ADDRESSING THE CHALLENGES OF LOAD RATING SMALL OFF-SYSTEM BRIDGES WITH NO PLANS:

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Presentation Outline

➤ Project Background

➤ Testing Program – Bridge Selection

➤ Testing Program – Overview & Goals

➤ Testing Procedures & Results

➤ Field-Verified Model Calibration Procedures & Results

➤ AASHTOware BrR Model Conversion

➤ Load Rating Procedures & Results

➤ Summary of Results

PROJECT BACKGROUND

➢ ITD oversees ~2,500 off-system bridges
  ➢ Many not designed according to AASHTO
  ➢ Many without plans
    ➢ Many unknowns (structure age, salvaged materials, creative designs)
➢ Typical ITD procedure for these structures
  ➢ Ratings by Engineering Judgement
  ➢ Evaluate based on field sketches and AASHTOware BrR software
    ➢ Overly conservative assumptions
    ➢ Often no composite action can be assumed

PROJECT BACKGROUND

Why ITD selected load testing for analysis refinement:

➢ Provide reconciliation of "model world" results with "real world" experience

 ➢ Bridges with NBI condition 6 or more were requiring posting.

➢ Verify assumptions

 ➢ Composite action? Uneven load distribution?

➢ Obtain fully-calibrated model for structure

 ➢ Use/adjust when condition changes (wearing surface, deterioration, etc.)

➢ Use test data to extrapolate to similar structures

TESTING PROGRAM – BRIDGE SELECTION

➢ Six Bridges were selected so far based on the following criteria:

   ➢ Major/only economic route (logging, agriculture, etc.) in area

   ➢ Bridge performance / load rating mismatch

      ➢ NBI Superstructure rating of 6 or higher (5 of 6 bridges)

      ➢ Conservative assumptions may be causing bridge posting and/or overly restrictive posting limits.

   ➢ Likelihood of load testing benefiting structure's load rating

      ➢ Effect of Composite Action

      ➢ Redundant structure w/ possible improved distribution

Testing Program – Bridge Selection

Bridge Key	Superstructure Type	LS Bridge (Yes/No)	Other Notes	Primary Question/Verification
23373	Steel Multi Girder	Yes	30° skew	Composite action w/ deck Lateral distribution
24345	Steel Girder/Stringer	Yes	Short-span w/ significant member size difference, 10° skew	Lateral distribution / Relative member behavior (girder/stringer)
24931	Slab w/ Exposed ASCE Rail Reinforcement	Yes	Unique hybrid of beam/slab design, 25° skew	Lateral distribution / overall behavior
25085	Slab w/ Exposed ASCE Rail Reinforcement	Yes	Unique hybrid of beam/slab design	Lateral distribution / overall behavior
29385	Two Steel Girder	No	Fracture critical / Long span	Composite action w/ deck
31205	Steel Multi Girder	Yes	Embedded top flanges / 30° skew	Composite action w/ deck

"LS bridge" – Locally sourced structure not likely designed according to AASHTO

TESTING PROGRAM OVERVIEW

OVERALL GOAL: Provide refined load ratings through a better understanding of the structure's live-load behavior, including a field-verified BrR model for future use.

CAPTURE LIVE-LOAD BEHAVIOR: Controlled diagnostic live-load testing (LLT)

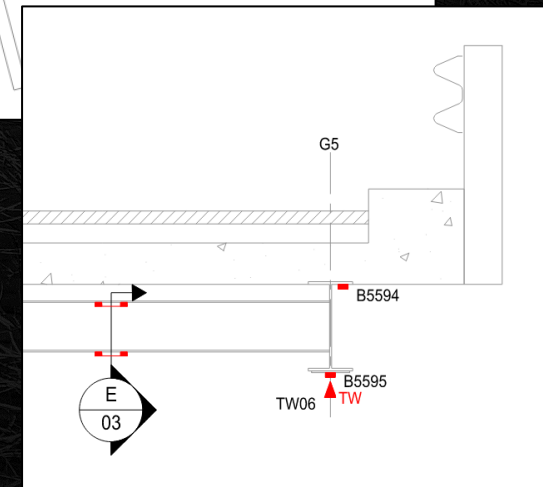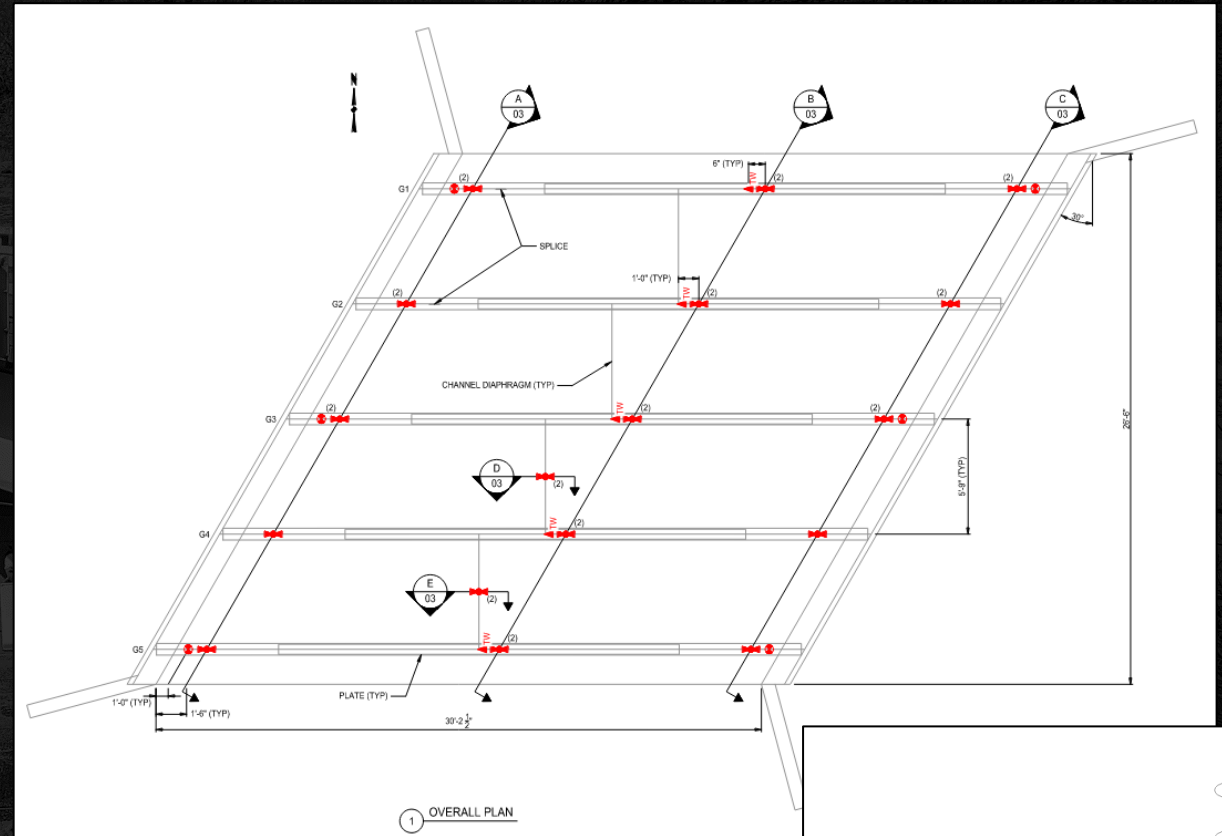CREATE FIELD-VERIFIED PLANAR FEM: LLT based FEM Model calibration

