Load Ratings for Standard Bridges

tech transfer summary

The findings from this study will aid the Iowa DOT and local bridge owners (Cities and Counties) in correctly documenting and posting the load carrying capacity of bridges built using the current standard designs.

Objectives

The primary objective of this project was to investigate the load carrying capacity of bridges designed using the current Iowa Department of Transportation (DOT) secondary road standard bridge plans which are based on Load and Resistance Factor Design (LRFD) methods. Proper evaluation of the load carrying capacity requires the use of Load and Resistance Factor Rating (LRFR) methods, which had not previously been completed. It was also the objective of the project to complete the analysis using the current version of the American Association of State Highway and Transportation Officials (AASHTO) BrR computer software. The final objective was to prepare a document that could be utilized by State and local bridge owners to easily reference the load carrying capacities that have been computed for the standard bridge designs.

Research Description

The Iowa secondary road standard plans include a number of configurations that local agencies can use to build bridges. Designs for four bridge types are included in the standard plans: Continuous concrete slab bridges (designated as the J Standards), multi-span precast prestressed concrete beam bridges (H Standards), single span precast prestressed concrete beam bridges (H-SI Standards) and rolled steel beam bridges (RS Standards). Multiple bridge width options are provided for the H and J Standards including 24', 30', 40' and 44' clear trafficways. The RS Standards only provide a 40' clear trafficway width and the H-SI Standards only provide a 30' width. The plans for each of these bridge types include a number of discrete bridge lengths: 9 different lengths for the H and J Standards, 7 for the H-SI Standards, and 10 for the RS Standards. A variety of skew angles are covered by the standards as are the open and closed barrier rail. This results in 754 possible bridge combinations that could be produced using the standard bridge plans. To reduce the number of combinations that required rating, multiple skews were grouped and the most conservative configurations for each group were analyzed. This reduced the number of combinations to rate and report to 297.

Since the results of this project would be utilized by many agencies for years to come, quality control was of the utmost importance. The complexity of the AASHTO BrR computer program, the large number of combinations to be analyzed and the high volume of numerical output to be accurately presented in the report required careful upfront planning of quality control and quality assurance procedures.

AASHTO BrR requires multiple screens of detailed input to describe each specific bridge that is being analyzed. A spreadsheet template was developed for each bridge type that would allow the input data to be identified, computed and then presented in a form that could be efficiently and independently checked by another member of the research team. The template

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RESEARCH PROJECT TITLE

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PRINCIPAL INVESTIGATOR

Stephen W. Moffitt, PE
smoffitt@hgmonline.com
(orcid.org/0000-0002-8277-2279)

PROJECT TEAM

Jon E. Peterson, PE
jpeterson@hgmonline.com
(orcid.org/0000-0002-4378-762X)

Payton D. Seager, PE
pseager@hgmonline.com
(orcid.org/0000-0002-2554-3015)

Joe T. Malloy, EI
jmalloy@hgmonline.com
(orcid.org/0000-0002-7539-0213)

Ryan P. Pritchard, EI
rpritchard@hgmonline.com
(orcid.org/0000-0002-3359-9470)

Shawn M. Muhle, EI
smuhle@hgmonline.com
(orcid.org/0000-0002-4009-940X)

Emmett M. Moffitt
emoffitt@hgmonline.com
(orcid.org/0000-0002-6173-2323)

HGM Associates Inc.
5022 S 114th Street,
Omaha, NE 68137
402-346-7559
www.hgmonline.com

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mimicked the screens used for input in AASHTO BrR which reduced the potential for error during the keypunch entry of the data into the program. Finally, a separate independent check was performed comparing the template information to the AASHTO BrR input data file to eliminate keypunch errors.

Global analysis parameters were determined and set within AASHTO BrR prior to execution of the data set. The trucks that would be analyzed were determined to be the Iowa legal trucks with some additional legacy configurations, emergency configurations and annual permit vehicles. Bridges would be analyzed in accordance with the AASHTO Manual for Bridge Evaluation, 3rd Edition (Interims through 2019) and the AASHTO LRFD Bridge Design Specifications, 8th Edition. H Standards were conservatively rated as simple spans, ignoring any benefits from the effects of continuous spans. RS Standards were rated considering moment redistribution and plastic section analysis.

