SAND2016-7046D

Sensing and Rating of Vehicle - Railroad Bridge Collision

Nonlinear Mechanics and Dynamics (NOMAD) Institute, 2016

Group 11

University of New Mexico (UNM)

Canadian National Railways (CN)

Institute of Disaster Prevention (IDP)

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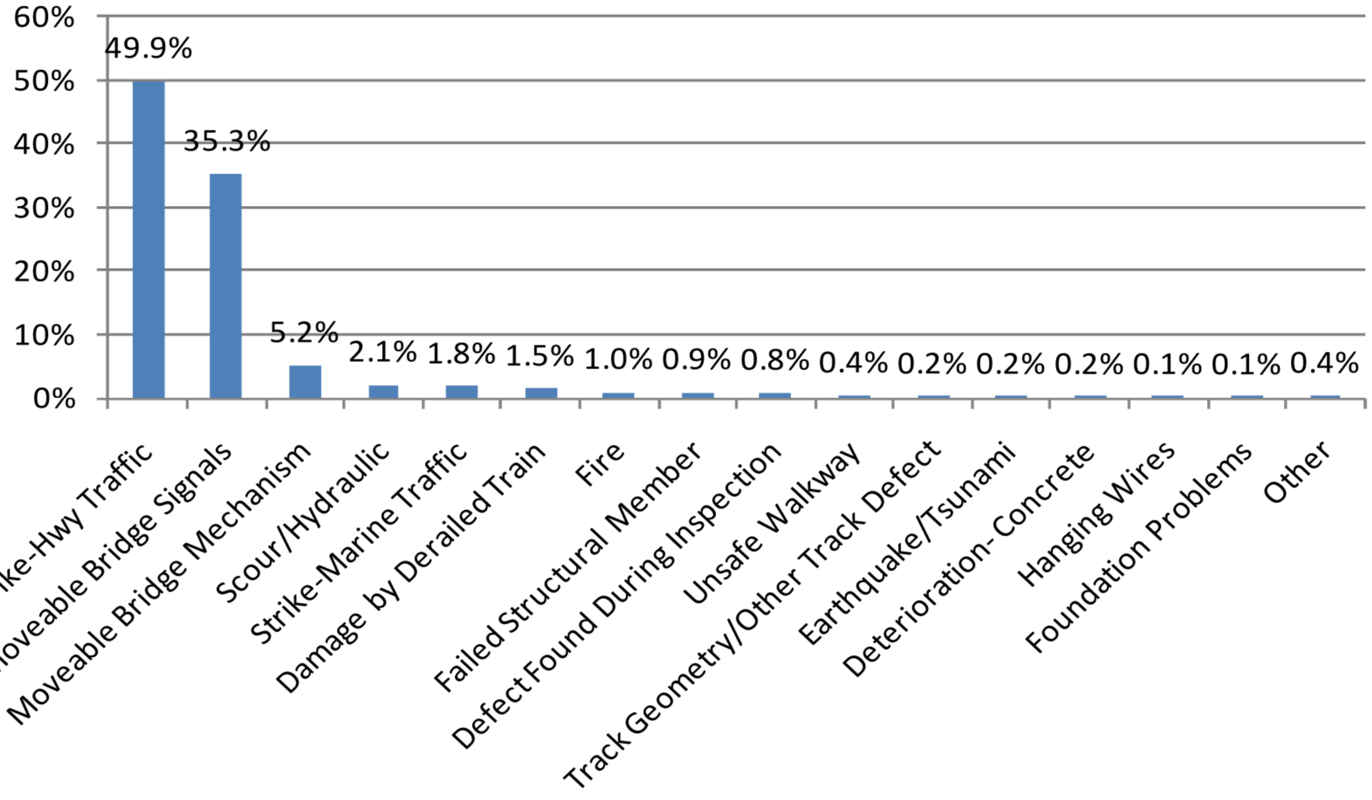
Background