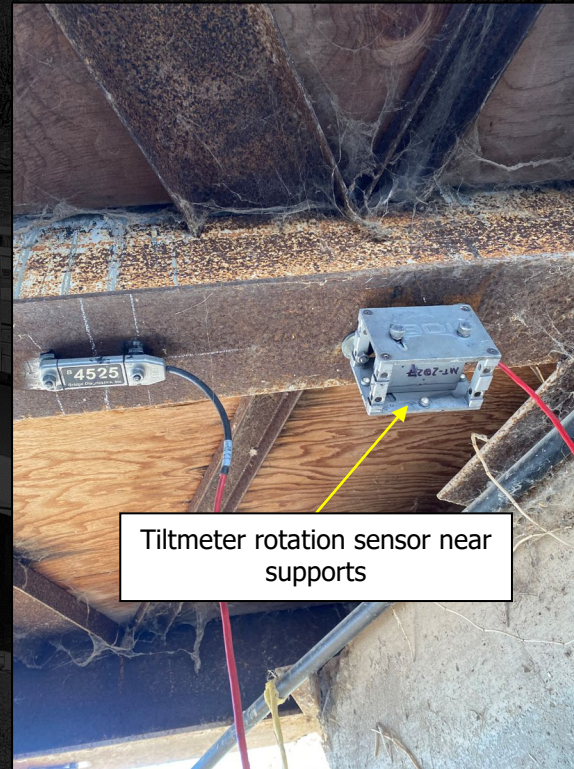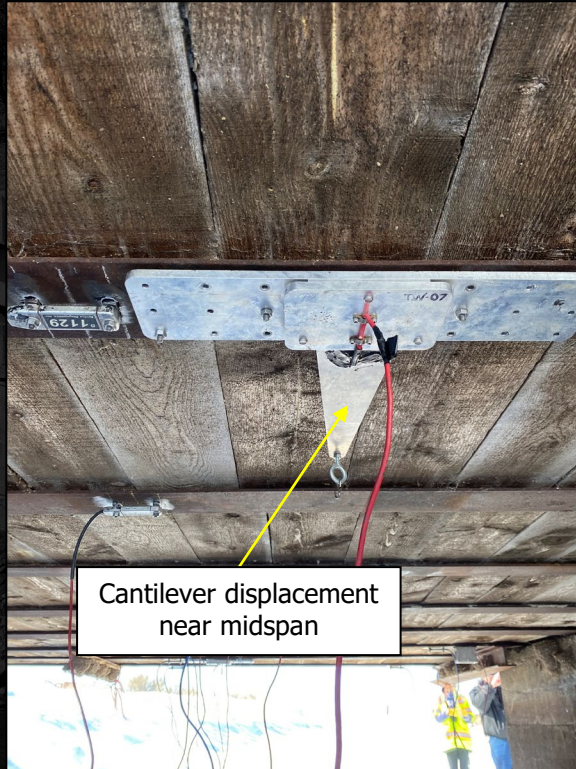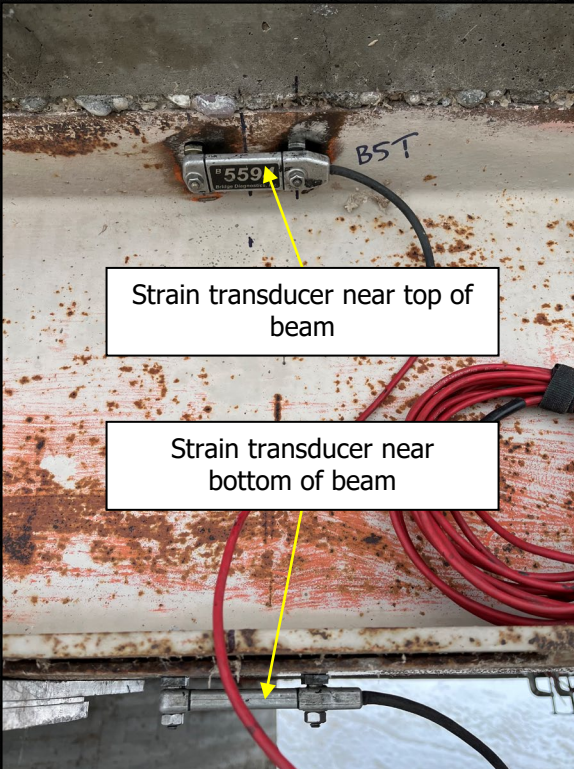FIELD-VERIFIED BrR MODEL: Revised AASHTOware BrR model of ITD's use
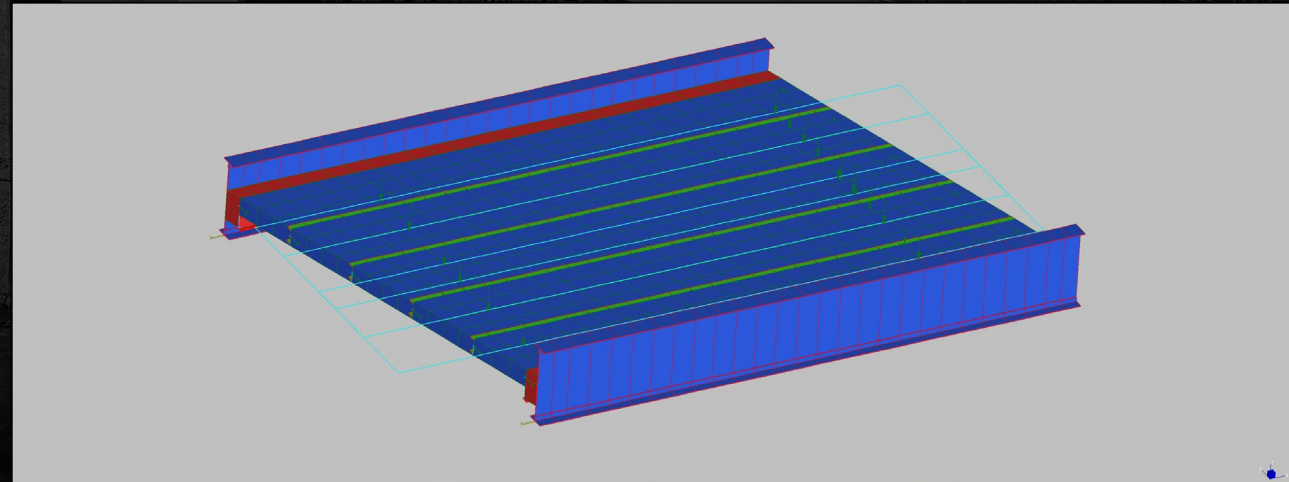
LLT Procedures – Instrumentation Setup

