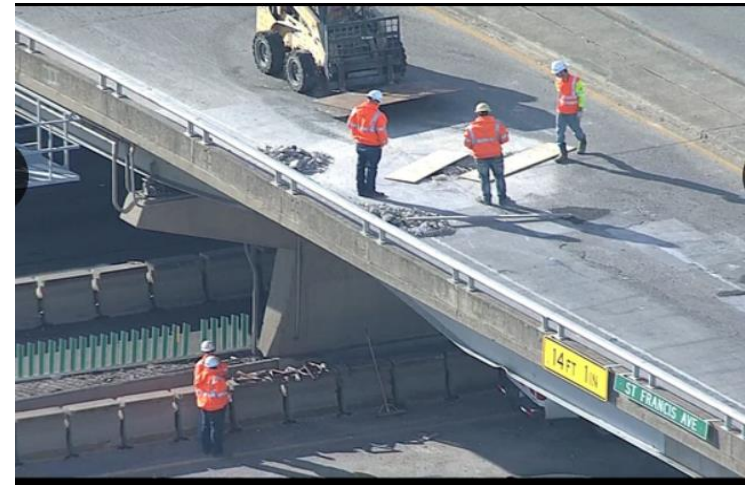




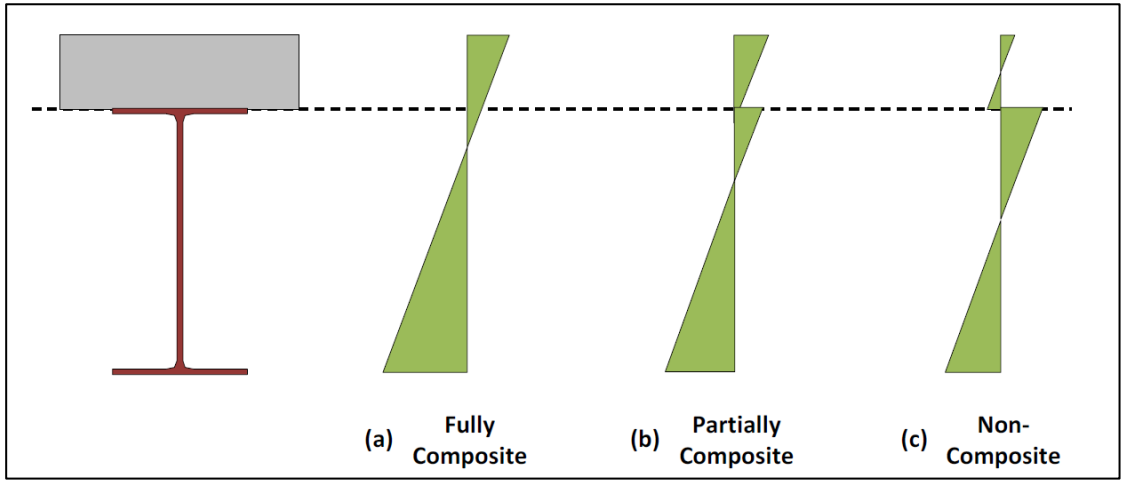
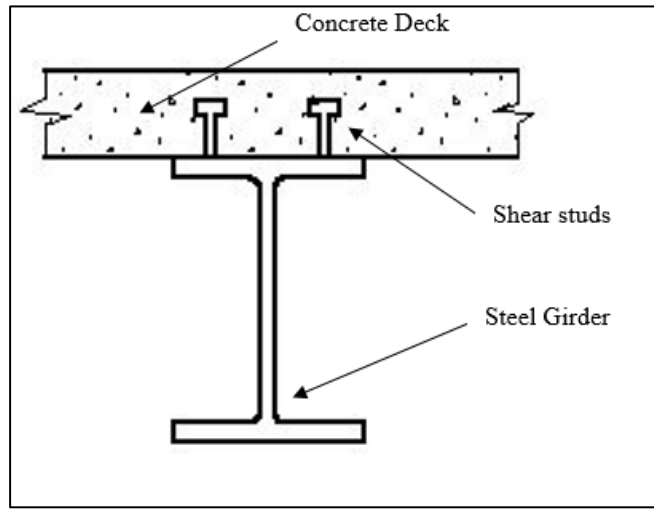
Performance Evaluation and Load Rating of Retrofitted Non-Composite Steel Girder Bridge Deck



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Dr. Eyosias Solomon Beneberu
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Introduction