Traffic interruption in US railroads

Caused by vehicle collisions in 50% cases

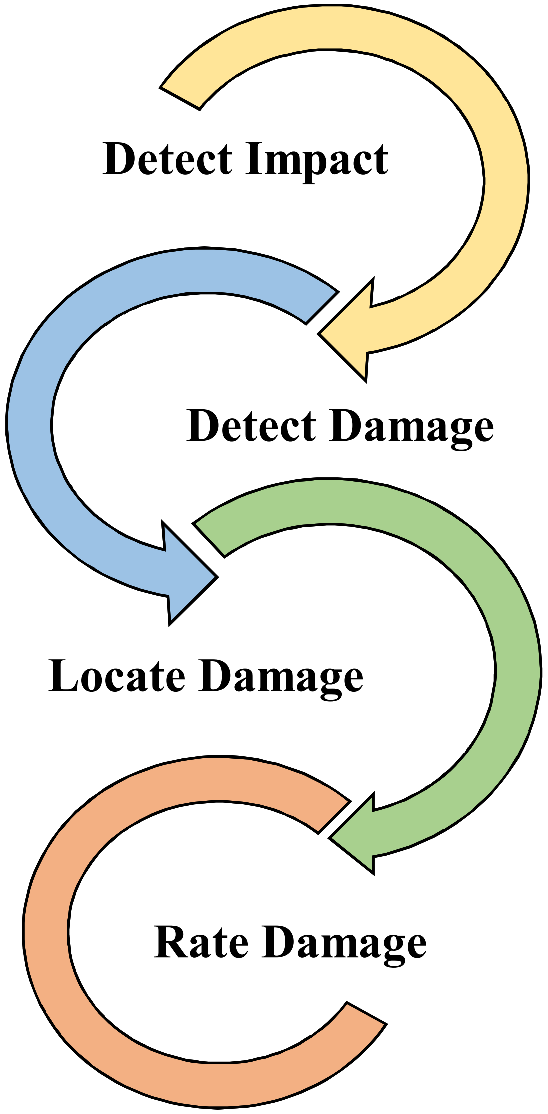
Methodology

Develop a full scale model of a railroad bridge and simulate overhead collision event
Rate nonlinear events of the impact using remote sensing so the impact can be rated at the site



Frequency of railroad reported events causing traffic interruption[1]

Objectives

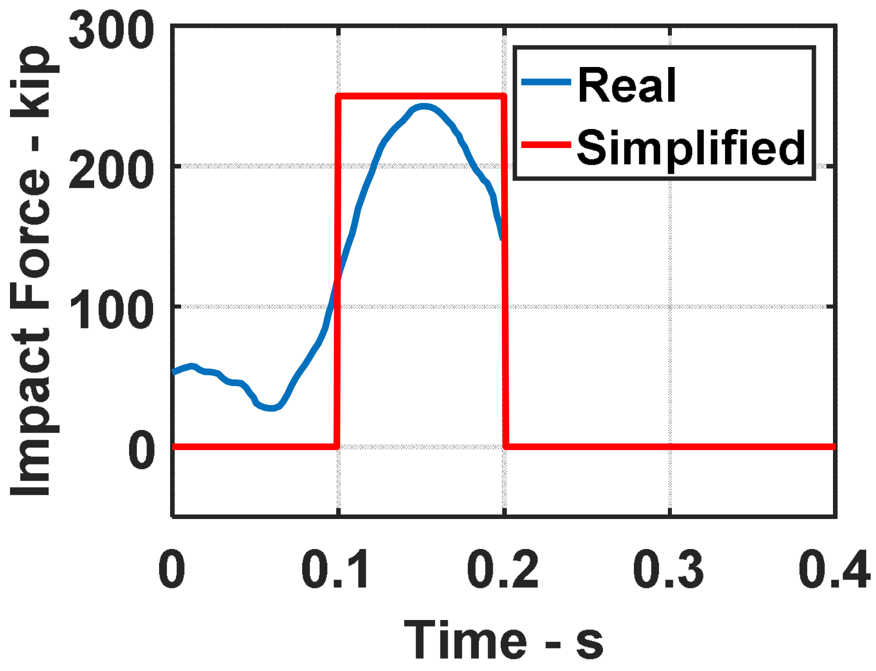


Impact Load Models

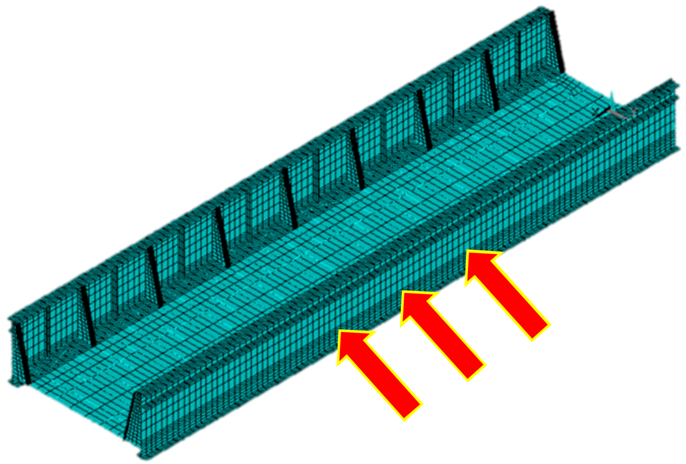
1982 Mack Econodyne Truck Model R688ST

- A 1982 Mack Econodyne Truck Model R688ST is selected as the impact source.
- This truck is very closely related to tractor-trailer model developed by National Crash Analysis Center for Federal Highway Administration.
- Simulated head-on truck-bridge pier collisions are idealized for the simplicity.[4]
- Load is scaled in amplitude to imitate overhead collision.
- The impact is idealized as a point and distributed contact load.
- Distributed load is a combination of multiple point loads.