- Distributed gage plan

- Gage lines setup to capture lateral distribution

- Multiple gages per cross-section (N.A.)

- Both local and global measurements (Strain / Displacement/Rotation)
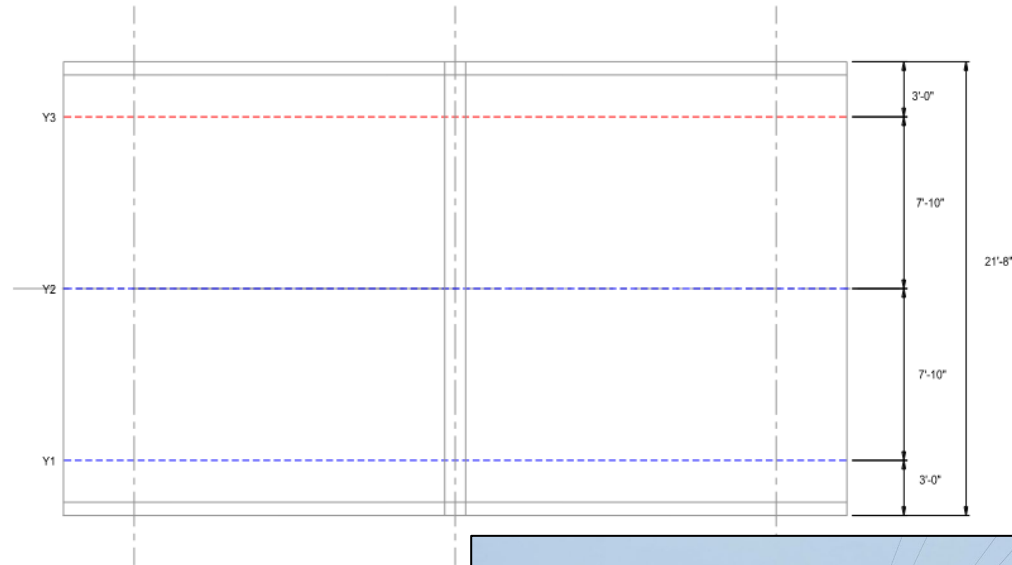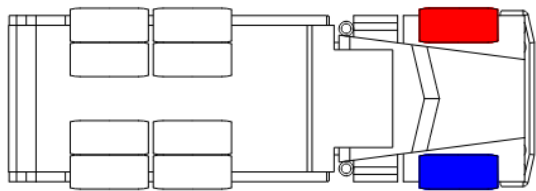
- Secondary elements instrumented where appropriate

LLT Procedures – Hardware Description

Strain transducer near top of beam

Strain transducer near bottom of beam

Cantilever displacement near midspan

Tiltmeter rotation sensor near supports

Sensors connected to wireless DAQ Nodes

Load position sensor

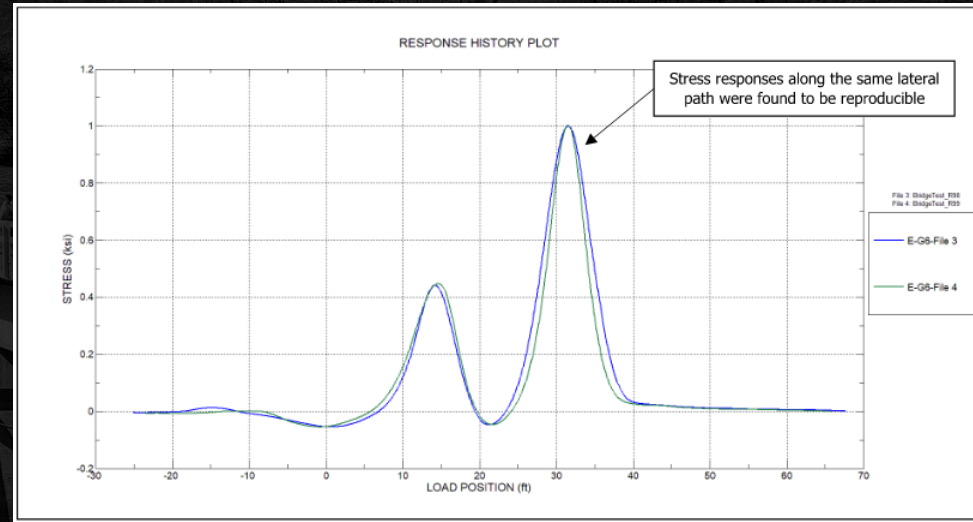➢ Continuous Data Collection (50 Hz)

➢ Symmetric Load paths (behavior symmetry)

➢ Multiple tests along each path (Reproducibility)

