

TDOT Project RES 2013 - 35

Enhance and Improve Rating Aids for the Evaluation of Existing Concrete Box/Slab Culverts

PROJECT SUMMARY

I. Purpose of the Project

The purpose of this project is to enhance and improve the rating aids and structural rating models for the evaluation of existing concrete box/slab culverts in Tennessee. These rating aids will allow bridge/culvert evaluators to efficiently rate existing culverts and make the culvert rating process an efficient and sustainable practice, consequently helping TDOT comply with the NBIS FHWA load rating requirements for existing culverts.

II. Scope and Significance of the Project

The scope of the project is outlined in the following tasks:

- Task 1.** Conduct a comprehensive review of rating results obtained in the previous research and categorize the culverts that possess unsatisfactory rating results into groups based on the controlling rating factors
- Task 2.** Perform load rating for culverts with unsatisfactory rating results
- Task 3.** Analyze and summarize the new rating results for additional evaluations of selected culverts
- Task 4.** Compare different formats of rating aids and identify the most efficient format
- Task 5.** Present the findings to TDOT

Approximately 44% of Tennessee bridges/highway structures (8,661 out of 19,616) are classified as culverts. The ages of existing culverts in Tennessee span a large range, with the oldest one built in 1905. Some of these culverts are currently in poor condition and need to be evaluated for their structural capacity. Furthermore, Federal Regulations require that all highway structures including culverts be load rated for their live load carrying capacity. Therefore it is essential that efficient tools be developed for culvert rating. During the TDOT Project 28012 – ED 1236527, *Developing Rating Aids for the Evaluation of Existing Concrete Box/Slab Culverts in Tennessee*, the Tennessee Tech University (TTU) research team has completed a number of milestones, including: the establishment of a culvert database; selection and verification of a culvert rating software; analysis of culvert models for load rating; initial screening of the rating results; and setting up a trial format for rating aids. The examination of the obtained rating results reveals that further refined analysis and research are necessary in order to have a better understanding of the results and have an in-depth study on certain loading responses, and, ultimately, to establish efficient culvert rating aids.

III. Expected Outcomes

The deliverables for the project will include rating aids (charts and tables) for culvert load rating and a full group of BRASS Culvert models of the existing Tennessee standard culverts. The

bridge evaluators in Structural Division at TDOT can use these rating aids to efficiently rate existing culverts. The BRASS Culvert models can be utilized for routine inventory and operating ratings of culverts with different rating requirements. The research team will make every effort to facilitate the smooth transition of rating aids and BRASS Culvert models. The implementation of the research results will help improve the efficiency, accuracy, and sustainability of the culvert rating process.

IV. Time Periods and Status of the Project

1. Time periods:

The project is effective for the period beginning August 1, 2013, and ending on July 31, 2018.

2. Status of the project

The Tennessee Technological University (TTU) research team has conducted extensive studies on current literature, culvert database assembly, software selection and verification, structural modeling of culverts, and development of culvert rating aids. Dr. Sharon Huo, Associate Provost and Professor of Civil Engineering at Tennessee Tech, is the PI of the project and a total of five M.S. graduate assistants have participated in the research at different stages (Figure 1).

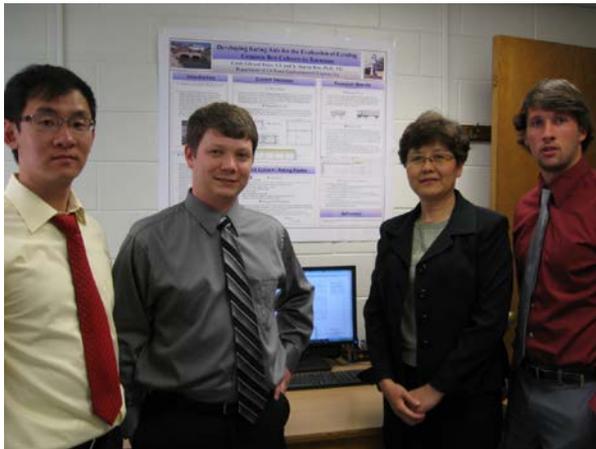


Figure 1. Tennessee Tech Research Team

Left photo: from left, Kyle Zhang, Michael Bednarczyk, Dr. Sharon Huo (PI and Professor), and Caleb); Right photo: Brandon Bartrom (left) and Heath Kaufman (right)