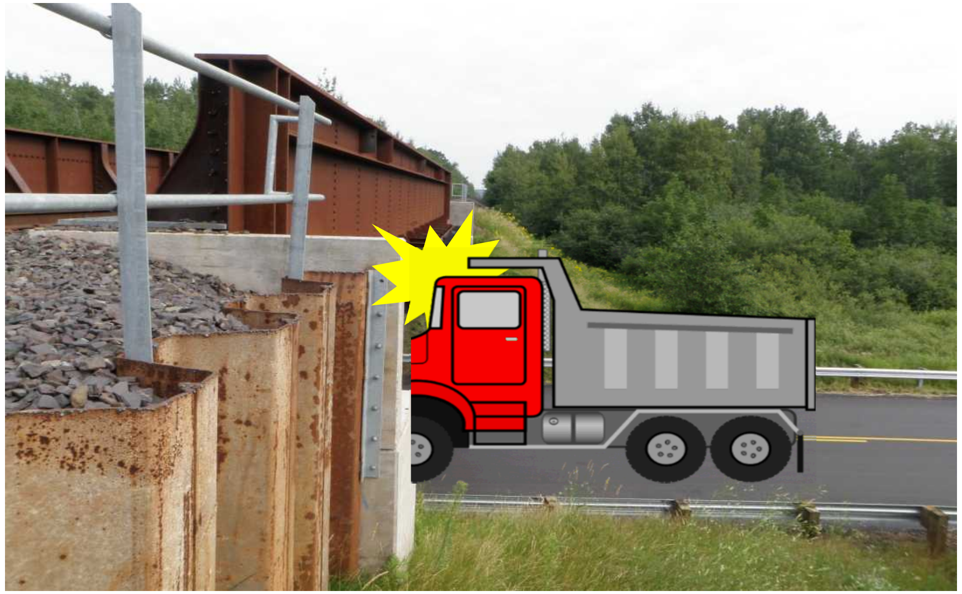
Load Profile A (Point Load)



Load Profile B (Distributed Load)