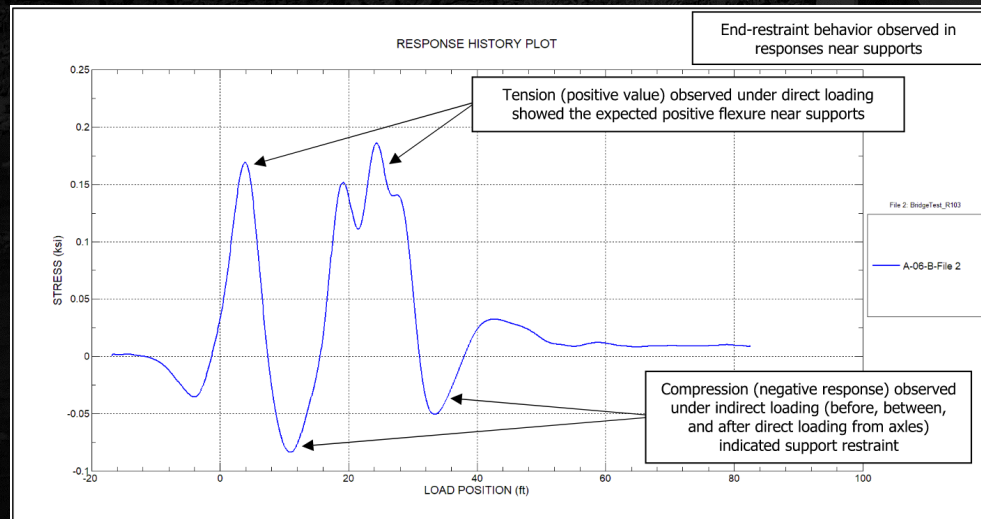Data Quality Review
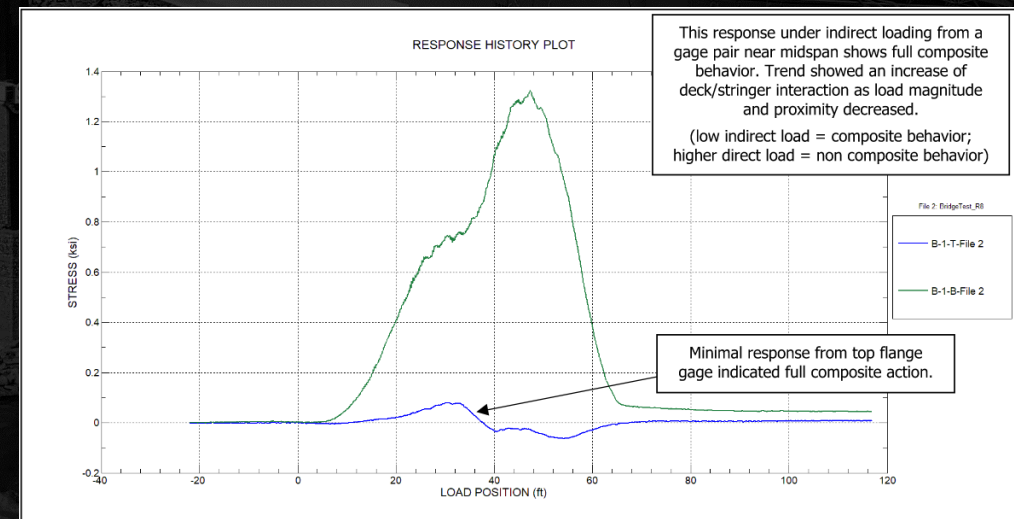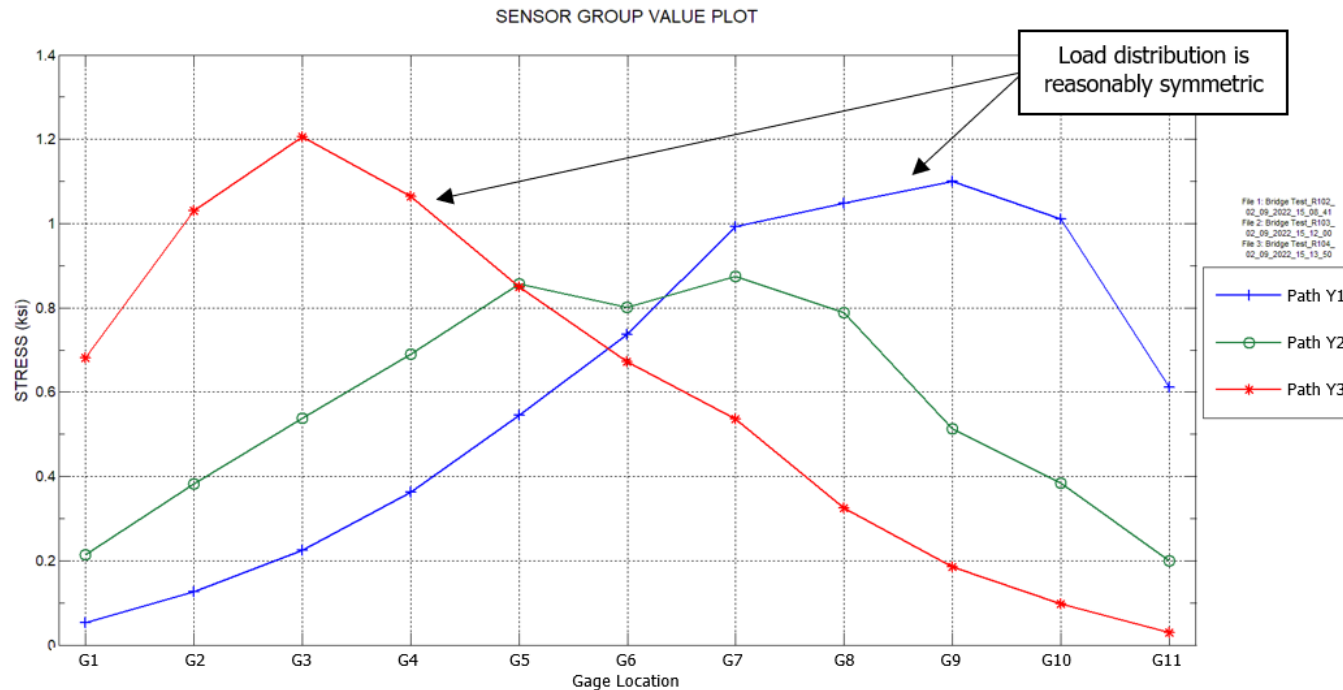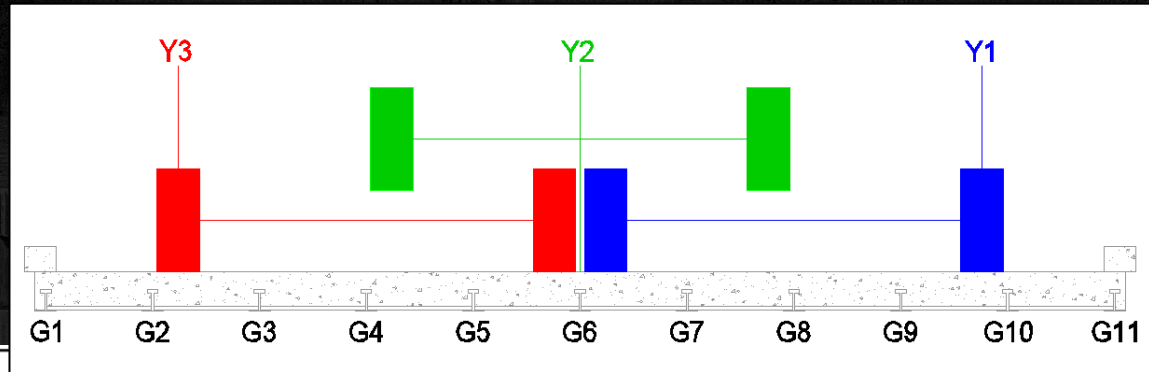