Non-Composite Behavior



Composite Behavior

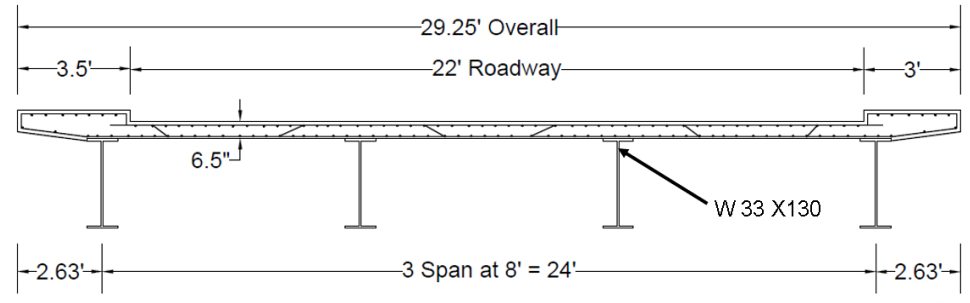
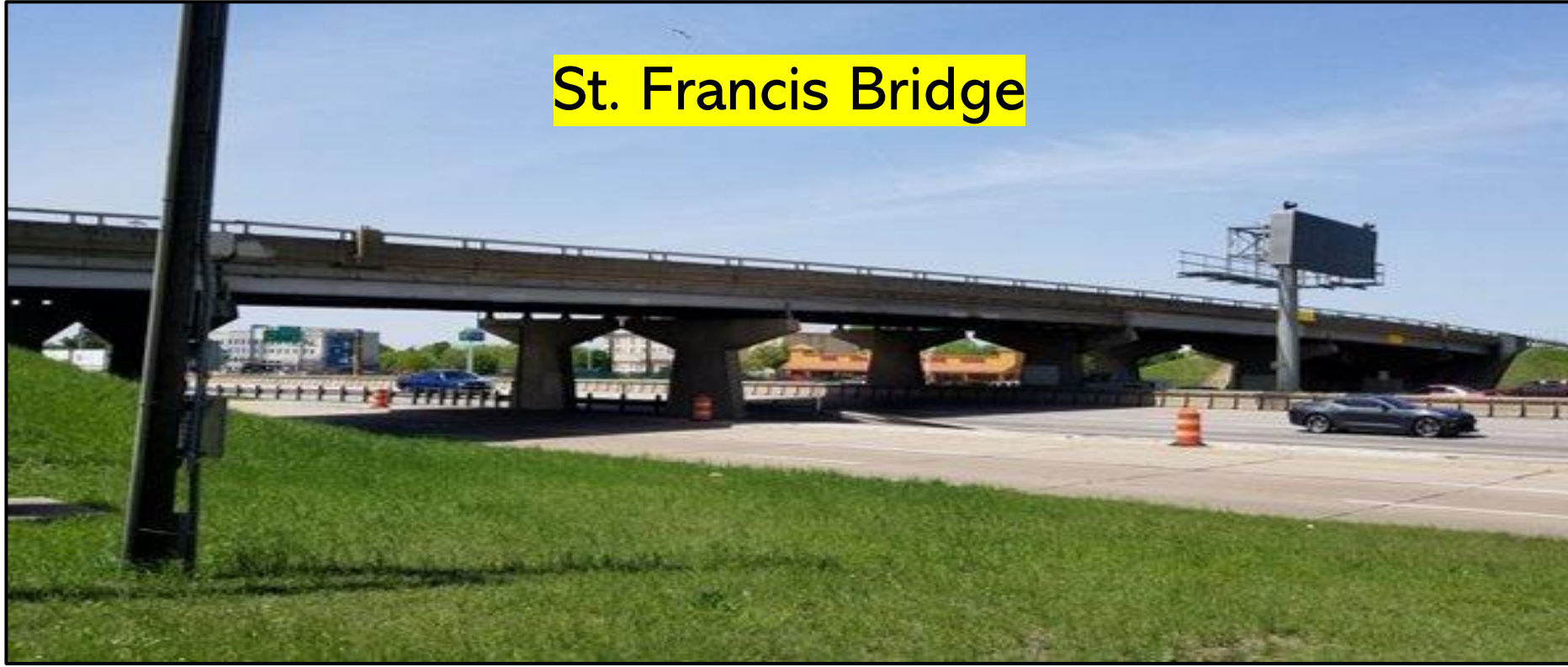
*(Kreitman, K., Reza, A., Azad, G., Patel, H., Engelhardt, M., Helwig, T., Williamson, E., Street, G., Engelhardt, M., & Klingner, R. (2016). "Strengthening Existing Continuous Non-Composite Steel Girder Bridges Using Post-Installed Shear Connectors. 7." FHWA.)





