FINAL STUDY REPORT FOR LOCAL BRIDGE STEEL FATIGUE DETAIL

DEPARTMENT OF TRANSPORTATION

PREPARED BY:

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Executive Summary

Fatigue of steel members of a bridge is detrimental to its structural capacity. For this project, Collins Engineers reviewed 150 bridge plans to identify fatigue prone details. Of the 18 fatigue details, 11 were found on 145 of the bridges. Five bridges did not have fatigue prone details present. All steel bridges on the local bridge inventory were ranked by likelihood of containing fatigue prone details and the importance of the bridge. In 1986 the steel code was changed and the likelihood of bridges having fatigue details after 1986 is low. There are 271 steel bridges constructed prior to 1986 on the local bridge system. Those 271 bridges were scored based on year built to account for likelihood of having a fatigue prone detail and ADT to account for consequence and likelihood of fatigue. Bridge plans were reviewed based primarily on the fatigue score but also to some extent on the availability of plans for the bridge. 150 bridges were evaluated under this contract considering the project budget and the understanding that there are diminishing returns as the likelihood of finding fatigue prone details is diminished.

Introduction and Approach

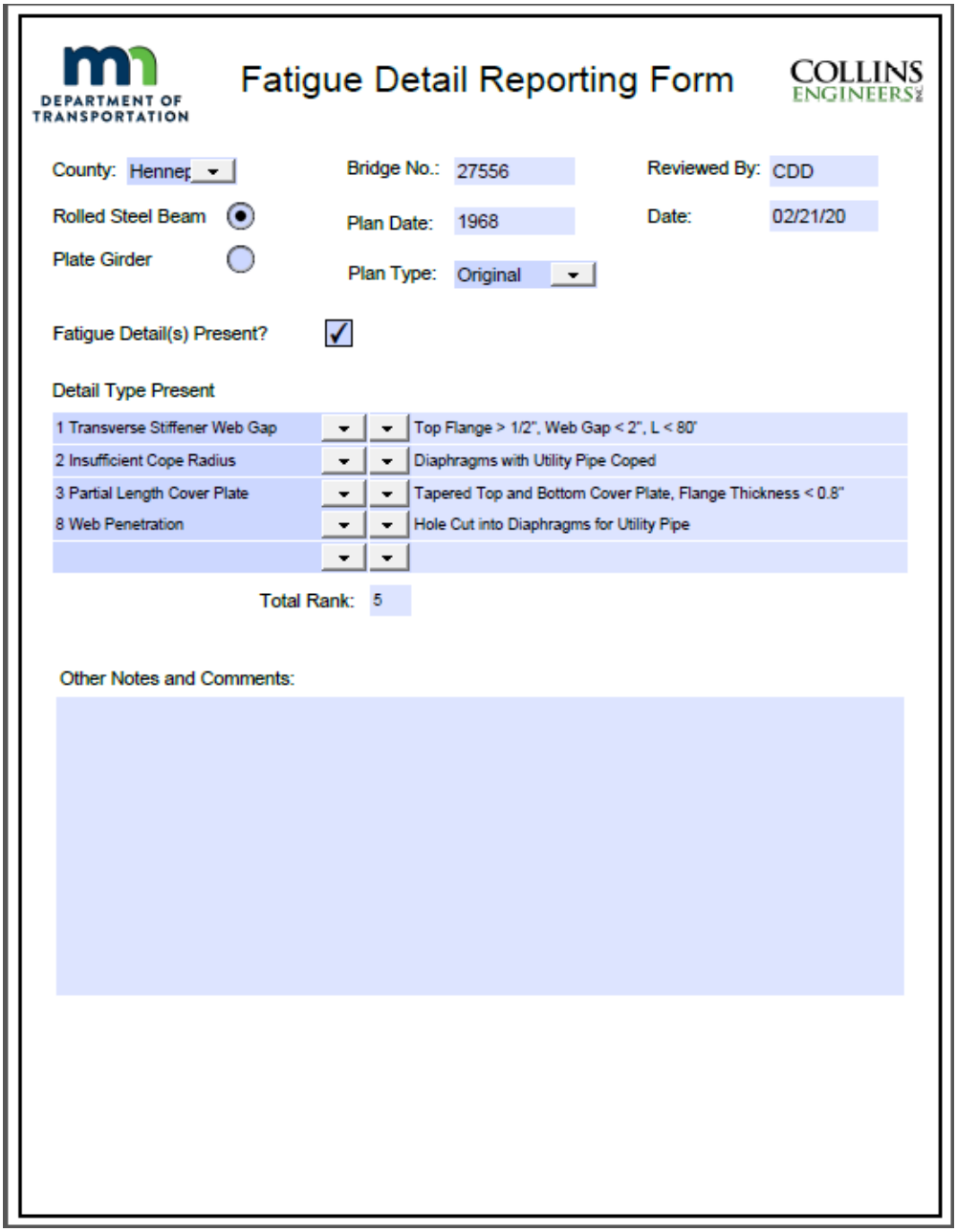
Fatigue in steel bridges is a concern nationwide and many bridges are approaching an age where fatigue life of steel details will be reached. A Local Road Research Board Project completed in 2007 by the Minnesota Department of Transportation (MnDOT) and the University of Minnesota addressed the fatigue and fracture susceptibly to MnDOT's Steel Bridge Inventory and provides a framework for enumerating fracture and fatigue prone details present in steel bridges. The results of this study were used to document these details in the trunk highway bridges on the Minnesota Bridge Inventory. This information is incorporated into the bridge inventory data and is used by bridge owners and inspectors to monitor and inspect these details to reduce the risk of undiscovered cracks. The information is also incorporated into the risk-based bridge management tools. This project will apply this methodology to the local bridge system to populate the bridge inventory information with fatigue detail data.