Evaluation of Support Behavior
(Strain Response near Support)

Evaluation at Peak Response Location
(Strain Response near Midspan)

Lateral Load Distribution

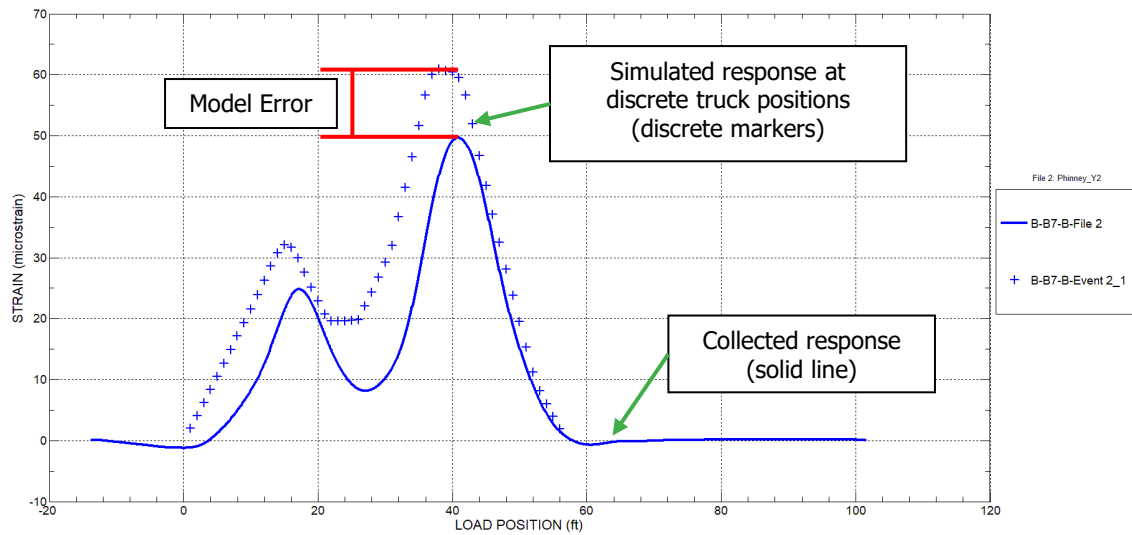# FIELD-VERIFIED MODEL CALIBRATION PROCEDURES

➢ **Create initial FEM** (design assumptions & data review conclusions)

➢ **Simulate LLT** using BDI's MORF software (Gages & Load Paths)

➢ **General model validation**

➢ **Adjust model parameters** until measured and simulated responses match to an acceptable level