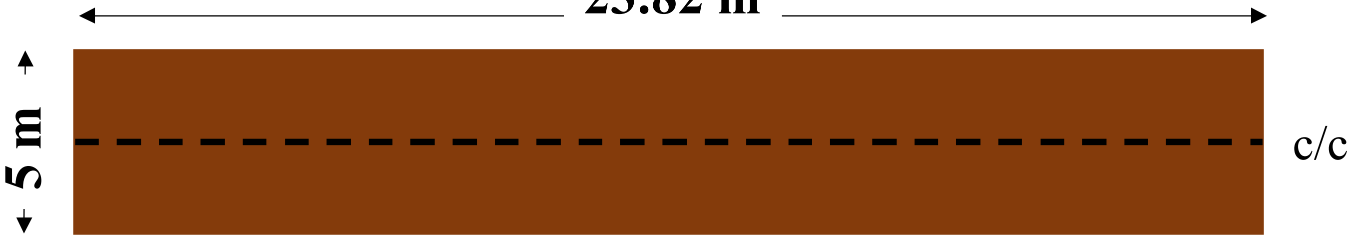


Steel Railroad Bridge

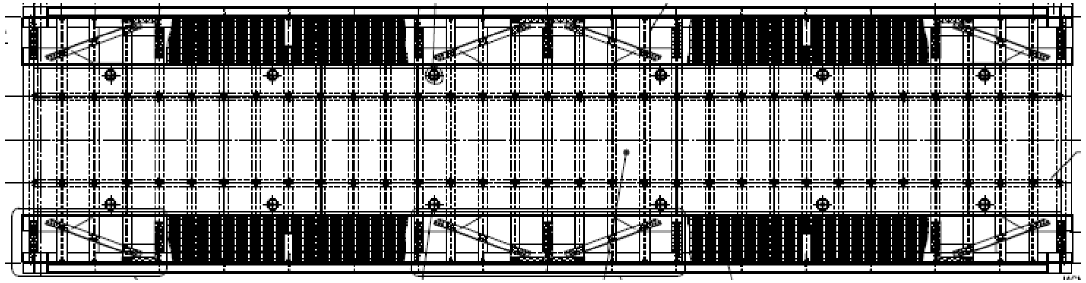


Elevation

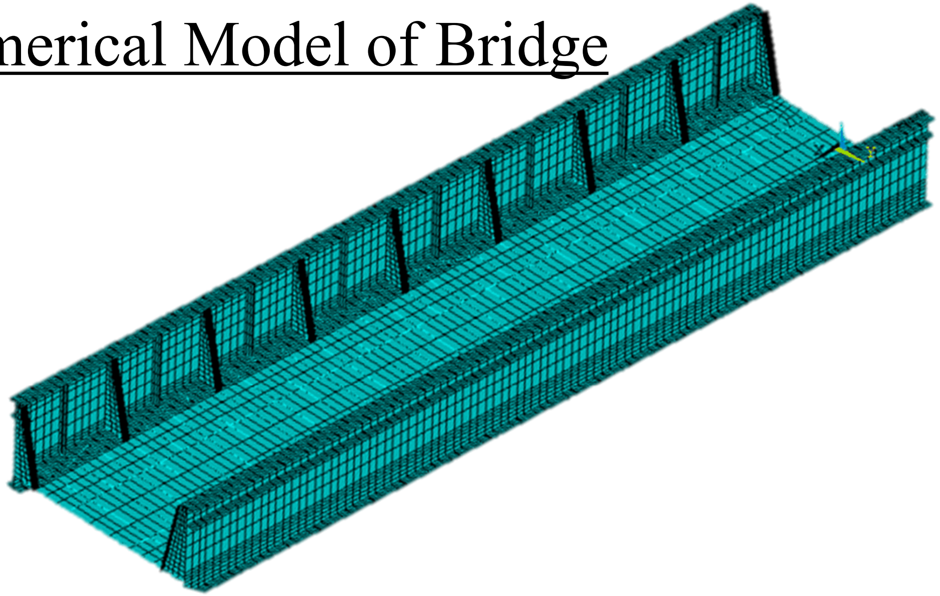
Plan