Description of the Bridge

St. Francis Bridge





Description of the Bridge

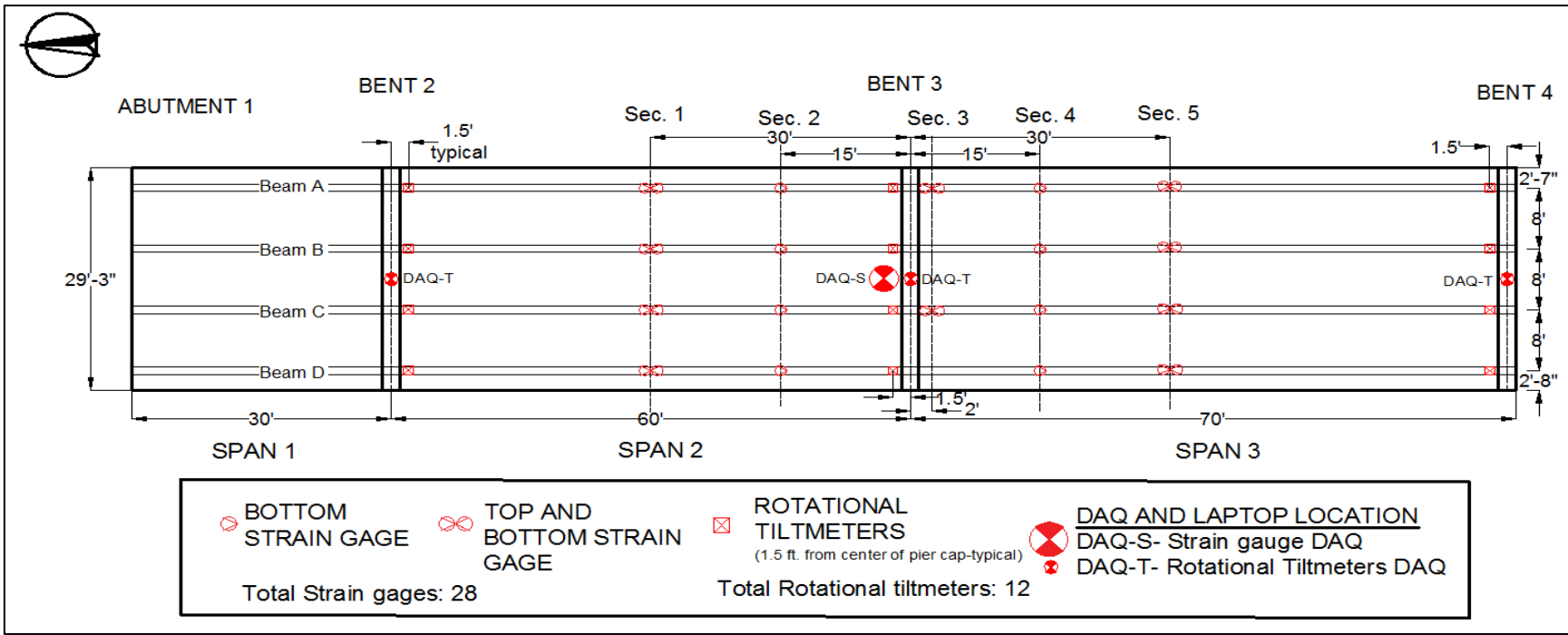
Impact Damage



- Evaluate the performance of an impact damaged bridge deck through non-destructive evaluation (NDE) and static load testing.
- Propose a distinct approach to load rate the non-composite concrete deck over steel girder bridges by incorporating NDE data in load rating procedure.
- Develop an advanced approach for load rating of non-composite bridge deck after retrofitting.

