
<th>Reaction Type</th>
<th>Unit</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fl</td>
<td>Ft-lb</td>
<td>8.00</td>
</tr>
<tr>
<td>Hg</td>
<td>Ton-ft</td>
<td>3.75</td>
</tr>
<tr>
<td>Lb</td>
<td>Ton-ft</td>
<td>4.50</td>
</tr>
<tr>
<td>Kg</td>
<td>Ton-ft</td>
<td>4.45</td>
</tr>
</tbody>
</table>
STATE OF ILLINOIS
DEPARTMENT OF TRANSPORTATION

ELEVATION AT EXISTING PIN ASSEMBLY
FOR INTERIOR BEAMS

Any Pin that can be easily removed without delay in the pin shall be salvaged and the Bridge Engineer shall be contacted for disposition. Cost of salvages is included in the cost of "Pin and Link Plate Replacement".

If the existing deck interferences with the new Pin aligning concrete, then Pin shall be realigned to provide clearance for the new Pin and for new concrete. Cost shall be included in the cost of "Pin and Link Plate Replacement".

ELEVATION AT EXISTING PIN ASSEMBLY
FOR EXTERIOR BEAMS

Existing 5/8" Web Reinforcing Plate shall remain in place each side (See Note A).

ELEVATION AT NEW PIN ASSEMBLY
FOR INTERIOR BEAMS

ELEVATION AT NEW PIN ASSEMBLY
FOR EXTERIOR BEAMS

WEB PLATE DETAIL
(LQ Required)

MAXIMUM REACTIONS AT PIN

UNIT DETAIL

* D-2 BRIDGE PIN REPLACE 1997-1

SECTION THRU PIN

BILLET OF MATERIAL

PIN AND LINK PLATE REPLACEMEN

F.A.I. RT. 80 SEC. 06-1849-1

BUREAU COUNTY
STA. 475+05.54

S.R. No. 006-0089
Massachusetts Department of Transportation

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

Design drawings - Pin and hanger assembly replacement.
CANTILEVERED PLATE GIRDERS

SUSPENDER DETAILS FOR ANCHOR SUSPENDED SPAN

ELEVATION
EXPANSION JOINT

ELEVATION
FIXED JOINT

STAY PLATE FOR FIXED JOINT ONLY

1" MIN. (TYP)

1/2" NYLON WASHER

1/2" STAINLESS STEEL WASHER (TYP)

1/4" NON-METALLIC BUSHING (TYP)

* PIN

1/4" RADIUS (TYP)

1/4" STAINLESS STEEL COTTER PIN (TYP)

FOR DETAIL
SEE GUIDE 8.15.01A

SECTION A-A
PIN DETAIL

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."

WELDED PIN PLATES

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

SECTION A-A
*FOR DETAIL SEE 8.15.01A
Oklahoma Department of Transportation

Design drawings - catcher beam system.
GENERAL NOTES

3.1 All new construction shall be in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

4.1 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

4.2 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.1 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.2 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.3 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.4 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.5 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.6 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.7 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.8 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.9 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.10 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.11 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.12 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.13 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.14 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.15 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.16 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.17 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.18 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.19 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.20 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.21 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.22 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.23 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.24 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.25 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.

5.26 The Project shall be designed and constructed in accordance with the latest edition of the Standard Specifications for Highway Bridge and Special Projects as published by the Oklahoma Department of Transportation. The Contract Documents shall follow the Bid Documents as listed in the Contract Documents.
<table>
<thead>
<tr>
<th>PAY QUANTITIES</th>
<th>DESCRIPTION</th>
<th>UNIT QUANTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>506</td>
<td>STRUCTURAL STEEL</td>
<td>77,180.00</td>
</tr>
<tr>
<td>515</td>
<td>PENETRANT WATER REPEL SURF.TR.</td>
<td>1,060.00</td>
</tr>
<tr>
<td>520</td>
<td>CEMENT EPOXY RESIN ABOVE WATER GAL.</td>
<td>17.50</td>
</tr>
<tr>
<td>640</td>
<td>FIELD OFFICE</td>
<td>1.00</td>
</tr>
<tr>
<td>641</td>
<td>MOBILIZATION</td>
<td>1.00</td>
</tr>
<tr>
<td>700</td>
<td>TRUE BEARING ASSEMBLY</td>
<td>1.00</td>
</tr>
<tr>
<td>701</td>
<td>EXTENSION BEARING ASSEMBLY</td>
<td>1.00</td>
</tr>
<tr>
<td>800.41SP</td>
<td>FALSEWORK AND JACKING</td>
<td>--</td>
</tr>
<tr>
<td>900.41SP</td>
<td>REPAIR CONCRETE PIER</td>
<td>8.00</td>
</tr>
<tr>
<td>900.42SP</td>
<td>EXPANSION BEARING ASSEMBLY</td>
<td>32.00</td>
</tr>
<tr>
<td>900.51SP</td>
<td>FALSEWORK AND JACKING</td>
<td>--</td>
</tr>
<tr>
<td>900.73SP</td>
<td>REPAIR CONCRETE PIER</td>
<td>8.00</td>
</tr>
</tbody>
</table>

