

Vehicle Dynamics and Safety Assessment of Railway Train Set during Earthquakes

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Introduction

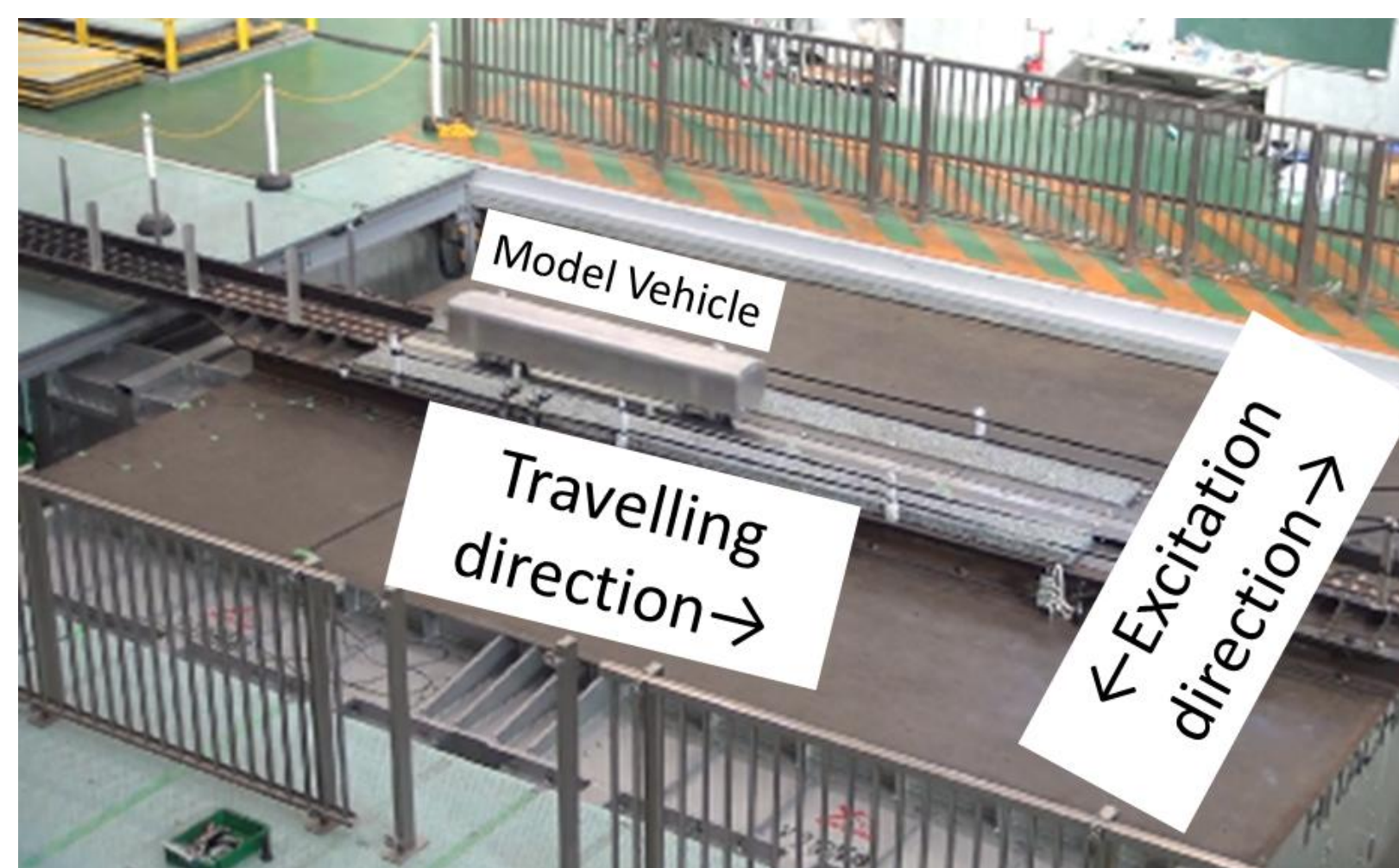
Large earthquakes repeatedly occurred in Japan, and derailment and overturning of railway vehicles occurred during these earthquakes in some cases. Safety measures are being implemented in various railway sectors, and it is important to continue studying to improve safety. On the other hand, it is difficult to conduct experiments in which derailment and overturn occur using actual vehicles. Also, conventional vehicle dynamics simulations can mainly handle vehicle behaviour up to derailment. This study is conducting research to overcome these problems and understand the derailment and overturn phenomena by using model vehicles and developing new vehicle dynamics simulations.



