Evaluation of Compression Behavior of the End-Structure of Intermediate Car

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When a moving train collides with an obstacle, it is often the case that not only the leading car but also the intermediate cars are subjected to an impact that may destroy the end-structure. As the strength of the car body underframe is higher than that of other parts, it is supposed that the car body deformation modes are significantly different when the underframes of two adjacent cars collide with each other at the same height and when the underframe of one car overrides the underframe of the other. In discussing the safety features of a train in a collision, therefore, it is important to clarify the collision behavior of the end-structure of intermediate car in the trainset. To assess the compression behavior of the end-structure of intermediate car, therefore, the Railway Technical Research Institute (RTRI) implemented static compression tests for part car bodies of actual size.

Specimens prepared by cutting the end section of a stainless steel car body were subjected to the test under two conditions: full-lap and vertical offset conditions (Fig. 1). Under the full-lap condition, the whole car body end plate surface was pushed by a rigid wall. Under the vertical offset condition on the other hand, the car body end plate was pushed by a rigid block that was set 170 mm higher than the bottom of the car body to override the 150 mm-high underframe. Figures 2 and 4 respectively illustrate the deformed shape and the relationship between the load and deformation for each test case thus obtained. Under the full-lap condition, the end-structure deformed with the end plate remaining almost flat. The load rapidly increased after the value of deformation exceeded 70 mm, eventually reaching a maximum of about 2,400 kN. Under the vertical offset condition on the other hand, the underframe remained almost intact and the parts above the underframe, which are the end plate, side plate, roof plate and other superstructures deformed because the welding joints between the end plate and the underframe were ruptured. No conspicuous peaks appeared in the load, which was about 900 kN at the maximum. These findings clarify that, when the collision between the coupled end-structures of intermediate cars occurred, the deformation mode and the generated load depend significantly on whether or not one car overrides the other car.

The RTRI also implemented FEM analysis equivalent to the static compression test. Figures 3 and 4 respectively show the deformed FE models obtained by the calculations and the relationships between the compression load and deformation, which were obtained from the test or the analysis. The deformed shapes indicate that FEM analysis reproduces the test results of the actual car body, in that it expresses not only the bending of plates and beams but also a rupture at the welding joints between the end plate and the underframe. The relationships of load versus deformation are also in good agreement with the test results for each condition. Therefore, it is conclusive that the analysis reproduces the test results satisfactorily.

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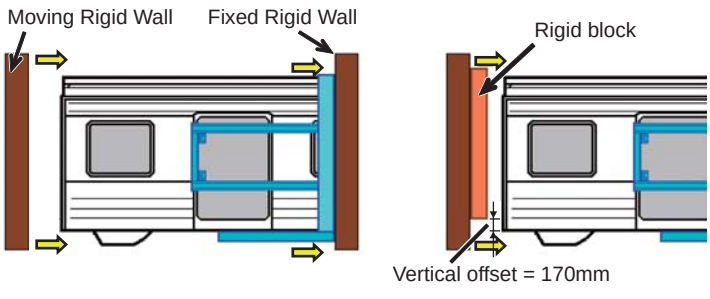

Fig. 1 Testing condition

Fig. 2 Testing results of deformed shape

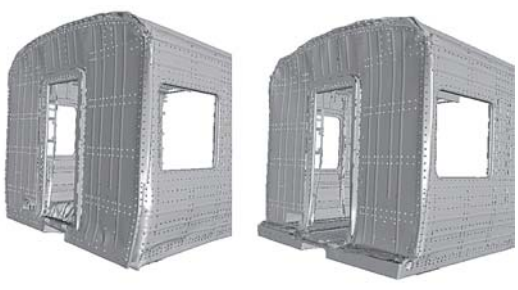

Fig. 3 Deformed FE models

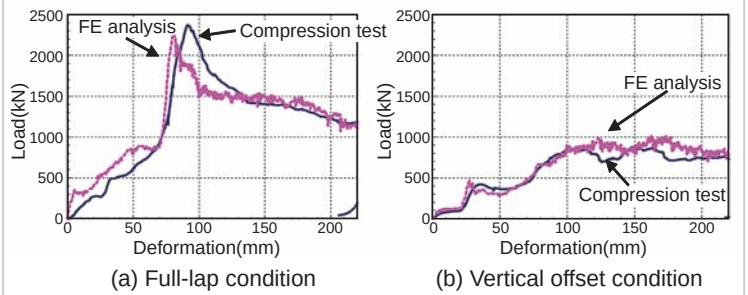

Fig. 4 Comparison of the compression load to deformation curves between testing and numerical results