**Design Data**

- **Load Factor Design:**
  - Dead Load (Class A, Reinforcing Steel, Column 4): 5 kips/ft
  - Live Load (Structural Steel, Column 5): 40 kips/ft
  - Allowable Stress (Structural Steel, Column 6): 25 kips/ft

- **Loading:**
  - 80-90 mph, Reinforcement Load Track

- **Design:**
  - AASHTO Specifications 1998 Edition and AASHTO Specifications

- **Reactions for Adjacent Bridges:**
  - Piers 77, 83, and 77 B, Piers 22
  - Reactions: 55 kips, 35 kips, 25 kips
  - Total: 44 kips

**Traffic Operations**

- Traffic operations are necessary due to the project location.
- Traffic operations are necessary due to the project location.

**Summary of Pay Quantities**

- (Bridge and Traffic)
- General Notes (Traffic)

**State of Oklahoma Department of Transportation**

---

1. **Control:** Gaylord & E.K.
JACKING STIFFENER

JACKING BEAM STIFFENER DETAIL

The jack on the jack beam shall be done at 50°F to 70°F. The jack beam shall be pre-tensioned with a minimum of 100 kips. The jack beam shall be placed on the west side of Pier 81 and the east side of Pier 78. The Contractor shall follow the following construction sequence:

1. Jacking shall be done when the temperature is between 50°F and 70°F.
2. Jacking shall be restricted to off-peak traffic hours, such as Sunday mornings.
3. The Contractor shall temporarily remove the existing crossframes except for the top member.
4. The Contractor shall bolt the jack beam to the 72" plate girder as shown on the plans using the bolt holes from the crossframes and all new A-490 bolts and jack the girder as shown on the plans to take the load off the existing expansion assembly. On the ramp, all three girders shall be jacked simultaneously. The reaction is approximately 70 tons per girder.
5. The Contractor shall 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.
6. Sandblasting may be required. Concrete surfaces in the bearing area shall be ground with a carborundum not be more than 2'-0" for this system. In the bearing area, the bottom of the steel girder shall be ground smooth.
7. The Contractor shall slide in the new bearing assembly, release the jacks, remove the jacking assembly, drill 3" holes for the 1"-112" anchor bolts, and drop in the new anchor bolts. The anchor plate extensions shall be welded to the anchor plate.
8. The anchor plates, anchor plate extensions, 3/4" 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, and the 'falsework' shall be completed.

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

QUANTITIES

<table>
<thead>
<tr>
<th>ITEM #</th>
<th>ITEM</th>
<th>UNIT</th>
<th>QTY</th>
</tr>
</thead>
<tbody>
<tr>
<td>90042</td>
<td>1</td>
<td>EA</td>
<td>1</td>
</tr>
</tbody>
</table>

DETAIL OF JACKING BEAM PLACEMENT

NOTE: For Construction Sequence at Pier 78 refer to Sheet no. 3.
COVER LAYERS
8 - (4"
INNER LAYERS

SECTION A-A

EXCAVATION DIAGRAM

PIER NO. 82
BAR LIST
EPOXY COATED GRADE (69)

PIER NO. 77
BAR LIST
EPOXY COATED GRADE (69)

PIER NO. 7 RASP 22
BAR LIST
EPOXY COATED GRADE (69)

PIER NO. 3 BAR LIST
EPOXY COATED GRADE (69)

QUANTITIES

NOTE:

NOTE:

NOTE:
All 3-unit concrete anchors shall be 3/4" x 9" long, embedded 6" into existing concrete.
DETAIL OF BEARING SUPPORT BRACKET
PIER 77 AND RAMP 22
CHANGE
IN PLANS

CROSSFRAME CONNECTION DETAIL

CROSSFRAME COLUMN CONNECTION DETAIL

SECTION A-A

SECTION B-B

COLUMN CONNECTION DETAIL

NOTES:
1. In locating the center line of anchor grade
   in less than 7/16" from the inside surface of
   the piers, the 19" x 5/8" connection
   plate shall change to a length of sufficient
   amount to connect directly to the angle on the
   column.

DETAIL "A"

DETAIL "B"

DETAIL OF CROSSFRAME AND HANGER CONNECTION

OKLAHOMA COUNTY

STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION

DESIGN

CONSTRUCTION

A - P - 35230

OKLAHOMA COUNTY

DEPARTMENT OF TRANSPORTATION

DESIGN

CONSTRUCTION

A - P - 35230

OKLAHOMA COUNTY

DEPARTMENT OF TRANSPORTATION

DESIGN

CONSTRUCTION

A - P - 35230
PLAN VIEW

SECTION C-C

JACKING ASSEMBLY

Note: Jacking shall stop when the crossbeam has been lifted approximately 1/3 off of the existing edge.