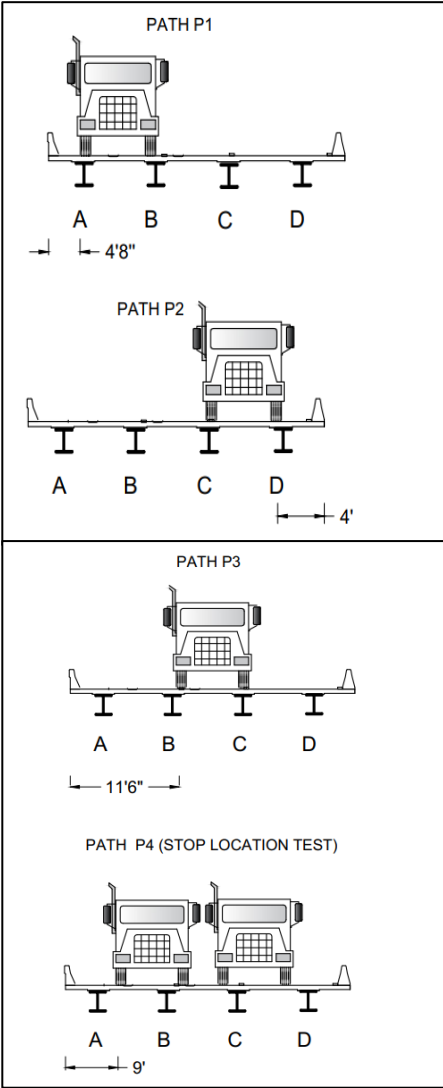


Instrumentation





Load Testing



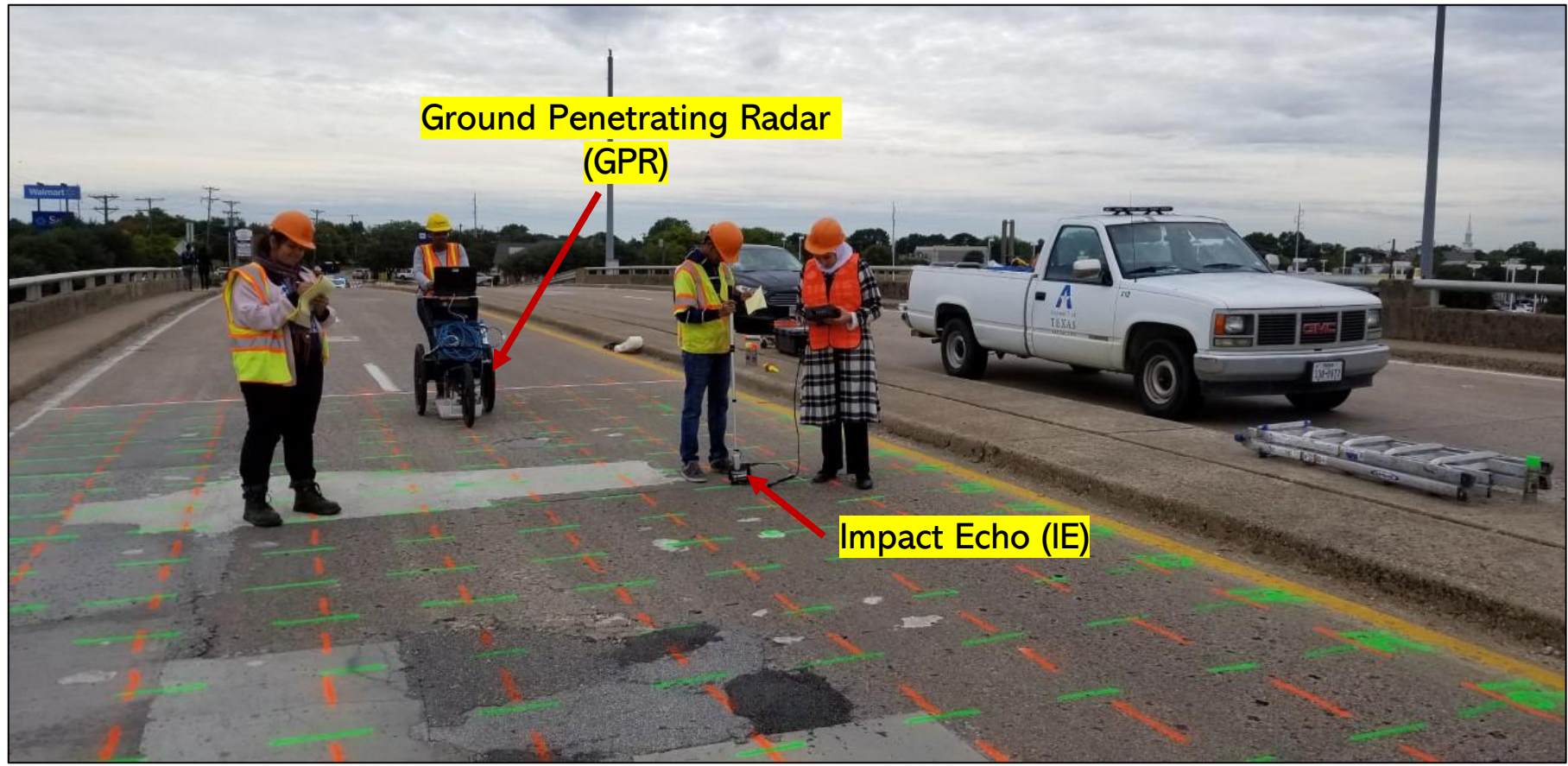
Test Paths



Dump Trucks



Non-Destructive Evaluation (NDE)

