Nonlinear dynamics of train-bridge interaction system under strong earthquakes

Xuzhao LU Keywords: Material nonlinearities, Train-bridge interaction, strong earthquake

【Background】

Running safety is a critical issue in civil engineering. In previous research, scholars have investigated dynamic responses of the coupled system under moderate earthquakes. However, the severe structural damage and train derailment accident happened in 2004, Niigata, Joetsu-Shinkansen shows the occurrence of nonlinearities under strong earthquakes. Till now, few research have been proposed on the nonlinear performances of the coupled system.

【Objective】

This study aims to investigate the nonlinear performances of the coupled system under strong earthquakes. For the bridge structure, this research focused on the material nonlinearities caused by plastic hinges. For the train sub-system, this research investigated the potential geometric nonlinearities caused by the large relative displacement between train components.

【Approach】

Finite element models were built and utilized on the foundation of field-test data validation. A complete model was proposed including both the bridge structure and train sub-systems as well as ground motions. Nonlinear elements were embed into the model for plastic hinge simulation. As for the train, some fundamental physical multiple degrees of freedom models were built to check the derailment mechanism.

【Publication plan】

- One journal paper for the nonlinear bridge responses.
- One journal paper for the geometric nonlinearities of the train sub-system involving derailment.

【Results】

The nonlinear responses of the plastic hinge on the bridge column were shown in the upper figure listed as follows. The lower figure shows the derailment phenomenon in numerical simulation.