SECTION B-B

The sand containment box shall be constructed and braced to the satisfaction of the engineer.

ELEVATION VIEW OF DAMAGED PIER BEAM

SECTION A-A

Continuous falsework can be replaced by intermittent falsework at the direction of the engineer.

CHANGE OF PLANS NO.
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 minor locations in spans 3 and 5 of the westbound structure and spans 3 and 5 of the eastbound structure.

Details and dimensions shown on these drawings to describe the existing structure were taken from the original plan from which the structure was originally built and may not reflect present conditions. Specify all dimensions and geometry of the existing structure in the field, as necessary, for proper fit of the proposed construction.

Contract plans and shop drawings for the existing bridge are available from the Pennsylvania Department of Transportation, at a normal charge. These plans and drawings are available in the forms required for preparing drawings for erecting a set of contract plans and for selective shop drawings required. Do not assume that all shop drawings relating to the proposed new work are available. Do not consider any of the data on the existing structure supplied in the original design drawings as more available by the department or its authorized agents, as positive representation of any of the conditions that will be encountered on the job site. Field conditions, therefore, must be used, and is not to be considered as a basis for computation of the unit prices used for bidding purposes. They are not intended to imply that information is currently shown. Assume the possibility that conditions affecting the cost and quality of quantities of work to be performed may differ from those indicated.

Provide all materials and equipment in accordance with Pennsylvania Department of Transportation Specifications publication 405-97, current supplement, AASHTO/ANSI/ASCE/ASHRAE/WCMA code 5.5-88 and contract special provisions.

Provide structural steel, conforming to A992, Grade E, 60 ksi, except where noted otherwise. Provide structural steel, conforming to A992 and for steel, denoted A36, and conforming to A36G#9 and A992 where steel is identified.

Fabricate auxiliary support beam flange plates, web plates and stiffeners and bearing plates assemblies using A992 grade structural steel, to conform to the requirements of AASHTO Guide Specifications for Fabrication-Critical, Non-Resistant Steel Bridge Members. Provide material conforming to the base metal, Charpy V-notch requirements listed in the special provisions.

Fabricate all fabricate critical components as AISC category III fabrication shop with fabrication critical certification.

Design specifications are Division 1 of AASHTO Standard Specifications for Highway Bridges, including factors through the 75 year design specifications. All specifications are supplemented by the Pennsylvania Department of Transportation archetypal loadings.

Live-load distribution in beams 10.0 based upon the AASHTO method.

Dead load includes the nominal weight of the structure and 300 pounds per square foot for traffic loading on the deck slab.

Dead load is further increased by the dead load factor method. A live load of the Pennsylvania dead load plus 133.3 percent of the alternate steel loads are also applied by the load factor method.

In addition to the normal requirements of permit and permits, the design of portions of the proposed construction is controlled by stress-strengthening occurring at the instant the auxiliary support system becomes active. When a portion of the structure will drop a short distance, for this case, the impact factor is applied to all loads and the following load combinations are used:

- HD2 loading: 1.30 x L + 0.30 x HD2 (impact factor)
- HD2 loading: 1.60 x L + 0.60 x HD2 (impact factor)

Members subject to these loadings are evaluated at load factor operating at stress levels. The strength of the bridge's post-tensioning capacity is not used. The overload provisions of the AASHTO do not apply.

Fatigue design is based on an AASHTO 60 ksi with 5,000,000 cycles of AASHTO dead truck loading.

All dimensions shown are parallel and normal to the axis of the main girder, except as noted.

Drawing shown for new steel are for a normal temperature of 60 degrees F.

Field splice of new auxiliary support beam are not permitted.

All new fasteners are ASTM Grade high-strength bolts, unless noted as ASTM-440 high-strength bolts.

Fill any bolt holes not used as part of the final construction with high-strength bolts.

Paint new structural steel in accordance with publication HSSP, Section 1005. Paint existing structural steel in accordance with Section 1006.

Field-welding on any part of the existing bridge is not permitted without prior approval of the engineer.

The maximum radius for re-entrant cuts is 0.5. In performance of work operations, exercise care to prevent damage to those portions of the structure which will remain in place. Repair, or replace any portion of the structure damaged by construction operations, at the discretion of the engineer, and at no additional cost to the department. Perform this work to the satisfaction of the engineer.

* See design load table, sheet 4, for dynamic factor.

SYMBOLS FOR FASTENERS:

- All fasteners to be used are:
  - New field-installed high-strength bolt in new hole.
  - Existing bolt to remain.
  - New field-installed high-strength bolt in new hole, hidden.