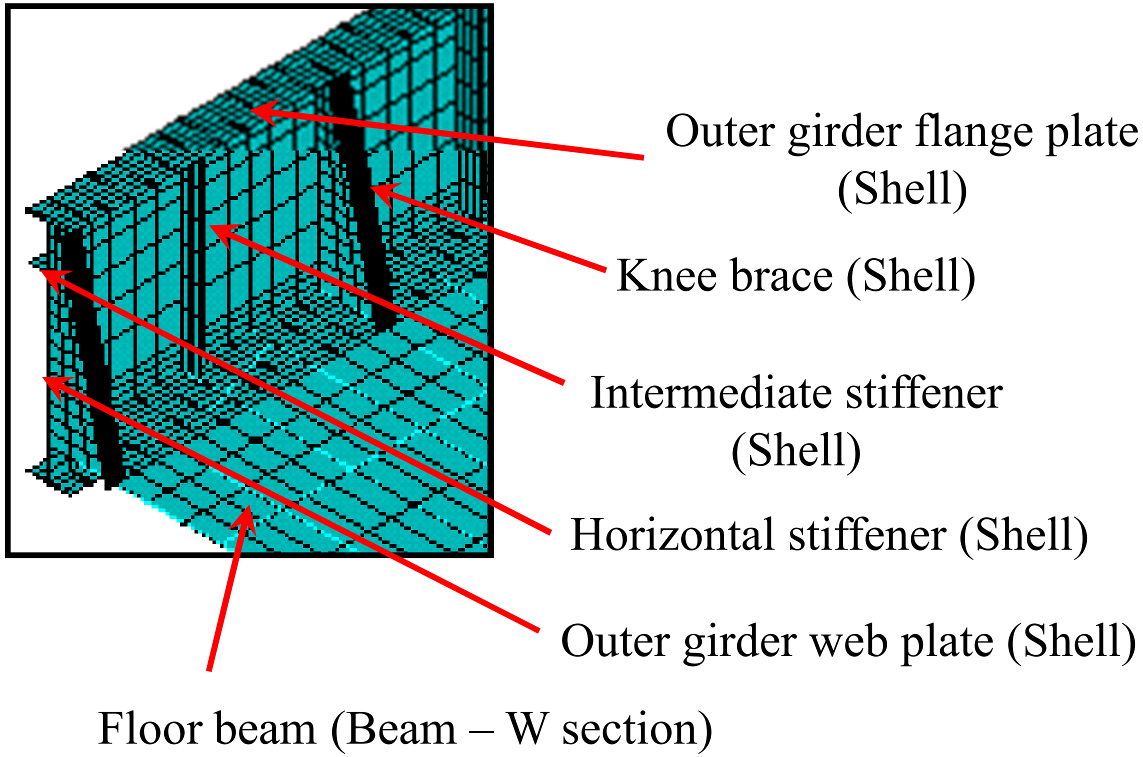


Framing Plan

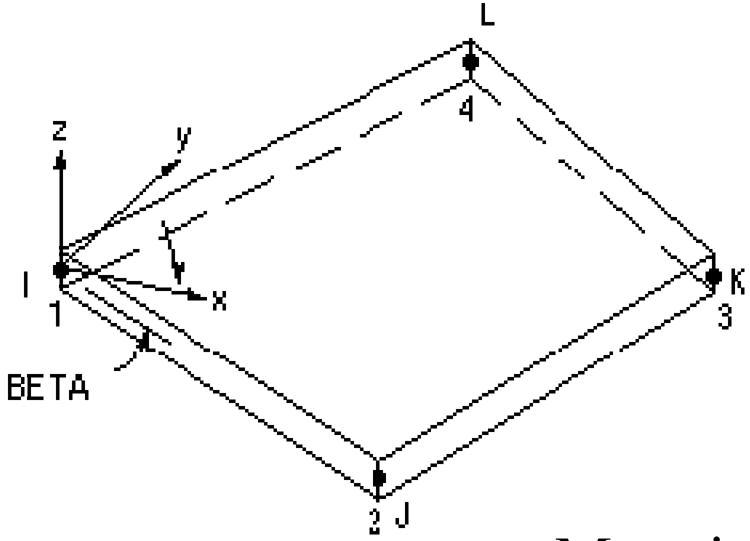


Numerical Model of Bridge

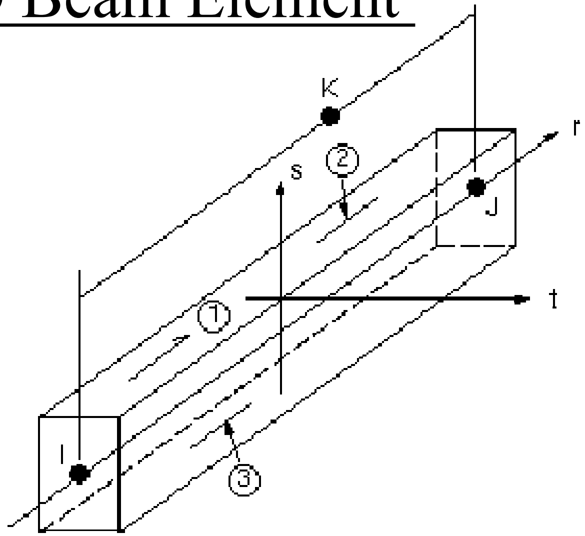




Shell Element