Fatigue is the process by which a structural component is damaged by repeated tensile or reversal loading, even when that loading is below the allowable design stress. The stress level at which fatigue begins is greatly affected by fabrication defects (such as notches, rough-cut edges, or weld inclusions) as well as specific design details. There are 18 fatigue prone details for steel members, below is a table of each detail and the corresponding code.

Code	Description	Code	Description
1	Transverse Stiffener Web Gap	10	Field Welded Splice
2	Insufficient Cope Radius	11	Pin and Eyebar Truss or Pin and Hanger
3	Partial Lenth Cover Plate	12	Lateral Bracing to Girder Bottom Flange
4	Shelf Plate Welded to Girder Web	13	Cantilever Floorbeam Bracket
5	Stringer of Truss Floorbeam Bracket	14	Backing Bar
6	Welded Horizontal Stiffener	15	Intermittent Weld
7	Haunch Insert	16	Tack Weld
8	Web Penetration	17	Tied Arch Floorbeam
9	Plug Welded Misplaced Hole	18	T1 Steel (A514)

Table 1: Fatigue Details

The 2019 "Bridge and Structure Inspection Program Manual" from MnDOT has a detailed description of each fatigue detail and how to rank them on pages D 187 – D 228. For this project, this information was used as a reference and an engineer reviewed the structural plans for each steel bridge and located all the fatigue prone details that were present. The located details were then entered into a form to be submitted to the bridge owners.



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Fatigue Detail Reporting Form

COLLINS ENGINEERS

County: Henner

Bridge No.: 27556

Reviewed By: CDD

Rolled Steel Beam

Plate Girder

Plan Date: 1968

Date: 02/21/20

Plan Type: Original

Fatigue Detail(s) Present? ☑

Detail Type Present

1 Transverse Stiffener Web Gap		Top Flange > 1/2", Web Gap < 2", L < 80'
2 Insufficient Cope Radius		Diaphragms with Utility Pipe Coped
3 Partial Length Cover Plate		Tapered Top and Bottom Cover Plate, Flange Thickness < 0.8"
8 Web Penetration		Hole Cut into Diaphragms for Utility Pipe

Total Rank: 5

Other Notes and Comments:

Figure 1 Fatigue Detail Reporting Form

Bridge List and Maps

Collins Engineers inspected 150 bridge plans in 45 counties for fatigue prone details. A list of the 145 bridges that contained fatigue prone details per county are as follows:

Beltrami County: 04511, 04512

Benton County: 05521

Blue Earth County: 07024, 07512, 07513, 07514, 07531, 07533, 07534, 07538, 07542, 07550, 7274

Brown County: 7203

Carlton County: 09505

Carver County: 10514

Cass County: 11513

Chippewa County: 12519, 6610, 6611, 7017

Clay County: 5270

Cottonwood County: 17502, 17503, 17521

Crow Wing County: 18503

Dakota County: 19010, 19503, 19504, 19512

Dodge County: 20502

Faribault County: 22540, 22553, 22554, 22822, 7217

Fillmore County: 23501, 23503, 23506, 23509, 23511, 23512, 23516, 23521, 23522, 23539, 23541, 23546