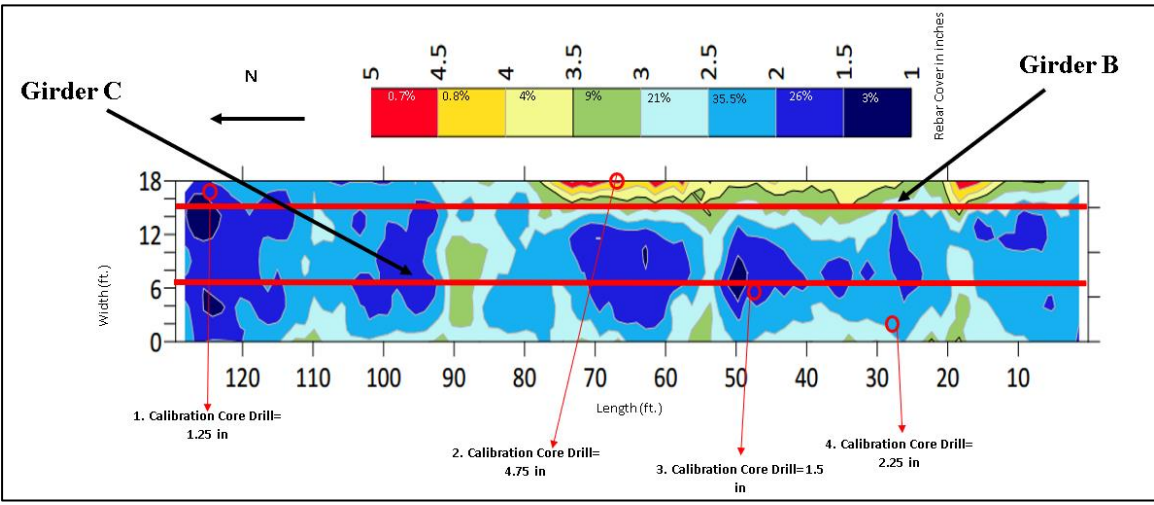


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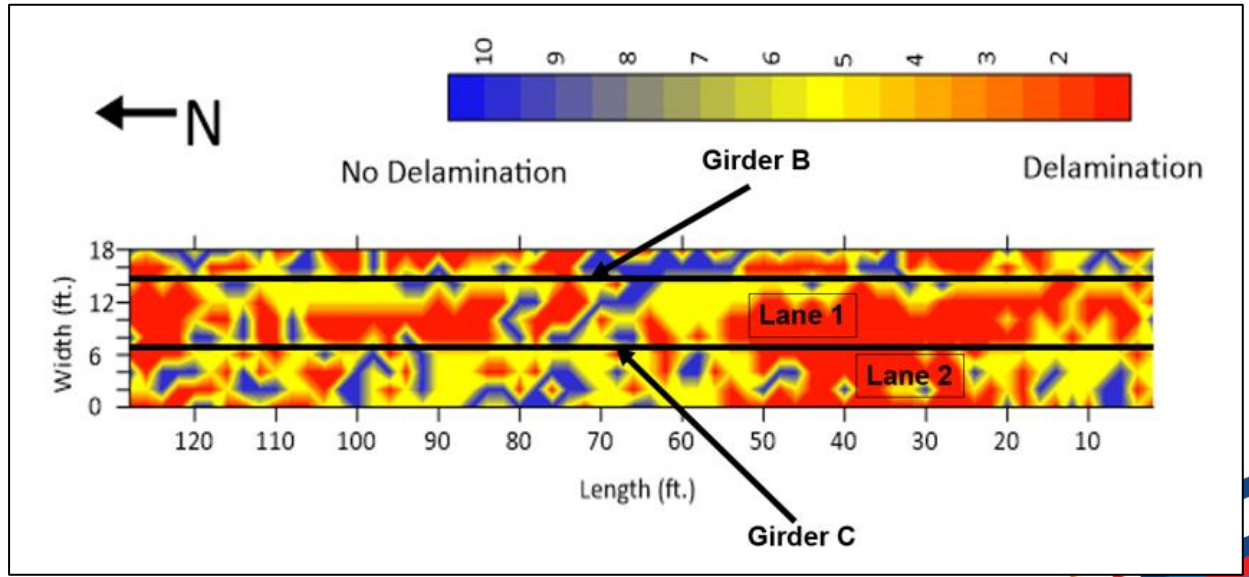


NDE Analysis



GPR Analysis

IE Analysis



Load Rating

Deck Rating

- GPR data was used to find the concrete cover and rebar spacing for the negative mild steel near the girder lines.
- From the Impact Eco (IE) data, the percentage delamination for both the negative and positive moment regions were found.

