Innovative Evaluation of Precast Prestressed Adjacent Box Beam Bridges (Computer Tool: AD-BOX)
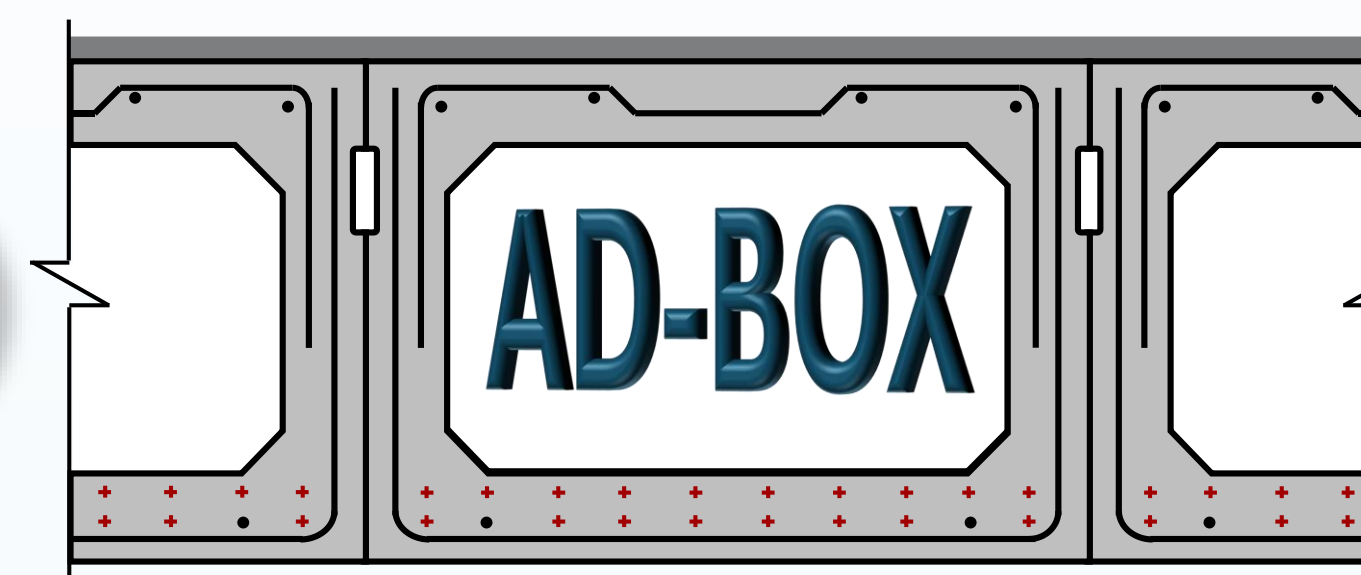
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AD-BOX

Problem Statement

Given the lack of automated tools for load rating, there is a need for a user-friendly tool to load rate simply supported precast prestressed adjacent box beam bridges (Figure 1), reducing labor-intensive calculations according to AASHTO LRFD Bridge Design Specifications, 10th edition (LRFD, 2024), AASHTO Manual for Bridge Evaluation (MBE, 2018), and ODOT Bridge Design Manual (BDM, 2020).
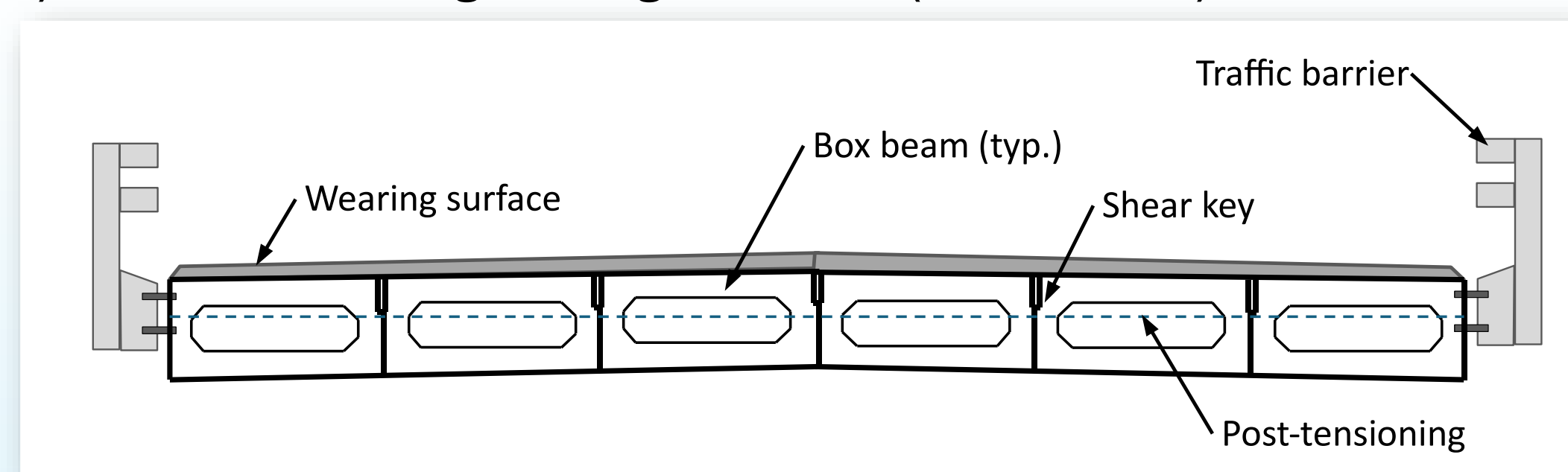