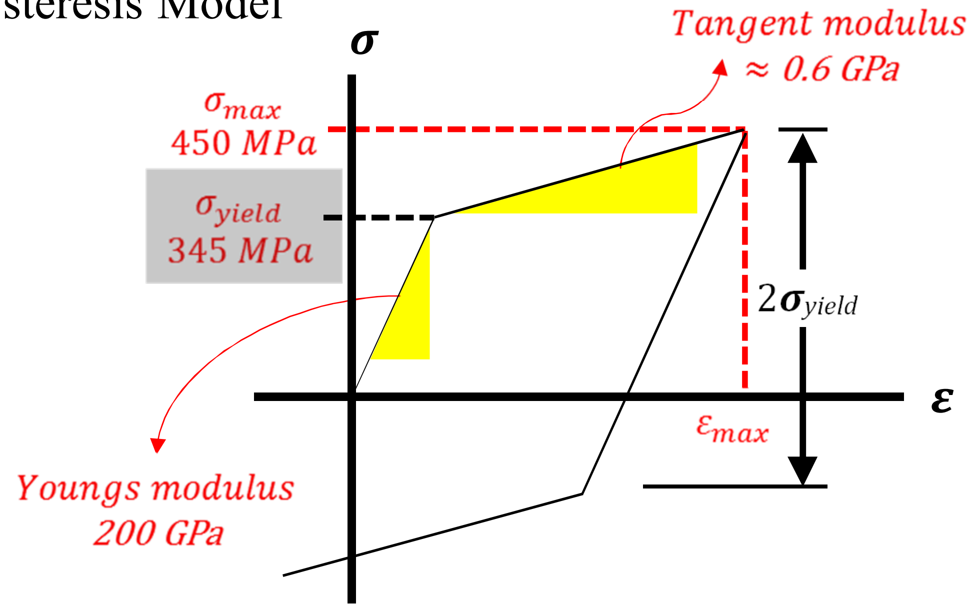
3D Beam Element



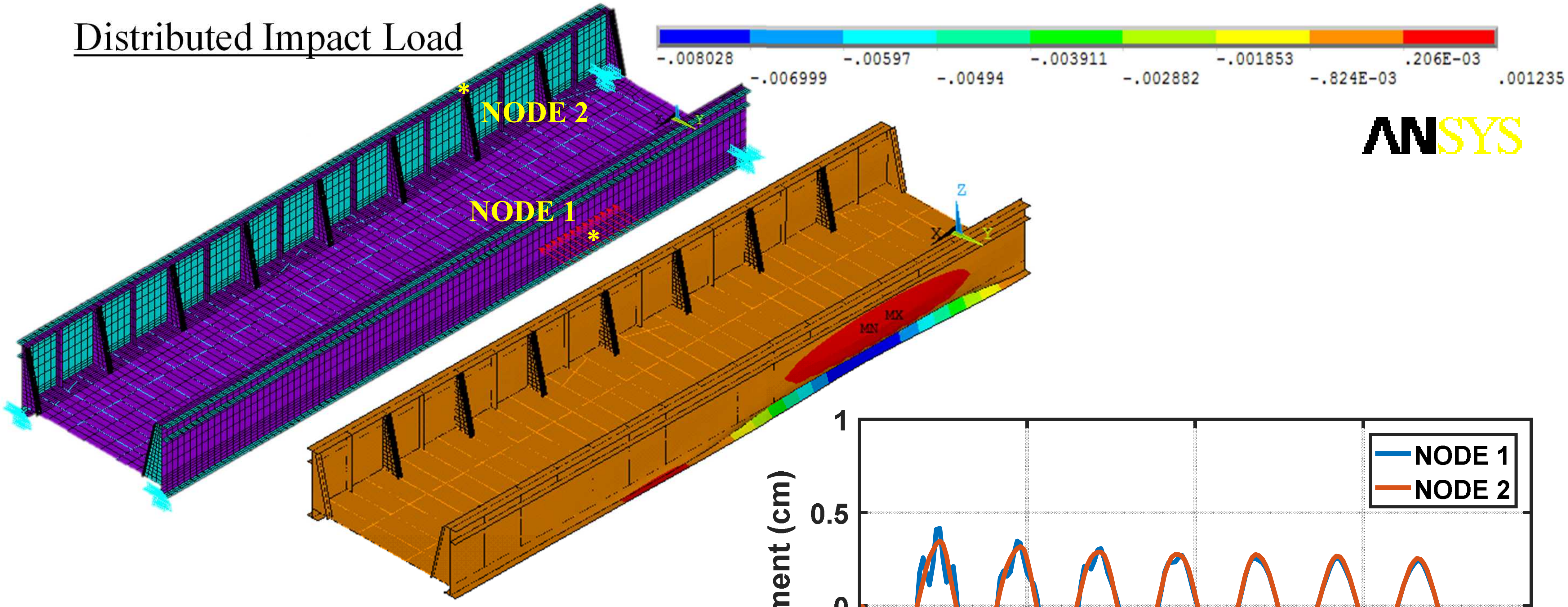
Material Properties

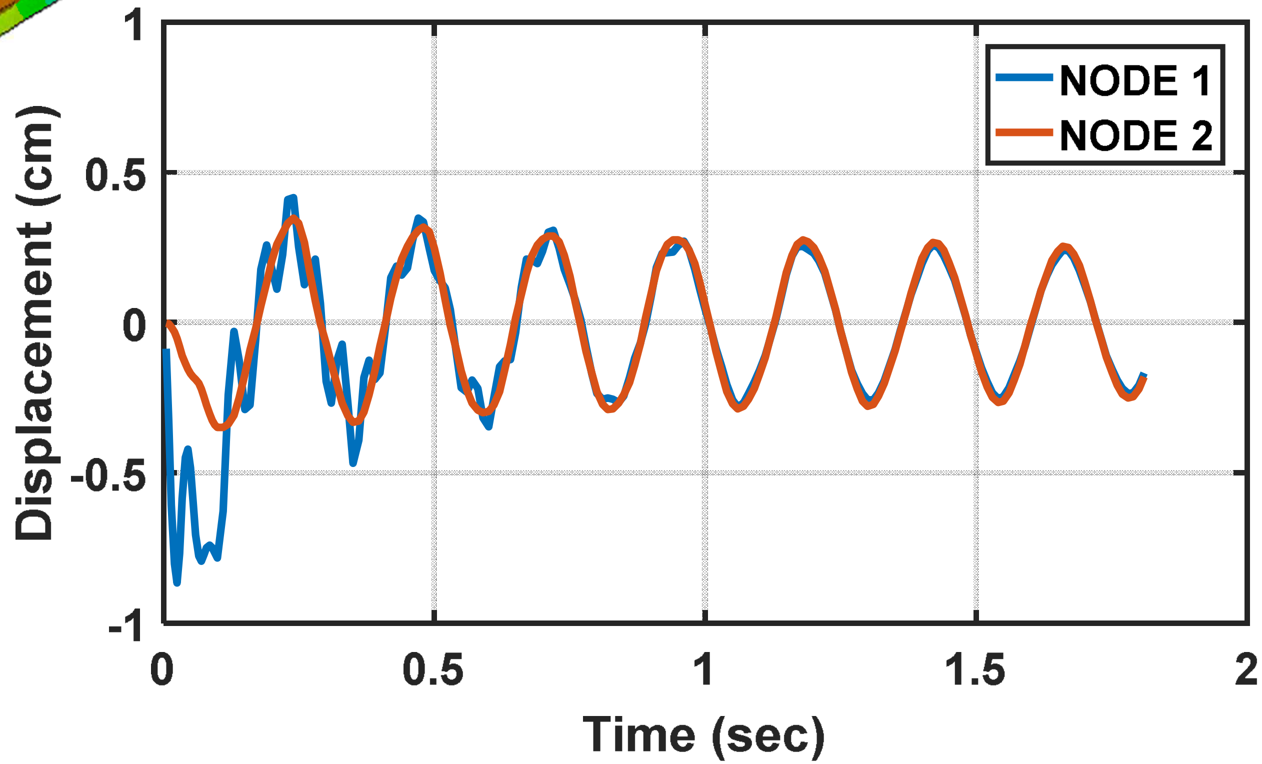
ASTM A572, Grade 50 Steel[3] is used.