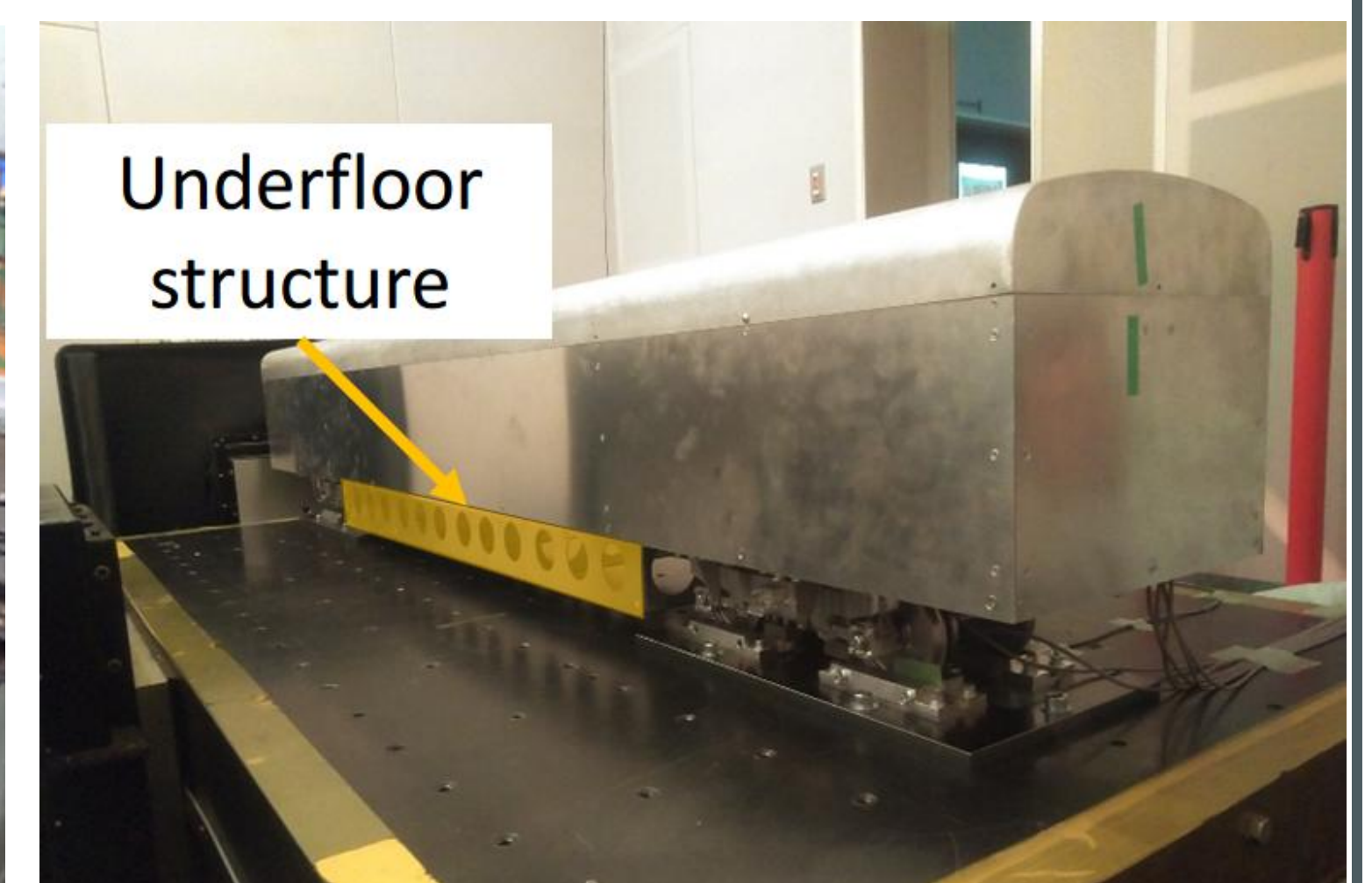
1/10 scale model vehicle

Understanding phenomena through model vehicle testing

- Natural frequencies of lateral and roll systems of the model vehicle were obtained through experiments of small displacements. They are generally similar to those of an actual vehicle.
- Frequencies and amplitudes of excitation when derailment or overturn occurred were determined through experiments of large displacements, and safety limit diagrams were created.
- The differences in the safety limits when the underfloor structure of the model vehicle is changed were identified.