Of the approximately 20,000 TDOT bridge/culvert drawings that TTU research team reviewed, a total of 883 standard culvert drawings were identified to comprise large structures (span length \geq 20 ft). Many of these drawings contained multiple culverts; therefore, well over 1000 standard concrete box and slab culverts have been investigated over the course of this project. The research team has structurally modeled the TDOT standard culverts using a culvert rating program for various fill depths within the limits of the designs and analyzed the culverts with appropriate rating loads. Rating factors of culverts were obtained at inventory and operating levels and were reported on the Rating Aid data sheets for the flexural moments and shear forces

at various locations of the culvert members. With the rating results, TDOT Culvert Rating Aids, a rating management program for concrete box and slab culverts, were created to best meet the needs of bridge evaluators.

The Rating Aids developed in this study retain a collection of rating factors for standard drawings of box and slab culverts from TDOT's bridge database. The intent of the Rating Aids is to allow for an efficient, effective and sustainable box/slab culvert rating process. After exploring various potential formats for Culvert Rating Aids, a new Rating Aid format was identified and hence the new Rating Aids were developed. The new Culvert Rating Aids show clear improvement from the previous version of the Rating Aids. The Search page of the program was developed to allow engineers a means to quickly and efficiently search through the Rating Aids by selecting the number of cells along with three optional parameters, skew angle, cell dimensions, and the design year. (Figure 2) The search leads to a list of hyperlinks that show the rating factors of the culverts in selected TDOT drawings.

This project is still in progress. We are currently working on Tasks 4 and 5.

The screenshot shows the 'Slab Culvert Rating Factor Browser' application. It features a search interface with the following components:

- Search Form:**
 - Number of Cells (Required):** A dropdown menu with options: 1 Cell, 2 Cells, 3 Cells, 4 Cells, 5 Cells.
 - Skew* (Optional):** A dropdown menu with options: All, 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30, 25, 20, 15, 10, 5, 0.
 - Cell Size (Width x Height) (Optional):** A dropdown menu with options: 6' x 3', 6' x 4', 6' x 5', 6' x 6', 8' x 3', 8' x 4', 8' x 4.5', 8' x 5', 8' x 6', 8' x 7', 10' x 4', 10' x 5', 10' x 5.5', 10' x 6', 10' x 7', 10' x 7.5', 10' x 8'.
 - Year (Optional):** A dropdown menu with options: 1920, 1921, 1922, 1923, 1924, 1925, 1926, 1927, 1928, 1929, 1930, 1931, 1932, 1933, 1934, 1935, 1936, 1937, 1938, 1939.
- Search Button:** A blue button labeled 'Search'.
- Warnings:** A section labeled '(Warnings)'.
- Remove Buttons:** Three buttons labeled 'Remove Skew', 'Remove Size', and 'Remove Year'.
- Search Results Table:**

Drawing; Skew	Size	Year
D-4-296; 75°	10' x 6'	1927
A-6-20; 75°		1930
A-8-12; 75°		1930
A-8-76; 75°		1931
C-2-54; 75°		1940
C-10-132; 75°		1948
E-4-11; 75°		1950
E-12-145; 75°		1954
G-10-135; 75°		1959
- Clear Button:** A blue button labeled 'Clear'.
- Culvert Image:** A small photograph of a concrete culvert structure with two openings.

Figure 2. TDOT Culvert Rating Aids for Slab Culverts

IV. Contact information

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