Bilinear Hysteresis Model



Distributed Impact Load

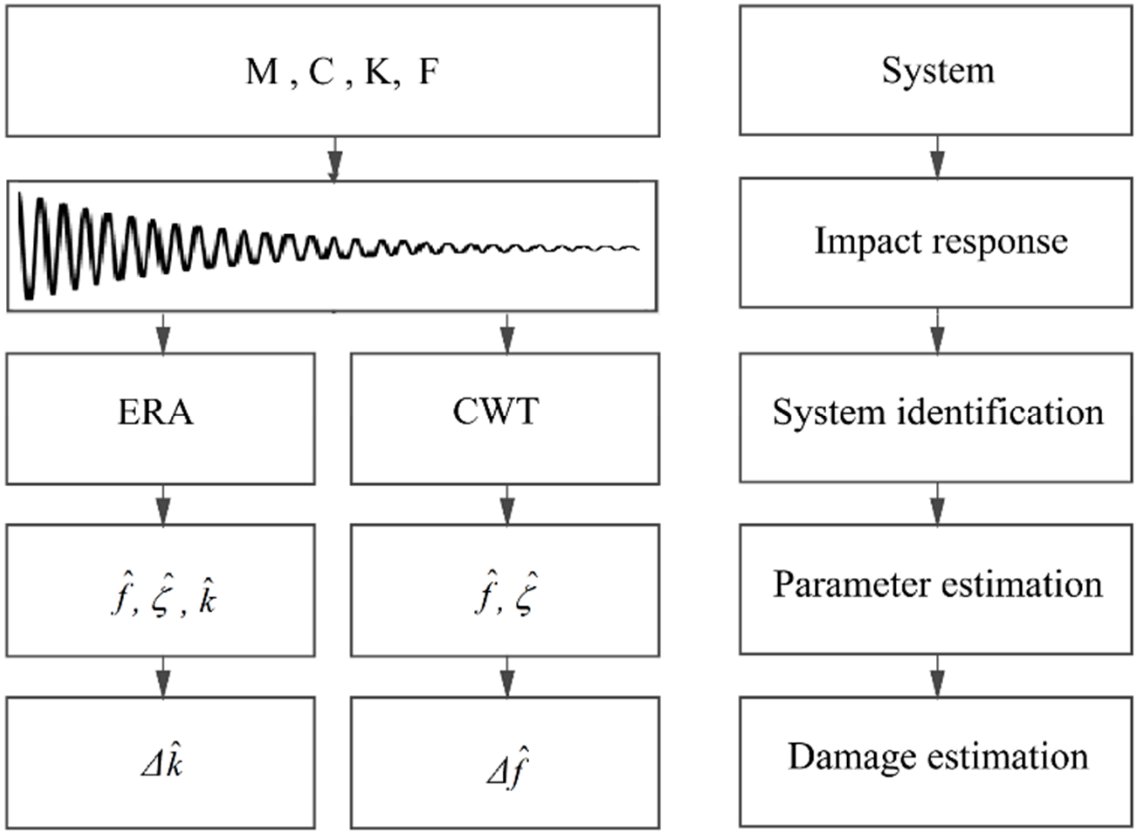




- Impact profiles are applied to simulate a realistic collision scenario.
- Impact load is applied as a distributed load at Node 1 location.
- Impact at Node 1 and displacement responses at Node 1 and Node 2 are obtained.