Rating Equation:

$$\text{Rating Factor, RF} = \frac{C - A_1 * D}{A_2 * (L + I)}$$

A_1 = Factor for dead loads

A_2 = Factor for live load

C = Capacity of the member

D = Dead loads

I = Impact loads

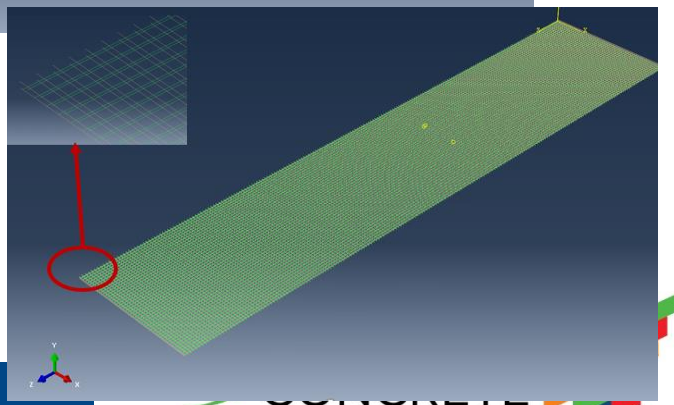
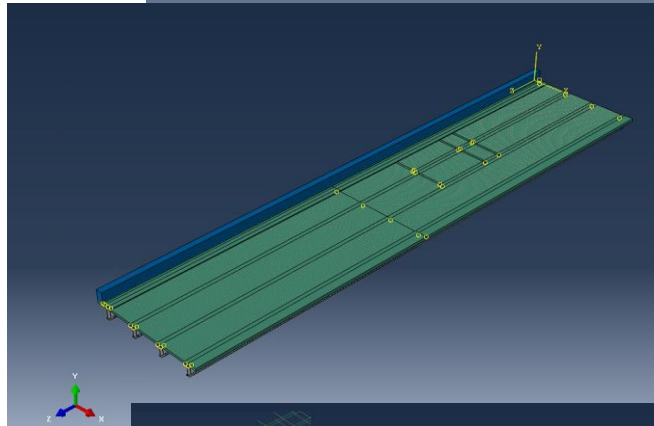
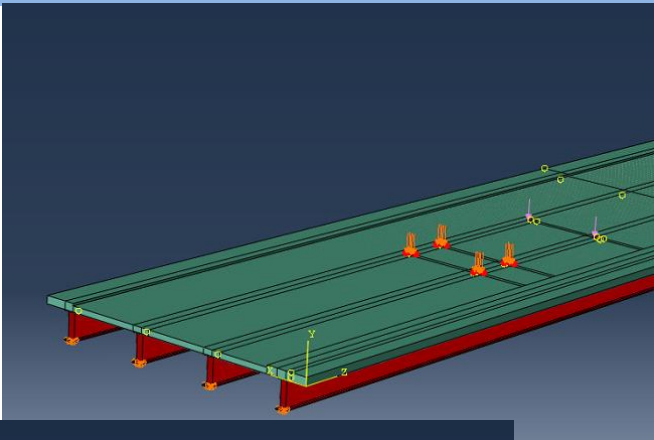
L = Live loads

Rating Level	Rating Factor (RF)	Bridge member rating (lb.)
Inventory level	0.33	23,760
Operating level	0.55	39,600



