# Ohio Department of Transportation Research Project Fact Sheet

## Innovative Evaluation of Precast, Prestressed Adjacent Box Beam Bridges

| | |
|---|---|
| **Researcher(s)** | Yugesh Maharjan<br>Suraj Dhungel<br>Dr. Serhan Guner |
| **Agency** | The University of Toledo |
| **Report Date** | June 2025 |
| **Project Number** | 120635 |

## BACKGROUND

- Ohio has approximately 30,000 bridges, about 8,000, or 27% of which are precast, prestressed adjacent box beam bridges (Figure 1).
- Accurate load rating of these bridges is essential for determining safe load-carrying capacities, posting requirements, and making informed permit decisions.
- Load rating these bridges is complex and time-consuming due to the lack of user-friendly tools, the large number of sections used over the years, and the extensive calculations required.

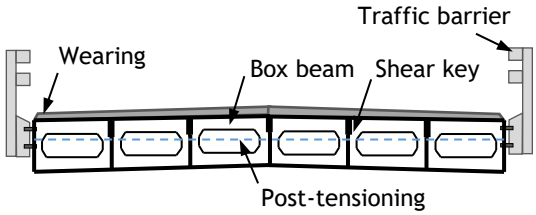


*Figure 1 Typical cross-section of an adjacent box beam bridge.*

## RESEARCH CONTEXT

- Develop a user-friendly computer tool, named 'AD-BOX,' which stands for Adjacent Box Beam Bridge Analysis and Rating.
- Develop using Visual Basic for Applications (VBA) and include in a Microsoft Excel spreadsheet to reduce the learning curve.
- Enable fast and automated load rating of simply supported precast, prestressed adjacent box beam bridges according to AASHTO LRFD (2024), AASHTO MBE (2018), and ODOT BDM (2020).
- Develop an optional feature to generate moment and shear envelopes due to the selected vehicle type on any single span simply supported bridges.

## RESEARCH APPROACH

- Develop an automated computer tool with approximately 3,000 lines of VBA coding and include in a Microsoft Excel spreadsheet.
- Thoroughly test, debug, and verify AD-BOX to ensure its accuracy and reliability.
- Load rate all 15 vehicle types as required by Ohio BDM and a custom vehicle (Figure 2).

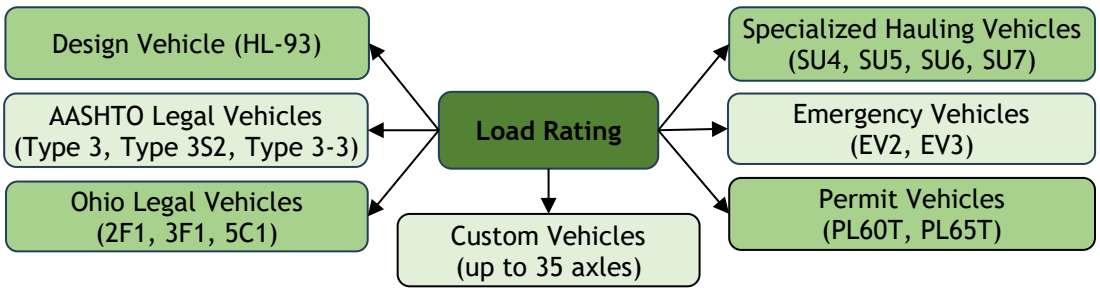


*Figure 2 Vehicle types included in AD-BOX for load rating.*

- Generate moment and shear envelopes due to the selected vehicle type from the list of 15 vehicle types and a custom vehicle on the simply supported bridge in both tabular and chart format.

***To access copies of the final report, visit:*** ***www.dot.state.oh.us/research***

*This research was sponsored by the Ohio Department of Transportation, and the Federal Highway Administration.*

# Ohio Department of Transportation Research Project Fact Sheet

## RESEARCH APPROACH

- Verify the accuracy of AD-BOX using independent hand calculations and assess its reliability by comparing it with AASHTOWare BrR for 18 sample bridges located in Ohio (Table 1).