Execution of the rating analysis program was completed and the output data was tabulated into the tables used for presentation. A quality control check method was developed that would compare bridge configurations that were similar and would look for differences that were outside an expected range. The comparisons were done for all bridge lengths of the same configuration and the differences were 'heat mapped' so that those which were outside an expected range could easily be identified. The research team would either identify an input error or identify the phenomenon that caused the difference to be outside the expected range.

	Bridge Length								
Truck	138 10	151 4	163 10	176 4	188 10	201 4	213 10	226 4	243 0
HL-93 Inv	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.1
Controlled by									
Location									
HL-93 Oper	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Controlled by									
Location									
IA Type 4	0.9	1.7	0.5	0.7	2.1	-0.6	-0.6	1.6	1.6
IA Type 3 *	0.9	1.7	0.5	0.9	2.1	-0.6	-0.6	1.6	1.6
IA SU4	0.8	1.6	0.5	0.5	2.1	-0.6	-0.6	1.6	1.6
IA SU5	0.9	1.7	0.5	0.9	2.1	-0.7	-0.6	1.6	1.6
IA SU6	0.9	1.7	0.5	1.0	2.2	-0.6	-0.6	1.6	1.6
IA SU7	0.9	1.8	0.6	1.3	2.2	-0.7	-0.6	1.7	1.7
IA 3S3A	1.4	2.6	0.8	2.0	3.1	-0.9	1.4	2.2	2.2
IA 3S2A *	1.4	2.6	0.8	2.0	2.9	-0.9	1.3	2.1	2.1
IA 3S3B	1.6	3.1	1.0	-0.2	4.0	-1.2	-1.1	3.0	3.0
IA 4S3	1.5	3.0	0.9	1.3	3.7	-1.1	-1.0	2.8	2.8
IA 3-3	1.3	2.5	0.8	1.9	2.9	-0.9	1.3	2.0	2.0
IA 5-2	1.4	2.7	0.8	1.5	3.3	-1.0	1.3	2.4	2.4
IA EV2	0.9	1.7	0.5	1.0	2.2	-0.6	-0.6	1.6	1.6
IA EV3	0.9	1.7	0.5	0.7	2.1	-0.6	-0.6	1.6	1.6
90k	1.3	2.5	0.8	-0.4	3.2	-1.0	1.3	2.3	2.3
100k Crane	1.0	1.8	0.6	1.5	2.2	-0.7	-0.6	1.7	1.7
136k A	1.5	2.9	0.9	0.9	3.7	-1.1	1.4	2.6	2.6
136k B	1.4	2.7	0.8	0.3	3.4	-1.0	0.2	2.4	2.4
156k	1.6	3.0	1.0	0.3	3.9	-1.2	0.3	2.8	2.8

Quality Control Heat Map

Key Findings

Key findings as a result of this project included the following three items.

Load Ratings for Iowa Trucks on Current Iowa Standard Bridges

This was the primary objective of the project, and the result was that load ratings have now been determined for all of the current Iowa secondary road standard bridge designs using LRFD methods. The load ratings include all of the current truck configurations required by the Federal Highway Administration (FHWA) and the Iowa DOT.

AASHTO BrR Program Computation Error

During the RS Standard analyses, the research team found differences using the quality control tools that could not be attributed to input errors. Further investigation uncovered an error in the BrR analysis method of non-prismatic steel beam sections under specific bracing conditions. This error was brought to the attention of the AASHTO BrR development team for correction in a future release. The research team also developed a workaround that allowed the analyses for this project to proceed and to produce the correct results.

RS Standard Bridge Design Error

Also during the RS Standard analysis, the research team determined that certain bridge configurations of the 2010 version of the standard would require the bridge to be posted and restrict trucks from carrying their full legal capacity. The research team assisted Iowa DOT bridge staff in determining possible retrofit concepts to eliminate this deficiency.

Implementation and Benefits

The findings from this study will aid the Iowa DOT and local bridge owners in determining load ratings for bridges built using the current standard design plans. It will also simplify the required compliance documentation within the Iowa DOT's bridge management database by presenting all of the required data in a format that makes completing the database entries more efficient. The completed reference document containing the load rating findings is published on the Iowa DOT website for those that require the information.

References

AASHTO. 2019. *Manual for Bridge Evaluation, 3rd Edition.* American Association of State Highway and Transportation Officials, Washington, DC.

AASHTO. 2017. *LRFD Bridge Design Specifications, 8th Edition.* American Association of State Highway and Transportation Officials, Washington, DC.