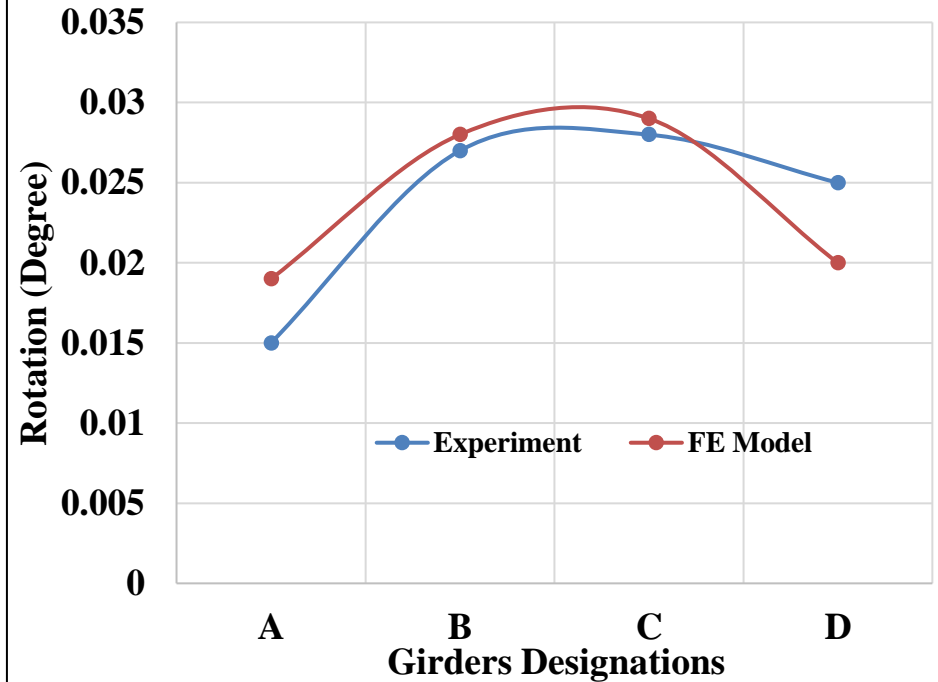
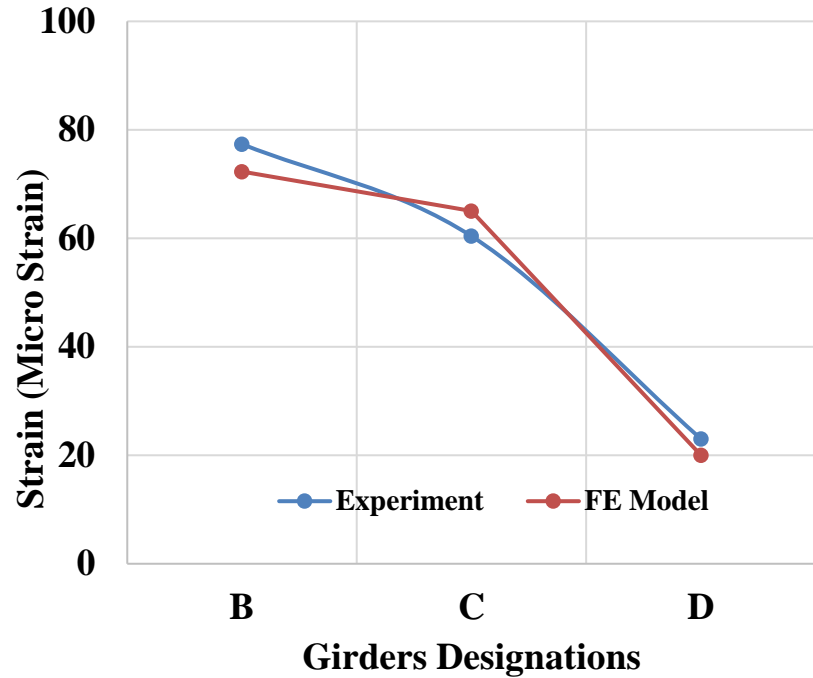
Finite Element Modeling (FEM)

- Cohesive contact properties were used to model the non-composite concrete deck over steel girders. Small sliding was allowed between the two surfaces.
- All the rebars were modeled as truss elements and embedded into the deck.
- Boundary condition were assumed as pin support.
- The load from the truck were applied as patch loads.
- An optimal mesh size was selected based on the mesh sensitivity analysis.





Model Calibration

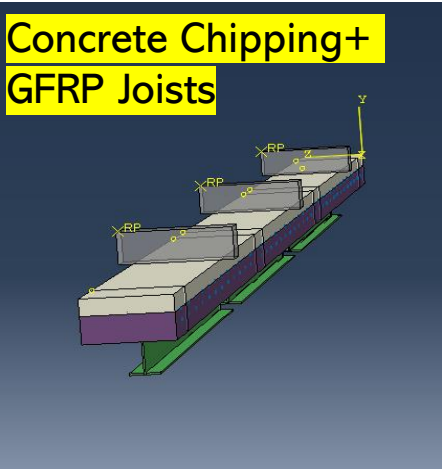
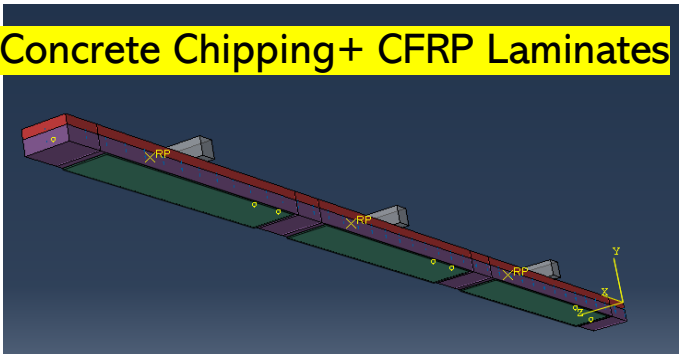
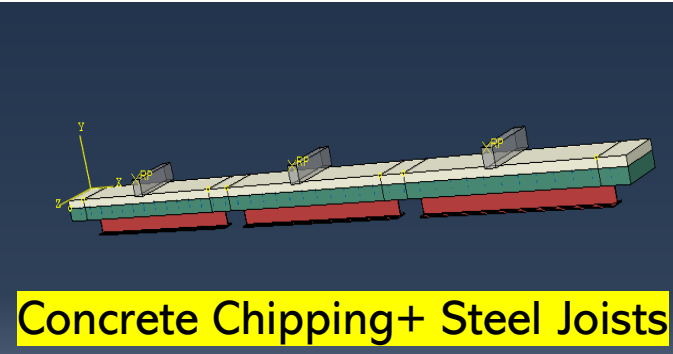