*Table 1 Verification of AD-BOX with independent hand calculations and AASHTOWare BrR for the design vehicle HL-93 (Inventory).*

| Non-Skewed Bridges | | | | | |
|---|---|---|---|---|---|
| No. | AD-BOX(a) | Hand calcs. (b) | Ratio (a/b) | BrR (c) | Ratio (a/c) |
| **Single-cell Box Beam Bridges** | | | | | |
| 1 | 1.703 | 1.703 | 1.000 | 1.645 | 1.035 |
| 2 | 1.546 | 1.546 | 1.000 | 1.546 | 1.000 |
| 3 | 1.036 | 1.036 | 1.000 | 1.039 | 0.997 |
| 4 | 2.258 | 2.258 | 1.000 | 2.275 | 0.993 |
| 5 | 1.495 | 1.495 | 1.000 | 1.434 | 1.043 |
| 6 | 1.183 | 1.183 | 1.000 | 1.189 | 0.995 |
| 7 | 1.395 | 1.395 | 1.000 | 1.392 | 1.002 |
| | | **Mean** | **1.000** | | **1.009** |
| | | **CV** | **0.01%** | | **2.05%** |

| Skewed Bridges | | | | | |
|---|---|---|---|---|---|
| No. | AD-BOX(a) | Hand calcs. (b) | Ratio (a/b) | BrR (c) | Ratio (a/c) |
| **Single-cell Box Beam Bridges** | | | | | |
| 8 | 1.639 | 1.639 | 1.000 | 1.655 | 0.990 |
| 9 | 1.004 | 1.003 | 1.001 | 0.999 | 1.005 |
| 10 | 1.004 | 1.003 | 1.001 | 1.004 | 1.000 |
| 11 | 0.341 | 0.341 | 1.000 | 0.361 | 0.945 |
| 12 | 1.718 | 1.718 | 1.000 | 1.632 | 1.053 |
| 13 | 3.473 | 3.473 | 1.000 | 3.541 | 0.981 |
| 14 | 3.314 | 3.313 | 1.000 | 3.271 | 1.013 |
| 15 | 2.032 | 2.032 | 1.000 | 1.950 | 1.042 |
| 16 | 1.001 | 1.002 | 0.999 | 1.057 | 0.947 |
| | | **Mean** | **1.000** | | **0.997** |
| | | **CV** | **0.01%** | | **3.72%** |
| **Multicell Box Beam Bridges** | | | | | |
| 17 | 1.159 | 1.158 | 1.000 | 1.191 | 0.973 |
| 18 | 1.428 | 1.428 | 1.000 | 1.492 | 0.957 |
| | | **Mean** | **1.000** | | **0.965** |
| | | **CV** | **0.03%** | | **1.17%** |

- A mean of approximately 1.0 with a coefficient of variation (CV) of nearly equal to 0% for the rating factor (RF) ratios of AD-BOX divided by hand calculations confirms the accuracy of AD-BOX.
- A mean of approximately 1.0 with a CV of up to 3.72% for RF ratios of AD-BOX divided by BrR confirms the reliability of AD-BOX.

## RESEARCH FINDINGS AND RECOMMENDATIONS

- A computer tool named 'AD-BOX,' is developed using VBA and is included in a user-friendly Microsoft Excel spreadsheet to reduce the cost and time required for learning sophisticated software.
- AD-BOX can load rate 15 vehicle types as required by ODOT BDM, including permit vehicles and a custom vehicle with up to 35 axles.
- AD-BOX provides more accurate load rating factors, obtained by the calculation of maximum moment and shear at the exact location on the bridge rather than using the conventional one-tenth-of-the-span method (Figure 3).
- AD-BOX contains the capability to load rate the older box beam sections with multicell configurations.
- AD-BOX contains an optional tab to generate moment and shear envelopes due to the selected vehicle type on any single span simply supported bridges to use in independent analysis.
- AD-BOX facilitates learning the load rating process and making more accurate decisions.

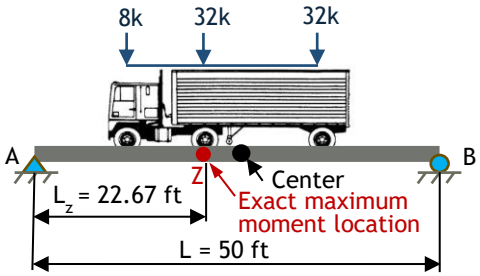


*Figure 3 Location for the maximum moment due to HL-93 truck on a bridge.*

## RESEARCH BENEFITS

- Simple and user-friendly interface for both input and output.
- Entire load rating process in less than thirty minutes.
- Load rating of longer vehicles with axles extending beyond the bridge span.
- Moment and shear envelopes in both tabular and chart formats.
- Error and warning messages to reduce the likelihood of input errors.

***To access copies of the final report, visit:*** ***www.dot.state.oh.us/research***

*This research was sponsored by the Ohio Department of Transportation, and the Federal Highway Administration.*