Freeborn County: 24523, 24528

Hennepin County: 27111, 27241, 27510, 27516, 27533, 27537, 27538, 27541, 27542, 27549, 27553, 27556, 27558, 27563, 27565, 27570, 27608, 27620, 27621, 9360

Houston County: 28505, 28512, 28513, 28521

Isanti County: 30508

Koochiching County: 36501, 36517

Lac Qui Parle County: 7132, 37510

Lake County: 38505

Lyon County: 42539

Mcleod County: 43509, 43519, 43520

Morrison County: 49528

Mower County: 7091

Murray County: 51510

Nicollet County: 52504

Norman County: 54510, 54511, 54519, 54520, 54532, 54533

Olmsted County: 55506, 55511, 55515, 55517, 55520, 55522, 55527, 55543

Pennington County: 6613

Pine County: 58513

Ramsey County: 5962, 62505, 62511, 62517, 62523, 62526, 62527, 62532, 6600, 90408

Redwood County: 64502, 64541, 7202, 89830

Renville County: 65532

Rice County: 66510, 66511, 66513, 66515, 66518

St. Louis County: 6665

Stearns County: 73503, 73510, 73527, 73528, 73530, 73533, 73538

Steele County: 74007, 74521

Wabasha County: 79508, 79523

Wadena County: 80002, 80003

Waseca County: 81504, 81507, 81518

Washington County: 82501

Wilkin County: 84505

Winona County: 85510

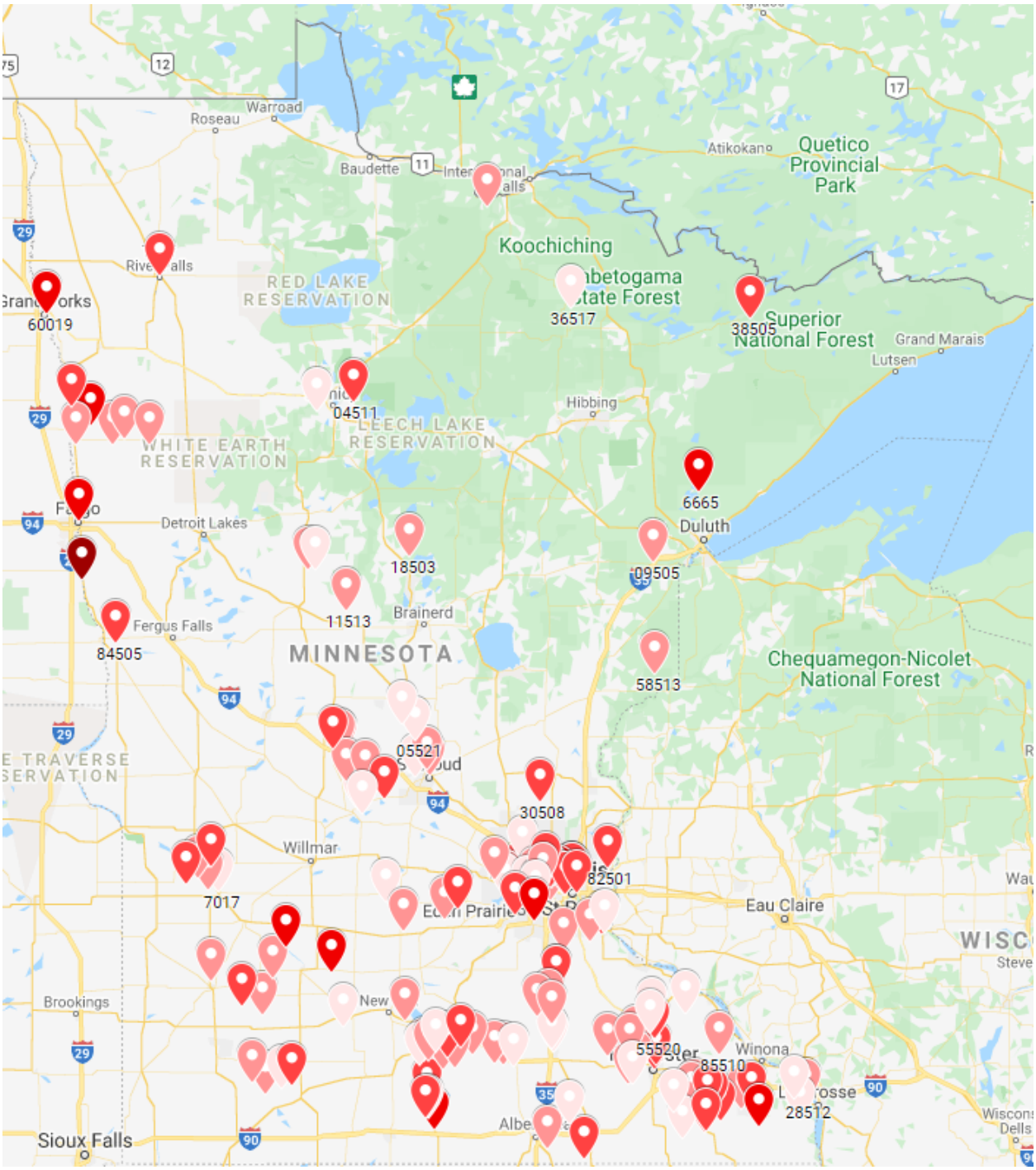