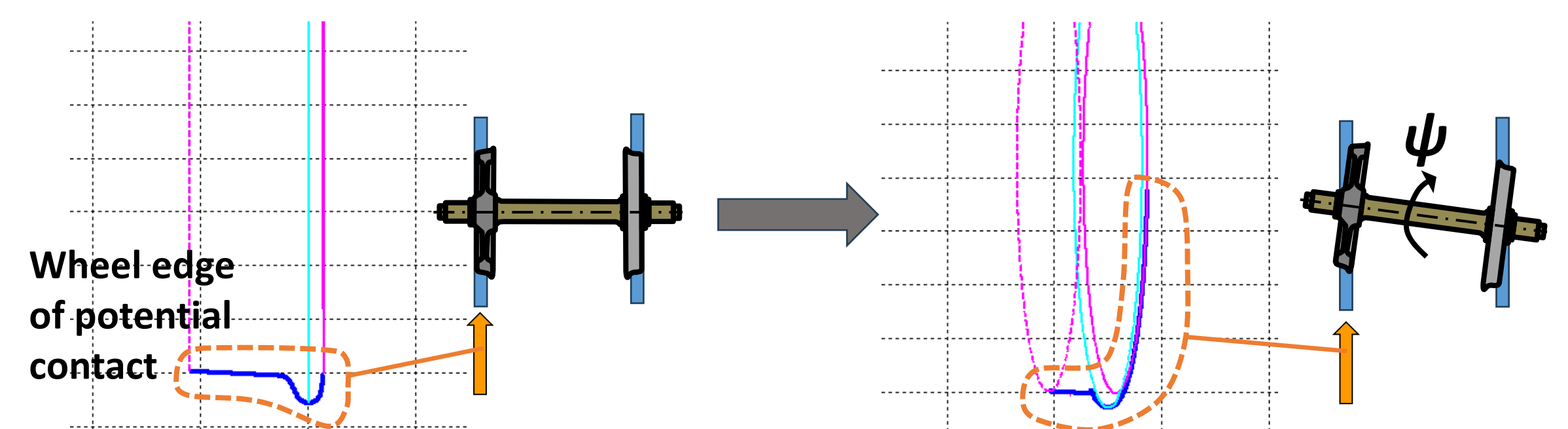
Running test of model vehicle



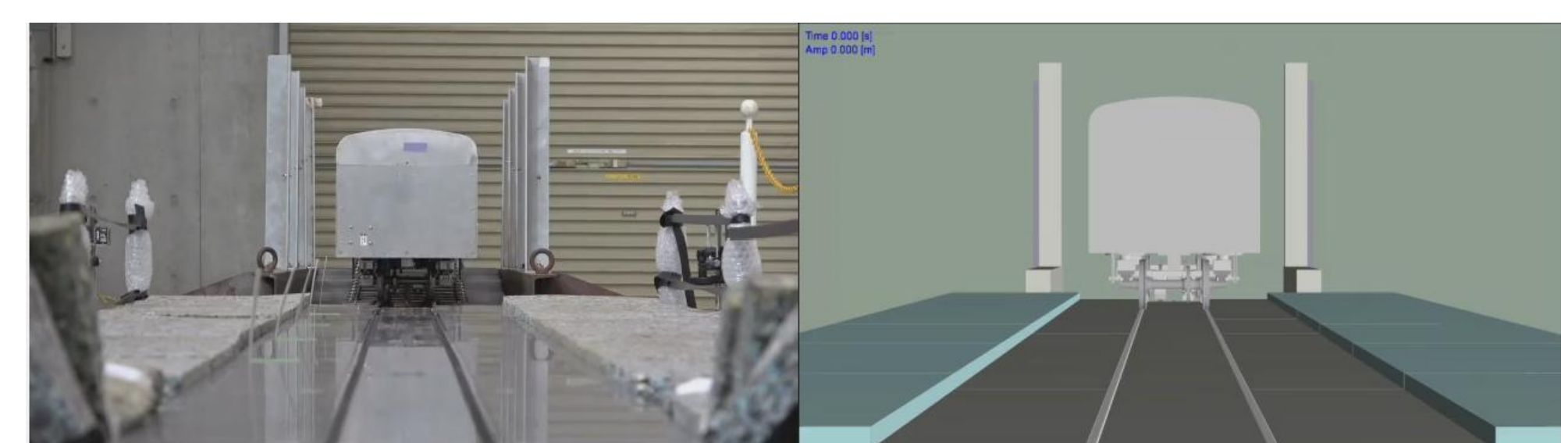
Attaching underfloor structure

Verification using vehicle dynamics simulation

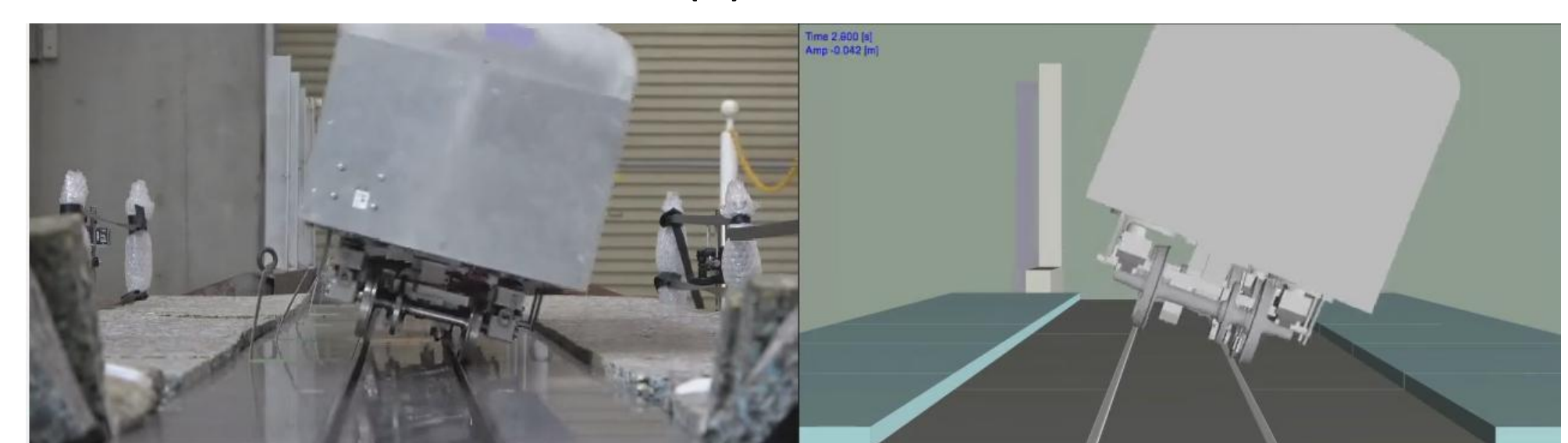
- The conventional vehicle dynamics simulation uses the tables of quantities required for contact calculations based on lateral, roll and yaw displacements of the wheels.
- ⇒ In the new simulation, online wheel-rail contact calculations enable simulations of vehicle behaviour which were impossible to calculate in the previous simulation.
- The new simulation is used to carry out vehicle dynamics simulations and compare the simulation results with the model experiment results.
- ⇒ Simulation results of the safety limit diagram and the behaviour of the vehicle show good correspondence with those of experiments.