Neutral Axis	From bottom of the girder (in.)
Theoretical	16.5
Experimental	18.8
FEM	17.5





Load Rating of Retrofitted Model

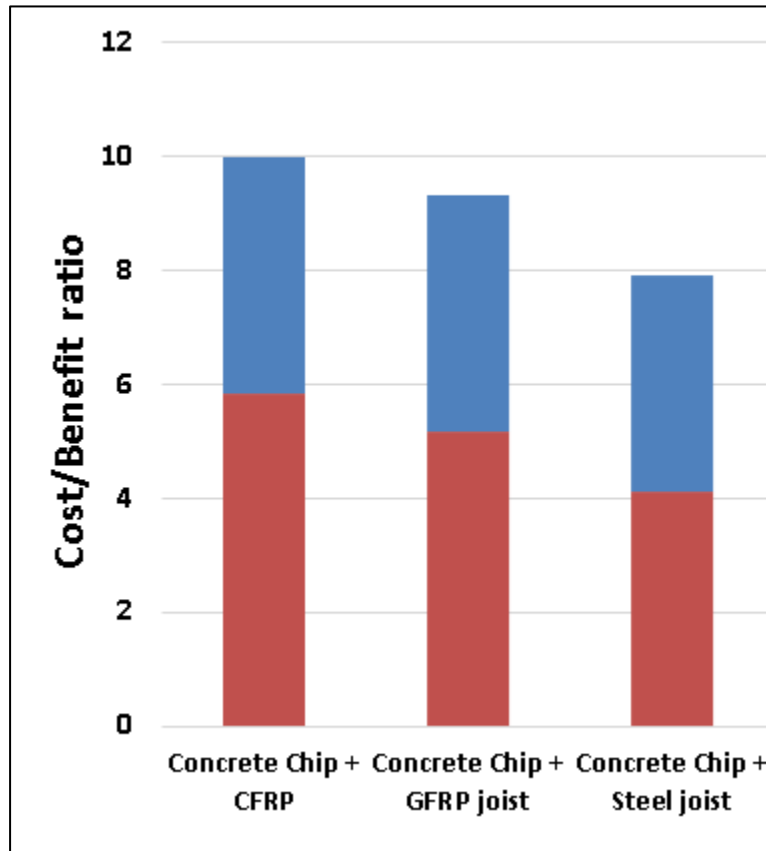


Retrofitting Options	Inventory Level	Operating Level
Concrete Chipping+ CFRP Strips	1.71	2.85
Concrete Chipping+ GFRP Joists	1.8	3
Concrete Chipping+ Steel Joists	1.92	3.20



Benefit-Cost Analysis

- To identify benefit/cost index the ratio of inventory load rating as benefit to initial retrofitting cost was considered.
- The ratios were standardized to a number between 1 to 10.



Conclusion

- The GPR data indicates that around 82.5% of the scanned deck area has a top cover ranges from 1.5 in.-3 in. and 71% deck area has top rebar cover more than specified in the as-built drawing. In light of a greater clear cover than specified, the moment capacity of the deck is compromised.
- IE contour plot demonstrate that structural integrity and strength have been compromised in the concrete deck.
- A distinct procedure was used to establish the bridge deck's rating based on the GPR and IE data. At inventory and operational levels, concrete deck was unable to carry HS-20 load.
- The deck rating after retrofitting was greater than one in both inventory and operating level, indicating that all retrofit solutions are applicable in different circumstances, however, CFRP laminates were a cost-effective choice based on cost analysis.



THANK YOU



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