Damage detection though system identification

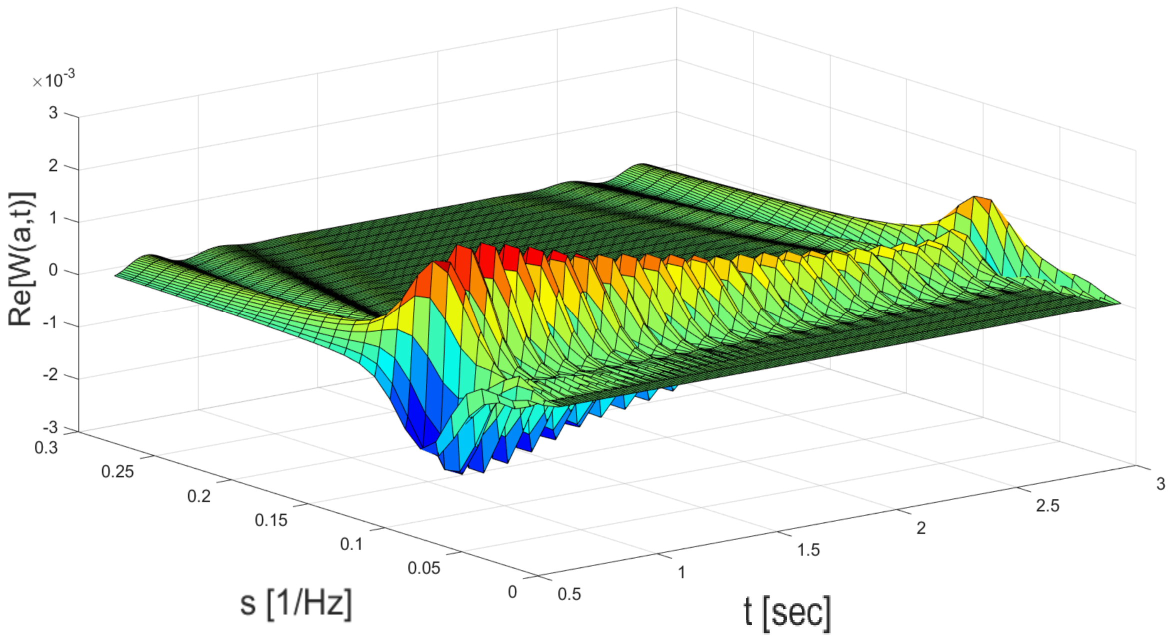
- Vibration based Structural Health Monitoring
- The system and impact response from 3D ANSYS model
- Identification by Eigen system Realization Algorithm (ERA)[5], and the ridge detection with the Continuous Wavelet Transformation (CWT)[6]
- Linear time-invariant (LTI) system with constant mass
- Damage indicator is based on changes in stiffness and natural frequency from undamaged to damaged
- Prior undamaged state must be known



Result of damage detection

CWT estimate with the impact response as input

Simulation no.	f [Hz]	ζ [%]
1	14.24	2.80
2	13.59	2.91
3	14.24	2.80
4	14.24	2.80
5	14.24	2.80



Conclusion and discussion

- Simplified impact load model makes the physics of the collision easier to understand.
- The nonlinearities linked with damage may serve as damage sensitive features.
- The damage detection method requires undamaged state to be known a prior.
- The system identification techniques capture the changes in the system, however they are not reliably identifying changes due to damage.

Required improvements and future work

- Simulation of impact event as a contact load.
- Simulation and evaluation of permanent displacements at supports due to impact.
- Evaluation of effectiveness of crash beams in protecting the bridge against impacts.
- Development of an hybrid approach, where detected location and magnitude of the impact can be used as an input to the simulation and assessment of structural integrity using hybrid simulation results.
- Utilization of neural network methods to increase the fidelity of damage detection.
- Classification of changes of frequency and stiffness, to distinguish between changes unrelated to damage, i.e. changes in mass, signal-to-noise ratio or boundary conditions.
- Development of output-only nonlinear system identification techniques
- Optimization of detection algorithms for wireless sensors.
- Development of a reliable impact rating.

Acknowledgements

University of New Mexico (UNM)

Sandia National Laboratories (SNL)

Smart Management of Infrastructure Laboratory (SMILab)

Denmark Technical University (DTU)

Institute of Disaster Prevention (IDP)

Transportation Technology Center, Inc. (TTCI)

Canadian National Railways (CN)

Embedor Technologies

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