Changes in projected wheel shape due to attack angle



(a) 0 s



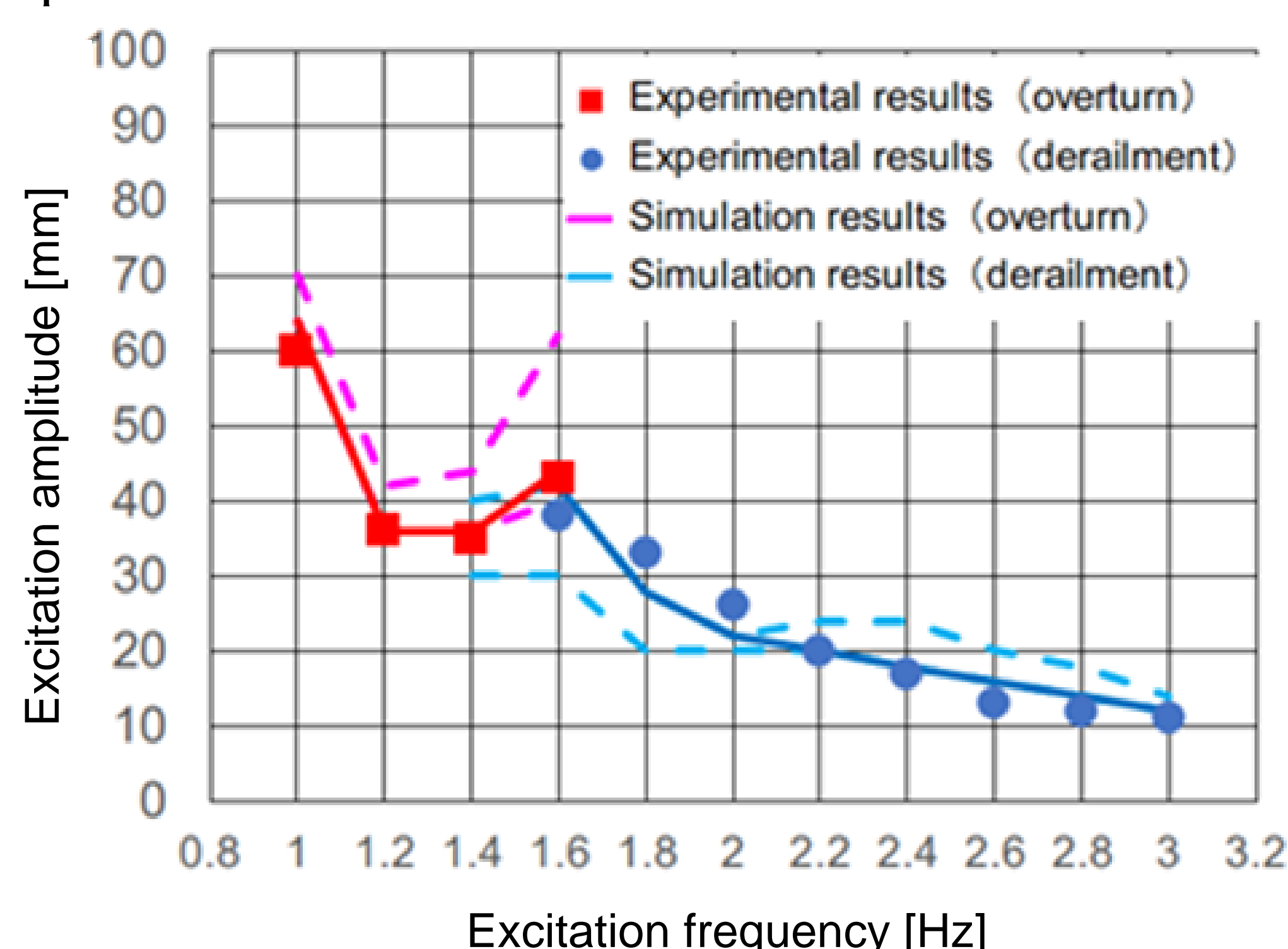
(b) About 2.9 s (The vehicle derailed to the right side of the paper.)



(c) About 3.5s (Overturn)

Motion of model vehicle

(Comparison between experimental and simulation results)



Safety limits of model vehicle

Publications

M. Kuzuta, K. Iida, and T. Shun and K. Nakano: "Experiments and Dynamic Simulations of Running 1/10 Scale Model Vehicle on Vibrating Track" Proceedings of Dynamics and Design Conference 2024, 2024. (in Japanese).