Joint Transportation Research Program

Principal Investigators: Robert J. Connor, Purdue University, rconnor@purdue.edu, 765.496.8272
Cem Korkmaz, Purdue University, ckorkmaz@purdue.edu, 765.494.5027
Amit Varma, Purdue University, ahvarma@purdue.edu, 765.496.3419
Program Office: jtrp@purdue.edu, 765.494.6508, www.purdue.edu/jtrp
Sponsor: Indiana Department of Transportation, 765.463.1521

SPR-4631 2024

Evaluating the Potential Benefits of Implementing AASHTO Guide Specifications for the Analysis and Identification of Fracture Critical and System Redundant Members

Introduction

An exploratory study was conducted for certain bridges in the state of Indiana that evaluated the implementation potential of the *AASHTO Guide Specifications for Internal Redundancy of Mechanically-fastened Built-up Steel Members* (IRM Guide Specification) and the *AASHTO Guide Specifications for the Analysis and Identification of Fracture Critical Members and System Redundant Members* (SRM Guide Specification). The outcomes for the project included (1) determining if a wider-scale application of the Guide Specifications would be beneficial to INDOT; (2) identifying which bridges or members are "truly" non-redundant in the selected bridges, thus allowing a more targeted inspection program that would minimize the risk associated with member failures; (3) developing a more targeted inspection program for the bridges eligible to be classified as IRMs and SRMs; and (4) proposing a strategy to move forward with a state-wide implementation plan to analyze other bridges presently classified as having NSTMs.

While an explicit cost/benefit analysis was not performed and was beyond the scope of this project, implementation should not be considered solely based on the initial cost of the analysis. Indirect cost benefits have the greatest impact associated with implementation. These are summarized as follows.

- Establishing an engineering-based inspection interval and strategy for members traditionally classified as NSTMs. In the absence of performing SRM or IRM evaluations, INDOT is forced to use a one-size-fits-all for these bridges and members. Hence some members are under-inspected while some are over-inspected. Since the member criticality in the context of redundancy is based on engineering and not perception, the reliability of the structure—or the vulnerability should a member fail—is better understood, which allows inspection resources to be allocated more effectively.
- In cases where the intervals can be extended, risks to inspectors and the traveling public are greatly reduced.
- In cases when NSTM inspection are eliminated entirely, there will be costs savings on a given bridge since the expenses of special access equipment (lane closures, etc.) are eliminated, or at most, only conducted at extended intervals.

Findings

This report addresses the bridge selection process used to determine the list of structures in the state of Indiana for IRM and SRM evaluation, and includes a detailed description of the IRM and SRM evaluation processes.

- Volume I: The evaluation demonstrated that nearly 94% of the main girders of the bridge are eligible to be reclassified as IRMs and contain a special inspection frequency of 10 years. The remaining 5% of the main girders, to remain labeled NSTMs, did not qualify as IRMs due to lack of cover plates or failing strength checks of fracture net section.
- Volume II: The evaluation of Girder Bridge 041-26-03917 demonstrated that 79% of the main girders of the bridge are eligible to be reclassified as IRMs and contain a special inspection frequency of 10 years. The remaining 21% of the main girders, to remain

labeled NSTMs, did not qualify as IRMs due to lack of cover plates or unmitigated damage.

- Volume III: The evaluation of Truss Bridge 062-65-T4020 determined that 53% of the NSTMs satisfied the requirements and were adequate in strength and fatigue to be recategorized as IRMs. Failed members did not pass due to the strength check, failing both the net section and gross section strength checks in the faulted state. For the truss members determined to be internally redundant, the maximum Special Inspection interval was calculated to be 10 years.
- Volume IV: Steel I-Girder Bridge I74-170-04684 over Whitewater River does not possess sufficient reserve strength in the faulted state when performing SRM analysis, thus bridge members currently listed as NSTMs should remain labeled as such.
- Volume V: Simple-Span Truss Bridge SR1 001-68-03408 over the Mississinewa River contains thirteen components that meet the performance criteria outlined in the SRM Guide Specification and thus are eligible to have the NSTM label removed and relabeled as SRMs and have the inspections adjusted accordingly. Other tensions members must remain classified as NSTMs.
- Volume VI: Two-Span Truss Bridge, Matthew E. Welsh Memorial Bridge, Mauckport (135-31-06504 B), does not possess considerable reserve strength in the faulted state, thus bridge members currently listed as NSTMs should remain labeled as such.

Implementation

Members determined to satisfy the internal redundancy requirements of the IRM Guide Specification were assigned specific maximum intervals between Special Inspections. The scope of the Special Inspections will be such that it is capable of reliably identifying large cracks or completely severed components in IRMs. The details associated with the inspection frequency and scope for each bridge were documented as part of the IRM inspection plan, which is included in each of the volumes. While the Special Inspection is focused on detection of broken components as noted above, other reportable conditions (corrosion, impact damage, etc.) found on an IRM member would also need to be documented and reported for use as needed in evaluating if the member needs to be reclassified as an NSTM. Specifically, “Any changes in the condition of the structural member that would justify a more frequent interval and/or a different level of rigor for the special inspections for IRMs” will be evaluated to determine if the member may remain classified as an IRM.

Any members that were relabeled as SRMs need not be subject to inspection protocols that apply to NSTMs (arms’ length in-depth inspections). However, future inspection strategies should be dependent on the overall assessment of the structure. Should a given inspection identify conditions that warrant a member being reclassified as an NSTM, this shall be clearly identified in the file for the given bridge and the future inspections altered as appropriate. The factors affecting this decision should include, but not be limited to, the presence of fatigue cracks, repairs/retrofits, impact damage, corrosion, age, traffic history, overall condition of the bridge, etc. Changes to the bridge that would cause any of the screening criteria, found in Section 2 of the SRM Guide Specification, to disqualify the bridge from being considered for SRM analysis must be corrected if the SRM label is to remain. If the issues are not corrected, the members must revert to being NSTMs.

Each volume associated with a specific structure provides an accurate and legal procedure in which bridge members can be evaluated for system level redundancy as well as internal redundancy. These procedures can be replicated to analyze additional bridges owned by INDOT. Since inspection intervals and scope are set using rational engineering-based approaches, it is likely that in some cases hands-on inspection can be extended or eliminated without compromising safety. Both Volume V and Volume VI provide specific documentation to INDOT on how to implement the SRM and IRM processes.

Recommended Citation for Report

Connor, R. J., Korkmaz, C., Varma, A., Kieffer, C. J., III., & Ebert, A. (2024). *Evaluating the potential benefits of implementing AASHTO Guide Specifications for the analysis and identification of fracture critical and system redundant members* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2024/13). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317746

View the full text of this technical report here: https://doi.org/10.5703/1288284317746

Published reports of the Joint Transportation Research Program are available at http://docs.lib.purdue.edu/jtrp/.