Figure 1 Typical cross-section of an adjacent box beam bridge.

Research Objective

- To develop an innovative computer tool for the evaluation of precast, prestressed adjacent box beam bridges.
- **'AD-BOX,'** which stands for **Ad**jacent **Box** Beam Bridge Analysis and Rating, has been developed to achieve this objective.

AD-BOX Features

✓ AD-BOX is developed using Visual Basic for Applications (VBA) and included in an MS Excel spreadsheet, to reduce the cost and time required for learning sophisticated software.

✓ AD-BOX is automated with approximately 3,000 lines of VBA coding.

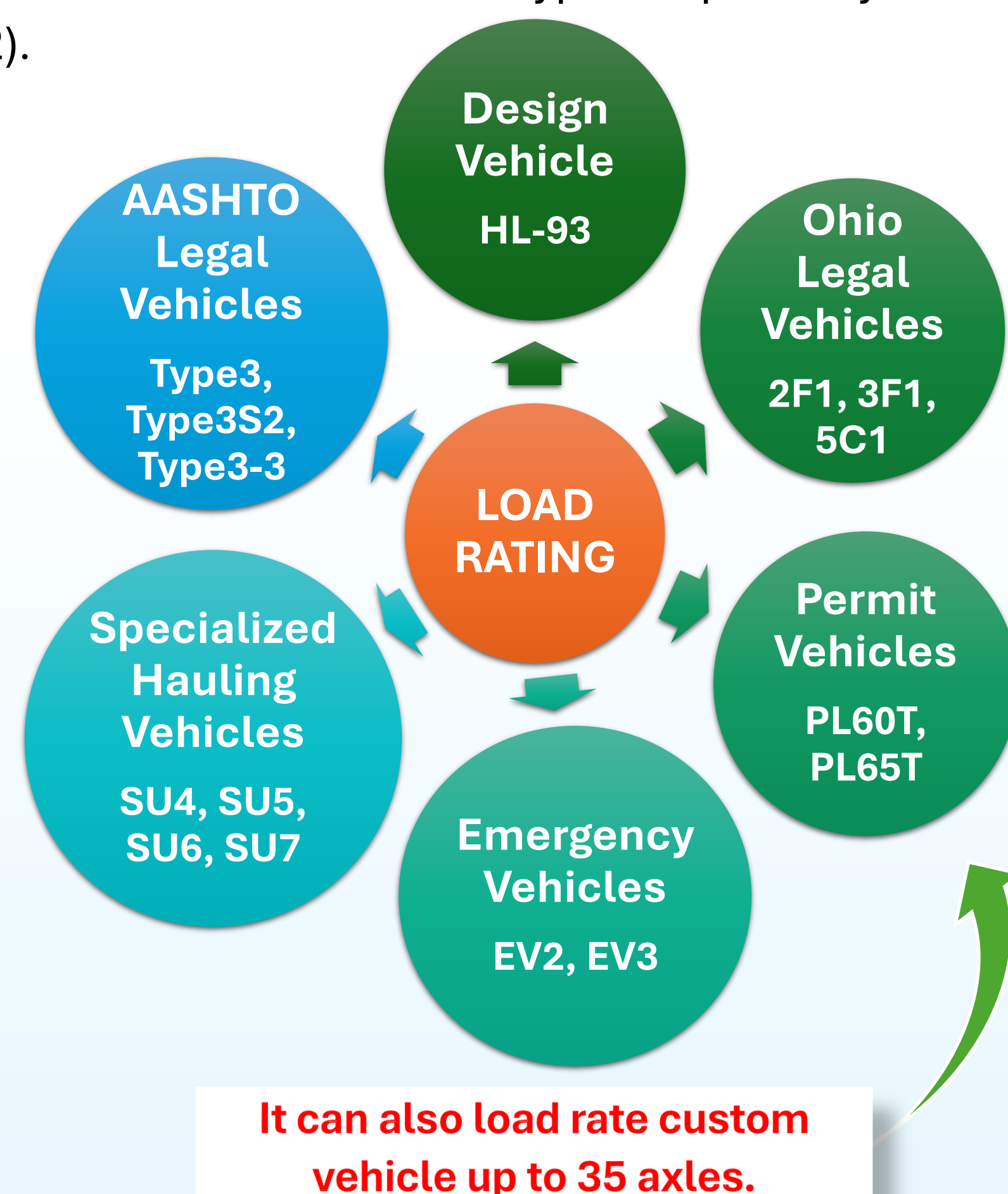✓ AD-BOX can load rate 15 vehicle types required by ODOT BDM (Figure 2).

