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Impact-resistant Behavior of Reinforced Concrete Bridge Columns

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Background

- The damage caused by a vehicle collision on a pier column can be catastrophic for the functionality of a bridge, even a total collapse of the bridge.
- A vehicle collision and a subsequent vehicle blast cause more damages on the bridge.
- Limited researches have been conducted to investigate the behavior of the bridge subjected to the combined effect of vehicle collision and blast.
- It is necessary to analyze the responses of the bridge under the vehicle collision and blast and provide some design suggestions to strengthen the bridge.

Fig.1. Failure modes of bridge column

Objectives

- To develop high fidelity finite element models for bridge columns subjected to vehicle collision and vehicle blast using software LS-DYNA .
- To analyze the responses of the bridge columns under the vehicle collision and vehicle blast.
- To offer design suggestions for preventing potential failures and improving behaviors of bridge columns

Prototype of Bridge Pier

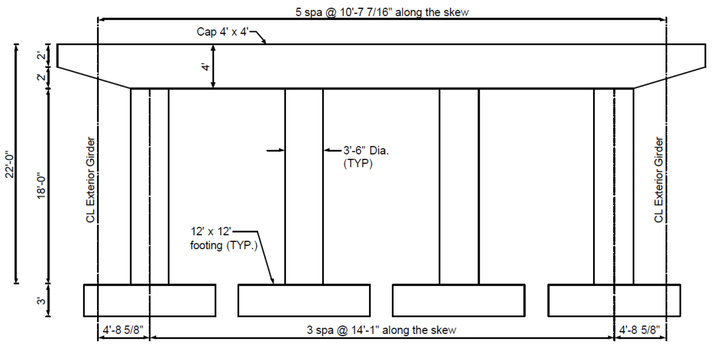


Fig.2. Prototype of bridge pier [Reference]

Finite Element Modeling

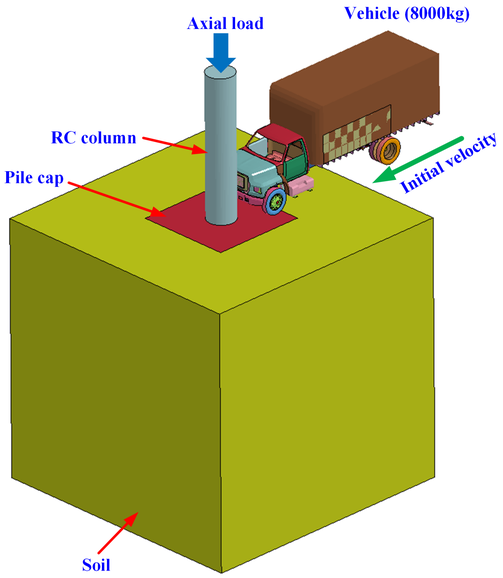


Fig.3. FE model of vehicle collision with column

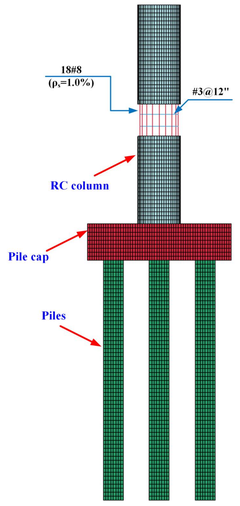
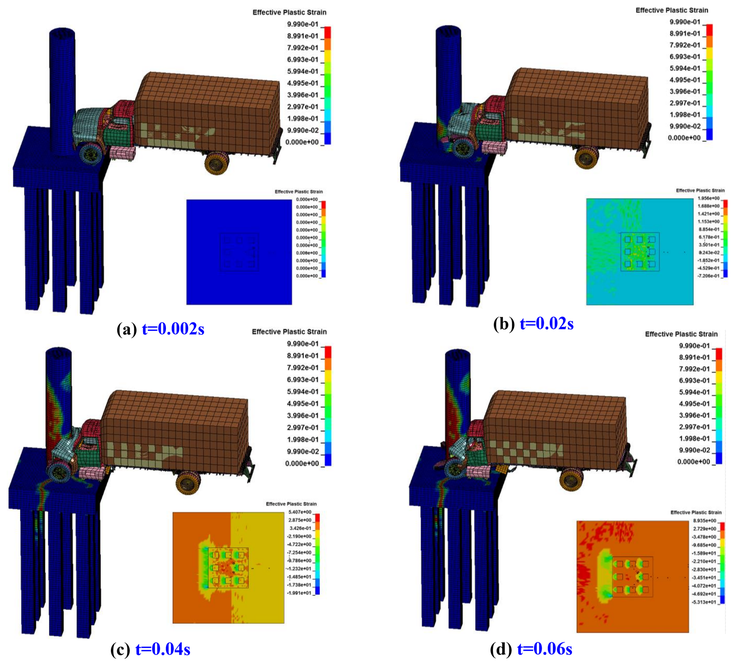


Fig.4. FE model of column

Sample Results

- **A 3.5ft diameter column subjected to a vehicle impact**



Results (Cont'd)

- **The effect of column diameter (including D_g=2.5ft, 3.5ft, and 5ft) is considered in the research.**

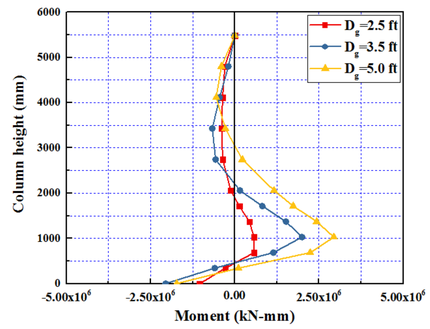


Fig.5. Moment-time curves

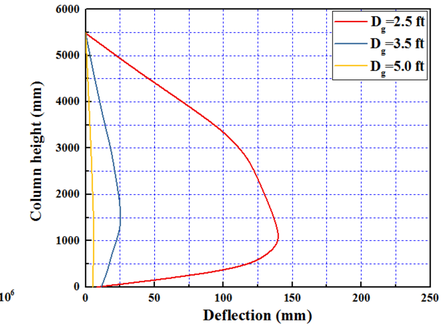


Fig.6. Deflection-time curves

Conclusions

- The finite element models including column, pile cap, piles, and soil are feasible and accurate to simulate the responses of bridge columns subjected to vehicle collision.
- The shear failure plane with 45 degree was initiated at the location of impacting and then propagated through the whole column. The maximum shear occurred at the point of impact.
- The maximum moment of the bridge column increases with the increase in the column diameter, and the increase in the deflection along the column height is also caused by the increase in the column diameter.

Future Work

- To consider vehicle blast in finite element model based on the vehicle collision results.
- To investigate effects of different variables including the spacing of transverse reinforcement, vehicle velocity, and vehicle mass on the responses of bridge column.
- To summarize design considerations for bridge columns subjected to vehicle collision and vehicle blast.

References

- Wassef, W., et al. "Comprehensive Design Example for Prestressed Concrete (PSC) Girder Superstructure Bridge with Commentary." Federal Highway Administration report no. FHWA NHI-04-043, grant no. DTFH61-02-D-63006. Washington, DC: US Government Printing Office (2003).