Secondary Member Effects

Beam Stiffness

Deck Stiffness

Eccentricities

End Restraint
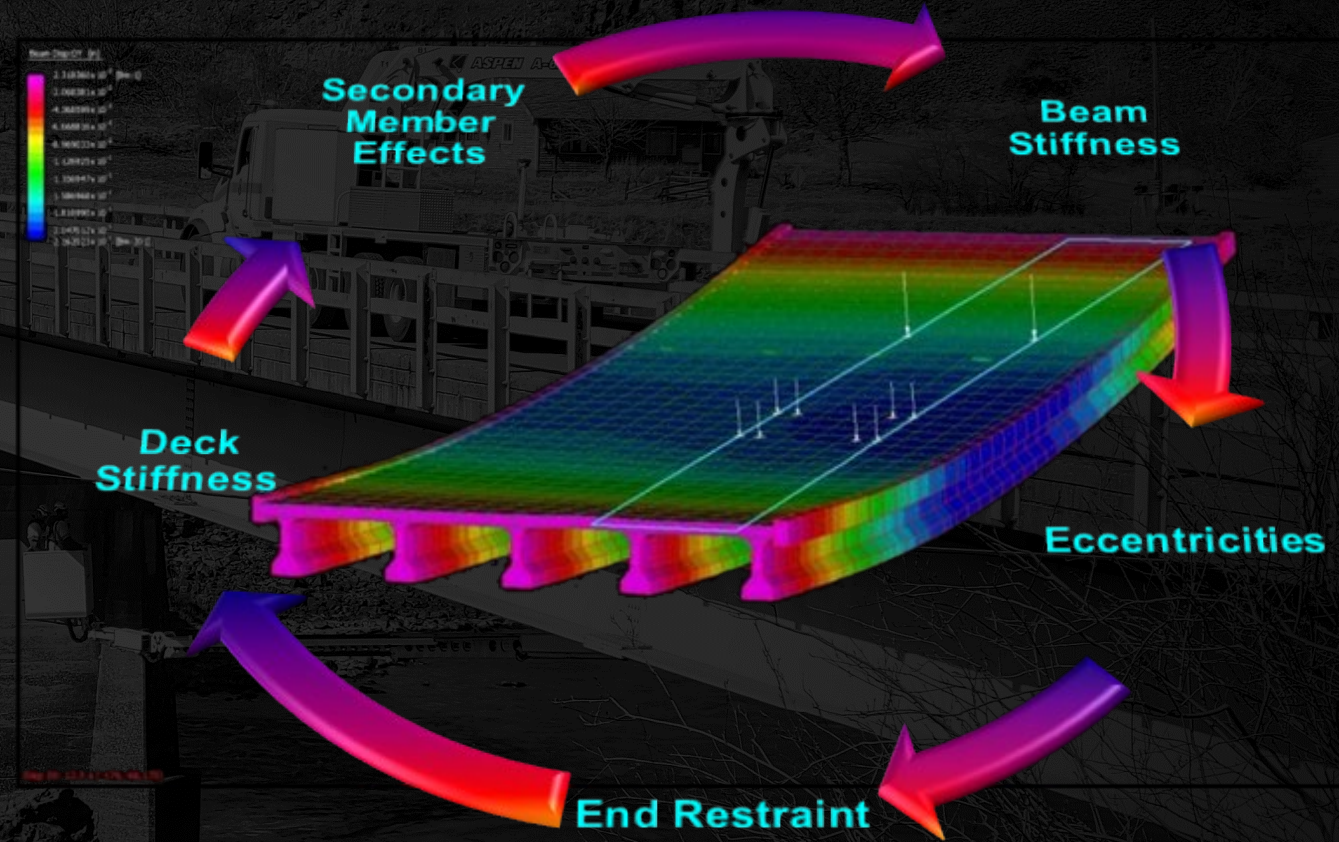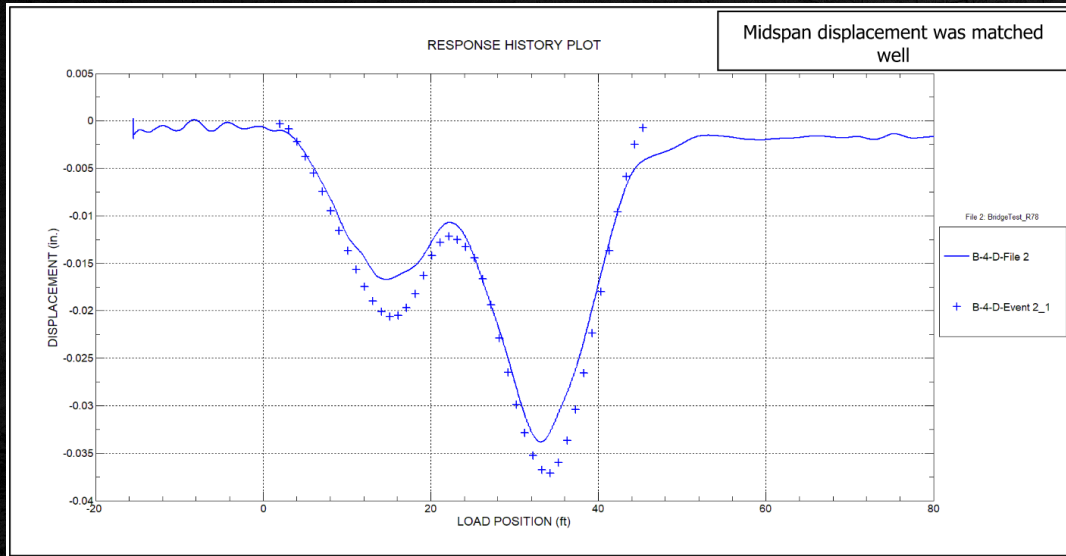
FIELD-VERIFIED MODEL CALIBRATION PROCEDURES