It can also load rate custom vehicle up to 35 axles.

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

AD-BOX Features

✓ AD-BOX has simple and user-friendly interface for both input and output.

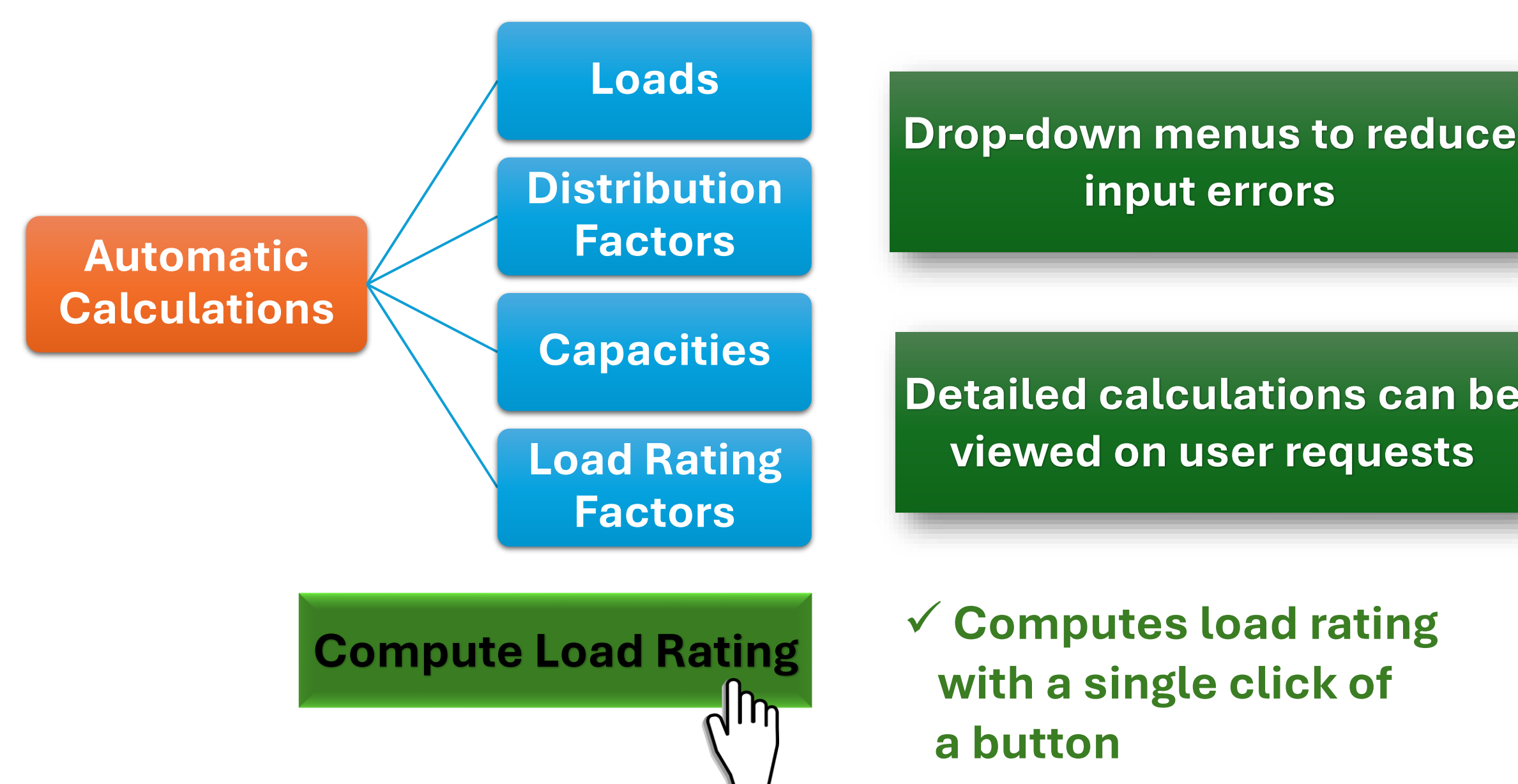✓ AD-BOX can handle rigorous calculations automatically (Figure 3).

