Behavior Analysis of Seated Passengers at a Train Collision

Koji OMINO
Senior Researcher, Laboratory Head, Ergonomics, Human Science Division

Injuries sustained by passengers on a bench seat

Rail transportation safety measures take a variety of approaches, but always focus on either preventing an accident, or on reducing injuries and preventing a domino effect of injuries if an accident does occur. Research into reducing injuries in the event of a train collision examines not only the primary impact of the vehicle collision, but also the secondary impact caused by the force of the collision hurling passengers against part of the compartment interior or against other passengers. Primary impact studies examine the car body structure, while secondary impact studies examine occupant kinematic factors. Our previous numerical simulations of secondary impacts indicated a pattern in which passengers on bench seats may sustain injuries to the chest area after striking a divider, but these results required confirmation through actual collision experiments. We therefore conducted such experiments, using an impact test dummy to identify passenger kinematic injury patterns. The experiment results provide one perspective on the degree of safety obtained from dividers in the event of a collision.

Collision experiments and results

To experimentally re-evaluate the above-mentioned injury patterns, we seated an impact test dummy "passenger" on a bench seat next to a divider. A collision force was applied to generate a secondary impact in which the dummy was hurled against the divider. Assuming that the most severe injury pattern would involve fractured ribs, we examined the amount of buckling in the chest area to evaluate the degree of safety offered by dividers.

Tests included two types of dividers, a panel type and a tubular type. One dummy was placed in a seated position first beside one type, then beside the other. Three structures taking the place of ribs were installed in the dummy's chest area, one each to represent the upper, middle and lower part of the chest. Devices to measure the extent of chest buckling during the secondary impact were incorporated in the "ribs." Figures 1 and 2 show the secondary impact against the tubular and panel dividers, respectively. Results obtained from measurements of chest buckling are shown in Fig. 3. The most severe buckling was observed after a secondary impact against the tubular divider. That buckling was nearly twice as severe as when the impact was against the panel divider.

Experiment results compared with results from numeric simulations

The collision experiments reproduced conditions that had previously been hypothesized in numeric simulations. The numeric simulation results are shown in Fig. 4. In the collision experiments, the buckling in the chest area as a whole was less than that indicated by the numeric simulations. However, results of the collision experiments and the numeric simulations were in agreement that the maximum amount of chest buckling during a secondary impact tends to be less against a panel divider than against a tubular one. Furthermore, results from both the collision experiments and numeric simulations were also in agreement that, when the secondary impact was against the tubular divider, buckling occurred most in the lower chest area. The collision experiment results support data from the numeric simulations which show that chest injuries are less likely to occur upon impact with a panel divider than with a tubular one, and that a panel divider is therefore preferable from a collision safety standpoint.

(This research was subsidized by the Ministry of Land, Infrastructure and Transport.)

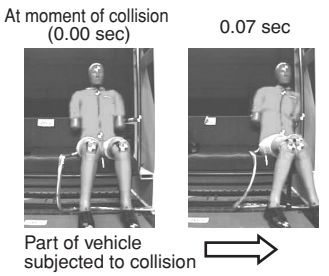

Fig. 1 Collision experiment with tubular divider

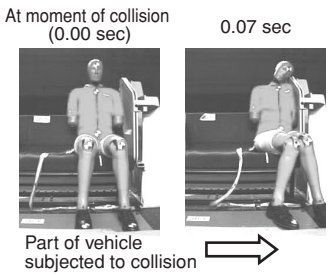

Fig. 2 Collision experiment with panel divider

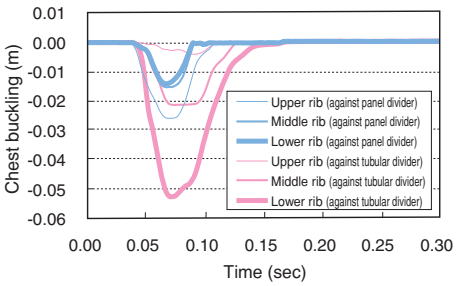

Fig. 3 Data indicating extent of rib buckling in an impact test dummy

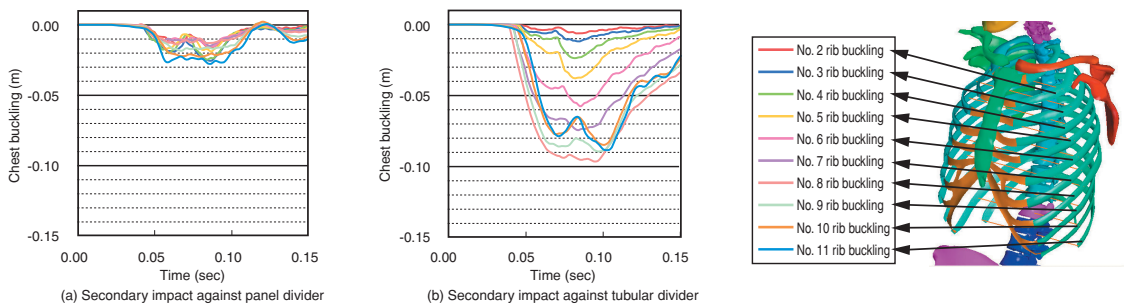

Fig. 4 Extent of chest buckling inferred from numeric simulations