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DYNAMIC INTERACTION ANALYSIS OF A SHINKANSEN TRAIN AND RAILWAY STRUCTURE AFTER DERAILMENT DURING AN EARTHQUAKE

***M. Tanabe[1], H. Wakui[2], N. Matsumoto[2], M. Sogabe[2] and Y. Tanabe[3]**

[1] Kanagawa Institute of Technology
Atsugi, Kanagawa, 243-0292, Japan
tanabe@sd.kanagawa-it.ac.jp

[2] Railway Technical Research Institute
Kokubunji, Tokyo, 185-8540, Japan
wakui@rtri.or.jp
nobel@rtri.or.jp
sogabe@rtri.or.jp

[3] Laboratory for Computational Mechanics Inc.
3-14-18 Kurihara-chuo, Zama, 228-0014, Japan

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ABSTRACT

When a high-speed train runs on the railway structure during an earthquake, a complicated dynamic interaction between the train and railway structure is anticipated. The train may derail during a strong earthquake. It is very important to study the dynamic interaction of the train at a high-speed and railway structure after derailment during an earthquake to design an earthquake-safe high-speed railway system, where some safety device or guard is needed to prevent the train deviating from the track even after derailment in the earthquake.

In this paper, a simple and efficient numerical method to solve for the dynamic interaction of a Shinkansen train (high-speed train in Japan) and railway structure including derailment during an earthquake is given. The motion of the train is modeled in multibody dynamics where nonlinear springs and dampers are used to express actual dynamic behaviors between components in the train [1-3]. Simple and efficient mechanical models are given to express contact-impact behaviors between wheel and rail before derailment and also impact behaviors between wheel and railway structure after derailment in a strong earthquake, where low-frequency mild vibration of the whole railway structure due to an earthquake is coupled with high-frequency vibration due to the severe impact of wheel on the rail and railway structure.

The motion of railway structure is modeled with various finite elements such as beam, truss, shell, solid, and nonlinear spring and damper elements. Here rail and guard elements, where the motion in the cross section is expressed in multibody dynamics and bending and tortional motions in the rail direction are expressed by FEM, have been developed to solve the contact-impact behaviors between wheel and rail, and wheel and guard in the railway structure effectively. The acceleration of a seismic wave is given at base nodes of railway structure.

The combined transient dynamic response during an earthquake is obtained by solving equations of motion of the train and railway structure subjected to the interaction between wheel and rail before derailment, and wheel and railway structure after derailment. A modal method has been applied to solve large-scale nonlinear equations of motion of the train and railway structure during an earthquake effectively [1-3] .

Based on the present method a computer program, DIASTARS, has been developed for the simulation of a Shinkansen train running on the railway structure at high speed including after derailment during an earthquake. Fig.1 shows the dynamic interaction of the train and railway structure under an earthquake with the maximum accceleration of 380gal given in the transverese direction, where guards are attached to the track to prevent the train deviating from it. Fig.2 shows the computational result of impact foece between wheel and guard after derailment. The maximum impact force on the guard is shown to be about 16 tonf during the earthquake. The dynamic interaction behavior between the train and railway structure including after derailment during earthquake is studied.

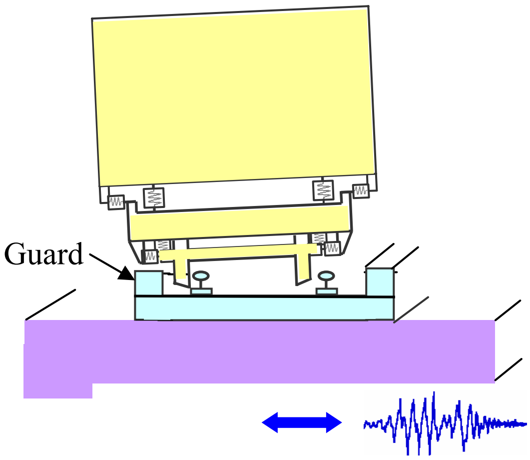

Fig.1 Dynamic interaction of train and railway structure with guard attached after derailment

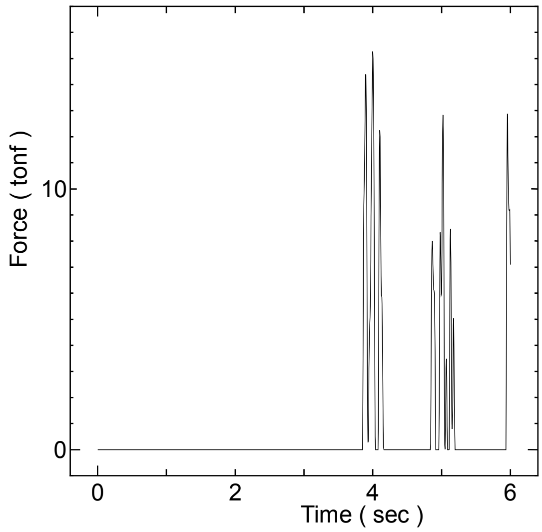

Fig.2 Impact force between wheel and guard after derailment

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