Figure 3 Automatic calculations performed by AD-BOX.

✓ 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 4).
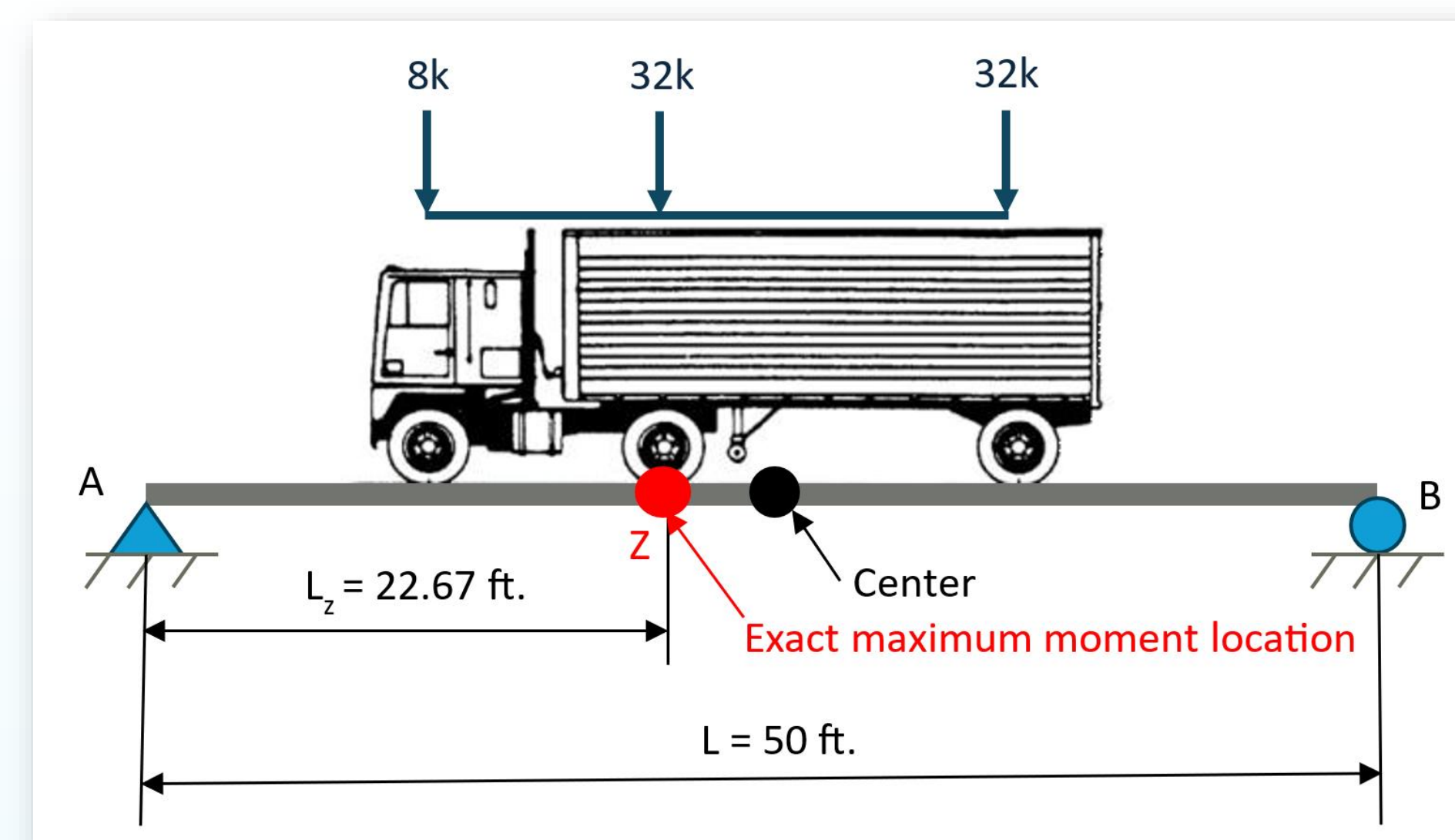