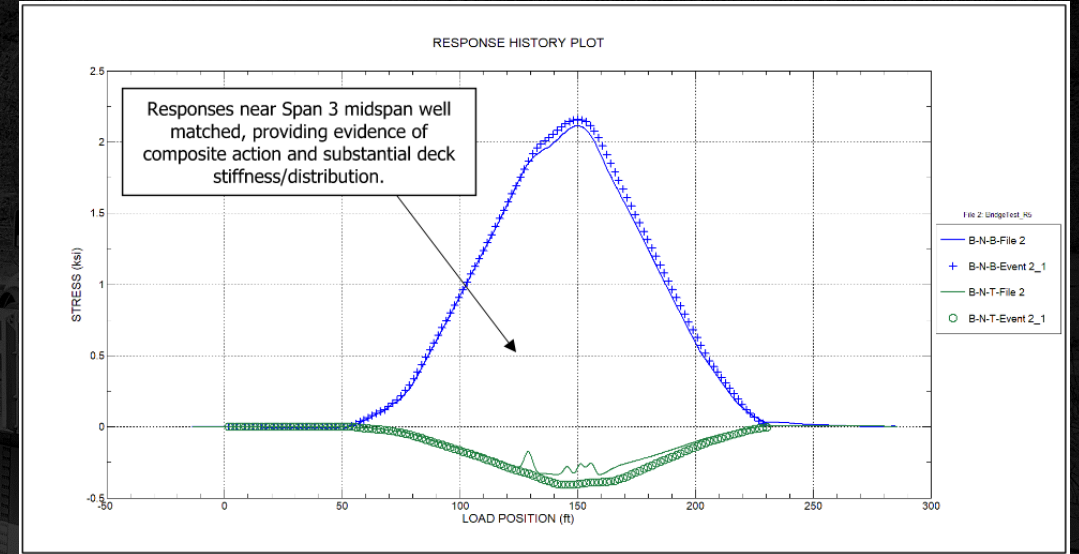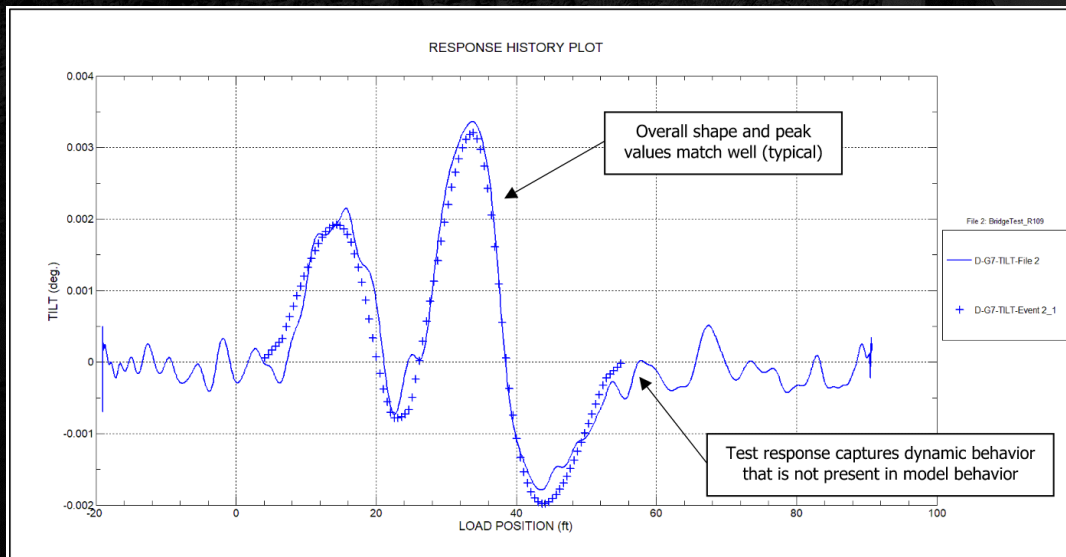Initial Response Comparison
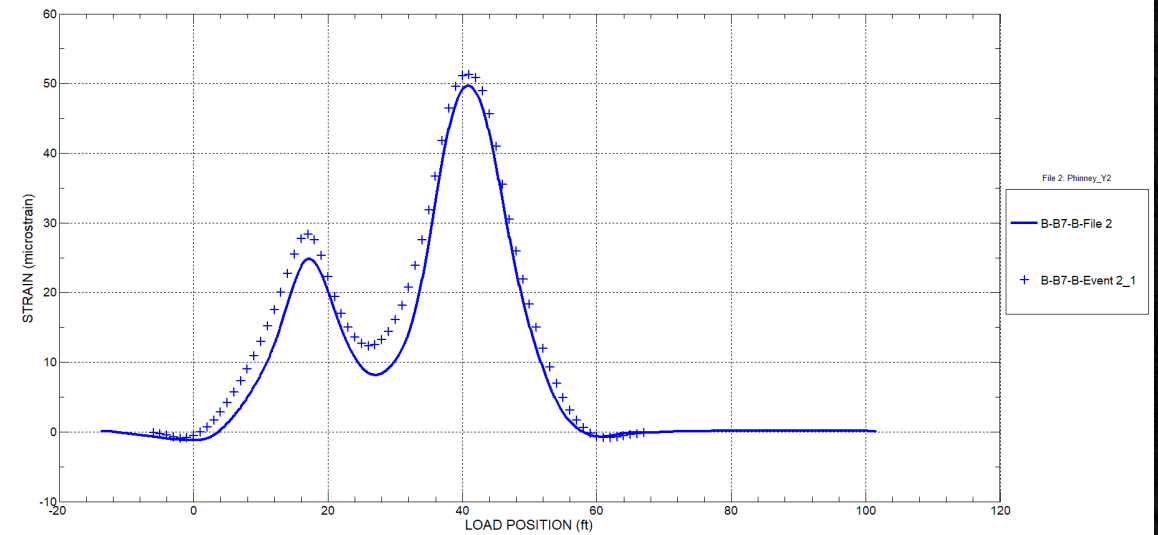
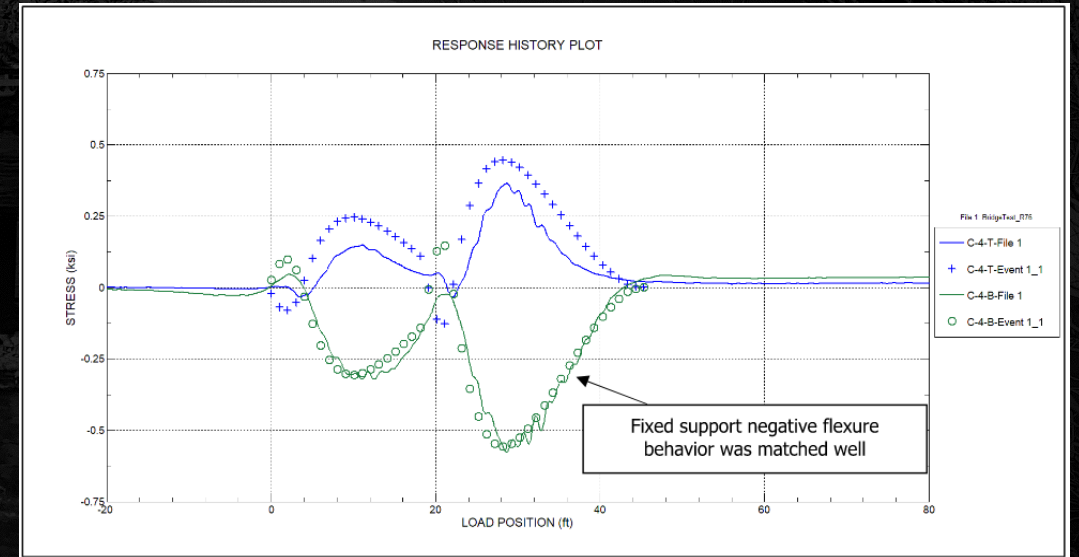Final Response Comparison