Figure 2 Map of Bridge Locations

Locations of the bridges can also be found here:
https://www.google.com/maps/d/u/1/edit?mid=19nrzpGjvsrIS_Cee01PaOyIGFz5DWIb9&usp=sharing

Summary of Results

From the 150 bridge plans reviewed, the following was found: The most common fatigue details were transverse stiffener web gap, partial length cover plate, and insufficient cope radius. *Figure 3* shows the number of bridges that have each of the 18 fatigue details.

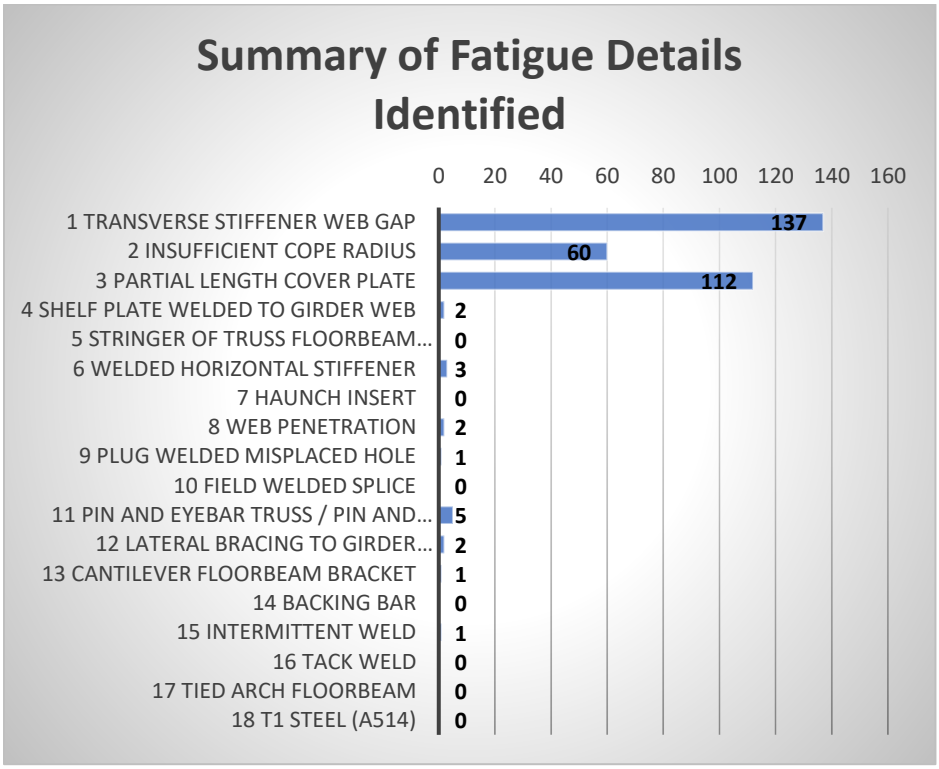

Figure 3: Summary of Fatigue Details Identified

When details were found, the rank of each detail was added up for a total fatigue ranking. The majority of bridges have a rank of 3 or 5. *Figure 4* shows the total rank of the bridges inspected.

Overall Summary of Bridges with Fatigue Details		
Number of Bridges Reviewed	150	
Bridges with Fatigue Details Present	145	97%
Bridges with 2+ Unique Fatigue Details	132	88%
Bridges with 3+ Unique Fatigue Details	48	32%
Bridges with 4+ Unique Fatigue Details	3	2%

Figure 4: Overall Bridge Summary

Most bridges had 2 different fatigue details. *Figure 5* shows the number of different fatigue details each bridge has.