Figure 4 Location for maximum moment due to HL-93 truck on a bridge.

✓ 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. (Figure 5).
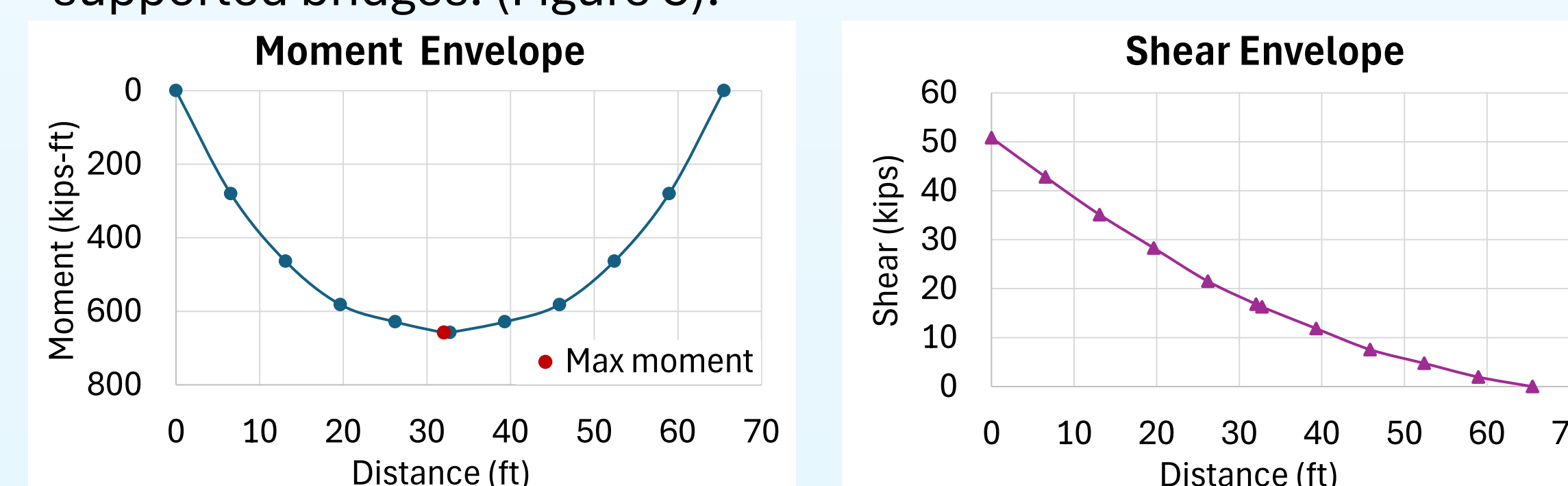

Figure 5 Sample of moment and shear envelopes in AD-BOX.

Verification of AD-BOX

- AD-BOX is verified using independent hand calculations and compared with AASHTOWare BrR for 18 sample bridges located in Ohio to check its accuracy and reliability.

Table 1 Verification of AD-BOX 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.

Conclusions

- An **accurate and reliable** computer tool, 'AD-BOX,' is developed for the load rating of adjacent box beam bridges.
- AD-BOX is **simpler and more user-friendly** than currently available load rating tools.
- AD-BOX can load rate 15 vehicle types as required by ODOT BDM, including permit vehicles.
- AD-BOX can also load rate **custom vehicles** with up to 35 axles, which cannot be easily performed with other available tools.
- AD-BOX can generate **moment and shear envelopes** for the selected vehicle type on any single span simply supported bridges.

Acknowledgments

dot transportation.ohio.gov
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