FIELD-VERIFIED MODEL CALIBRATION RESULTS
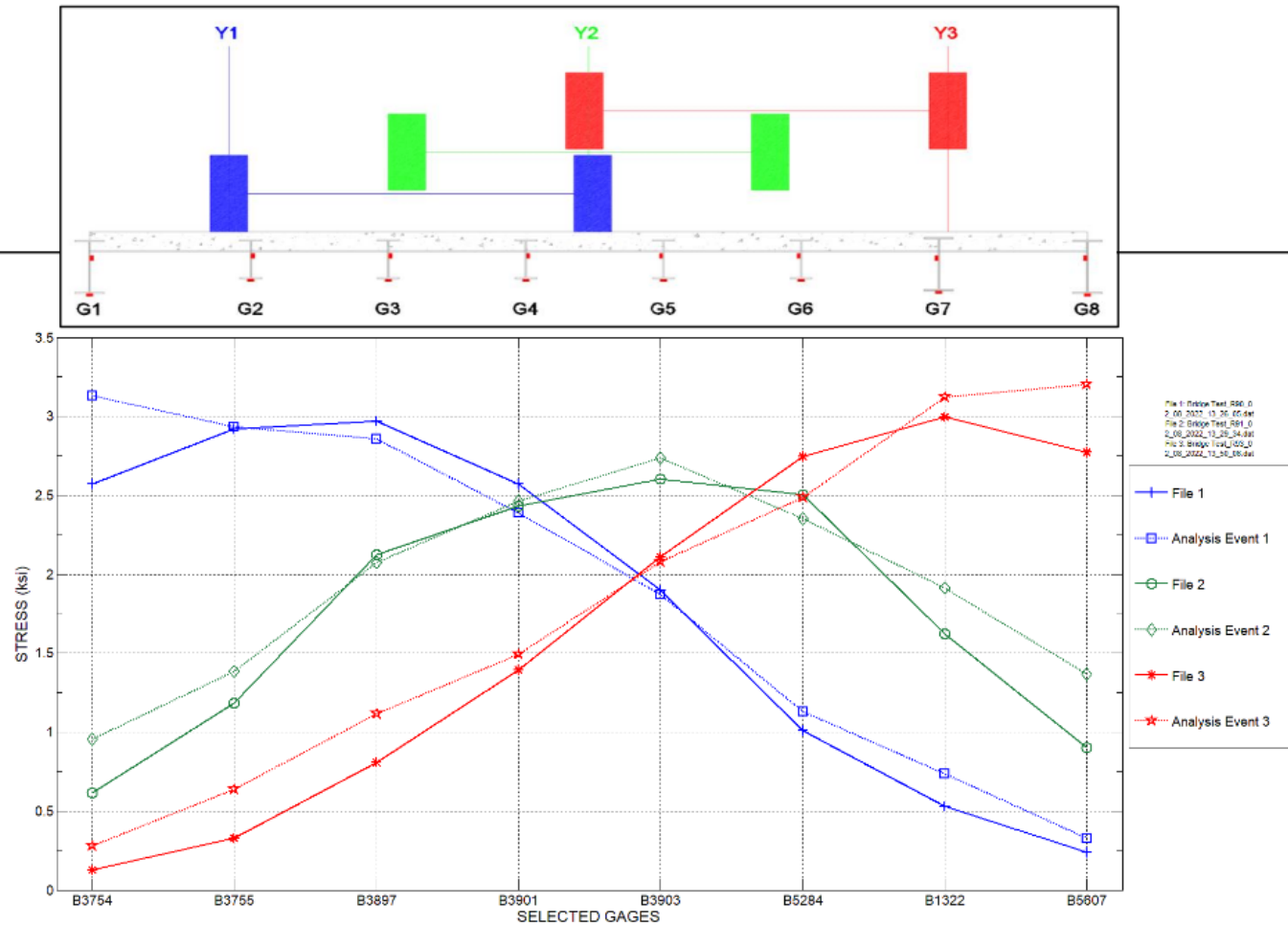

Displacement Comparison

Midspan Strain Comparison

Rotation Comparison

Strain Comparison near Support

Lateral Load Distribution Comparison

LOAD RATING SETUP / RESULTS

Before using the calibrated model for load rating, it was reviewed to ensure the reliability of all optimized model parameters.

The following model parameters were typically adjusted/considered:

➢ Beam fixity/composite action

➢ Reliability of secondary member participation/deck stiffness

➢ Appropriate dead load model adjustments

Bridge Key	Superstructure Type	Primary Question/Verification	Other Notes	Rating Improved?
23373	Steel Multi Girder	Composite Action Verified	Improved distribution due to skew	Improved Posting Limits (SHV & Permit still deficient)
24345	Steel Girder/Stringer	Exterior Girders Carry Majority of Load	Non-composite behavior (majority of sections)	No Posting Required
24931	Slab w/ Exposed ASCE Rail Reinforcement	Behaved like a slab	Unique capacity (compression controlled) forced use of ASR	No Posting Required
25085	Slab w/ Exposed ASCE Rail Reinforcement	Behaved like a slab	Unique capacity (compression controlled) forced use of ASR	No Posting Required
29385	Two Steel Girder	Composite Action Verified	Improved Distribution (distribution of deck and curb above)	No Posting Required
31205	Steel Multi Girder	Non-composite Behavior	Improved distribution	Posting Required

FIELD-VERIFIED BRR MODEL

Field-verified planar models were used to create refined AASHTOware BrR model for ITD future use

DF Evaluation: Beam-line vs Field-verified Load Rating Models

Support Evaluation: Verification of Reliability / Comparison

With Simply-Supported and Fixed Support models

Table 5 – Controlling bridge distribution factors – Single Lane – Flexure

| SECTION ID | SECTION TYPE | CONTROLLING SINGLE-LANE DISTRIBUTION FACTORS (WHEELS) | | CONTROLLING FIELD-VERIFIED DF | AASHTO LFD SINGLE LANE DISTRIBUTION FACTORS |
| | | BEAM LINE MODEL | RATING MODEL | | |
		PEAK HS20 POSITIVE MOMENT, (KIP-IN)	PEAK HS20 POSITIVE MOMENT, (KIP-IN)		
G1	W16x36	3,324.77	809.3	0.493	0.464
G2	S12x40.8	3,324.77	471.0	0.285	0.429
G3-G6	S12x40.8	3,324.77	407.2	0.249	0.393
G7	W16x36	3,324.77	718.6	0.433	0.411
G8	W16x36	3,324.77	702.9	0.424	0.429

ITD's Result Utilization

Five of Six bridges were able to see some improvement in their condition

- ➤ 29385 posting not needed (logging traffic can use)
- ➤ 23373 posting improved
- ➤ 24931, 25085, 24345 all recommended postings to be removed

Bridge Key	Superstructure Type	Primary Question/Verification	Other Notes	Posting Removed/Improved
23373	Steel Multi Girder	Composite Action Verified	Improved distribution due to skew	Slightly Improved Axle limit from 9 to 10 tons (SHV & Permit still deficient)
24345	Steel Girder/Stringer	Exterior Girders Carry Majority of Load	Non-composite behavior (majority of sections)	Existing posting could be removed
24931	Slab w/ Exposed ASCE Rail Reinforcement	Behaved like a slab	Unique capacity (compression controlled) forced use of ASR	No Posting Required
25085	Slab w/ Exposed ASCE Rail Reinforcement	Behaved like a slab	Unique capacity (compression controlled) forced use of ASR	No Posting Required
29385	Two Steel Girder	Composite Action Verified	Improved Distribution (distribution of deck and curb above)	No Posting Required
31205	Steel Multi Girder	Non-composite Behavior	Improved distribution	Posting Remains

SUMMARY OF RESULTS

OVERALL GOALS ACHIEVED:

➤ Established Field-Verified Behavior

➤ Created Load Rating BrR models

➤ Established refined load rating results per ITD BDM

➤ Adjusted posting based on results
  ➤ Most improved or removed

➤ Integrated field-verified BrR models into ITD BrR bridge system

THE END OF THE ROAD

QUESTIONS?