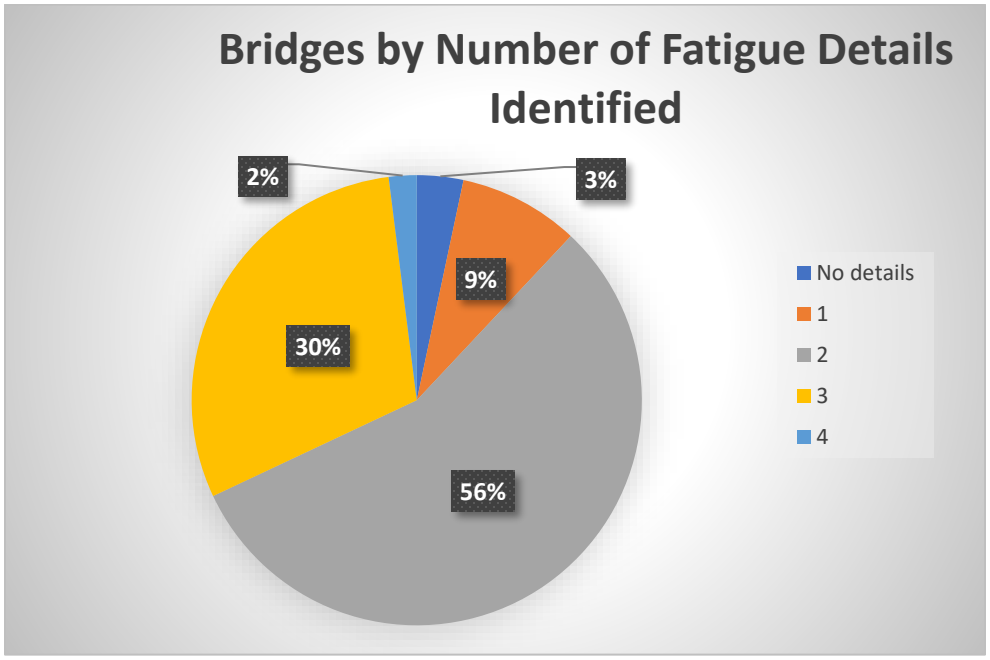

Figure 5: Number of Fatigue Details Identified

Conclusion

The results for the 150 Bridges that were evaluated have been uploaded into the MnDOT SIMS Inspection database. The resulting bridge inspection database for each bridge is populated with Element 882 Steel Cracking and is defaulted to Condition State 1 indicating a fatigue prone detail is present and prompting the bridge inspector to look for cracking at the fatigue prone detail. This fatigue screening effort prioritized bridges for evaluation and bridge owners should still review all their steel bridges during inspections for fatigue details and add element #882 Steel Cracking if fatigue details are present.

#882: Steel Cracking (1 Each)

This element applies only to primary steel structural members (typically superstructure). This element is intended to track the presence (and severity) of cracks due to fatigue or other causes. This element should not be used for culvert structures.

- This element should be rated for any bridge with a steel superstructure that has fatigue prone details of AASHTO category "C" or higher, even if no cracks are present.
- Reference the Minnesota Bridge & Structure Inspection Program Manual (BSIPM - Section D.7.10) for descriptions and photos of common fatigue prone details. Fatigue prone details present on a bridge should be noted in the inspection report under this element.
- For MnDOT (trunk highway) bridges, fatigue prone details identified by plan review are listed in SIMS under the SIA - One Column (Steel Fatigue Data) item.

Defect or Item	Defect Element Condition States			
	1	2	3	4
	Good	Fair	Poor	Severe
Cracking (Base metal on Primary Steel Structural Members)	Fatigue prone details are present on primary steel superstructure elements (no cracks are present).	Cracking has been arrested (drilled or ground out). Any resultant damage to the steel element has been repaired.	Cracking exists and has not been arrested. Note: This condition state is normally used when cracking is initially observed, or if additional cracking is observed after repairs.	Cracking has seriously damaged a primary steel superstructure element. Immediate repairs or structural analysis are required.
Tack Welds (on Primary Steel Structural Members)	No cracked tack welds are present.	Cracked tack weld is present, but has not yet propagated into the base metal of the primary member.	Cracked tack weld has propagated into the base metal of a primary structural member.	