A New Method to Evaluate Ride Comfort Under Braking Conditions

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Faster deceleration when stopping a train at a station would improve transport efficiency. This is an important technical goal, due to the need for prompt mass transit services and short train intervals. We performed tests with human subjects to examine braking patterns that would not reduce ride comfort even under higher deceleration rates, and to clarify the relationship between deceleration, derivative of deceleration (jerk), and ride comfort. We have also proposed a ride comfort evaluation method based on the test results.

Ride Comfort Levels during Braking

We assumed the braking patterns used at stations to stop a train, and performed tests on the Maglev test line of the Railway Technical Research Institute, with human subjects standing on board the train (Fig. 1). Our tests revealed the previously unknown relationship between deceleration, jerk and ride comfort in a high deceleration range. Fig. 2 shows ratios of passengers who could not adequately adjust to the various braking pattern used to stop the train, and these serve as one scale for measuring ride discomfort levels. The figure clearly indicates the rate at which ride comfort deteriorates as deceleration increases. A negative impact on ride comfort was observed even at approximately 0.1m/s^3 jerk difference, and there is a tendency for ride comfort deterioration rates to shift toward higher values as jerk increases.

Proposals for a Ride Comfort Evaluation Index and Optimum Braking Patterns

We used the test data to propose an index to evaluate ride comfort levels during deceleration and jerk that take the form of a trapezoidal braking pattern (Fig. 3). The curves in Fig. 2 are based on this index, and show that ride comfort deteriorates as the index value increases. We also analytically obtained the deceleration and jerk values that minimize the indices for various combinations of initial speeds at braking and stopping distances, and have proposed train-stopping braking patterns that offer optimum ride comfort.

Future RTRI Research in this Field

In the future we plan to study the practical application of brake controls, in order to introduce our proposed braking patterns to commercial operations. During those studies we will also examine ways to widen application of the index so that various other factors influencing ride comfort during braking, including the congestion often seen on commuter trains, can be taken into account. In addition, in order to examine ride comfort more effectively, we intend to develop a system that simulates the swaying of standing passengers when brakes are applied, using the ride comfort data obtained during the above-mentioned study.

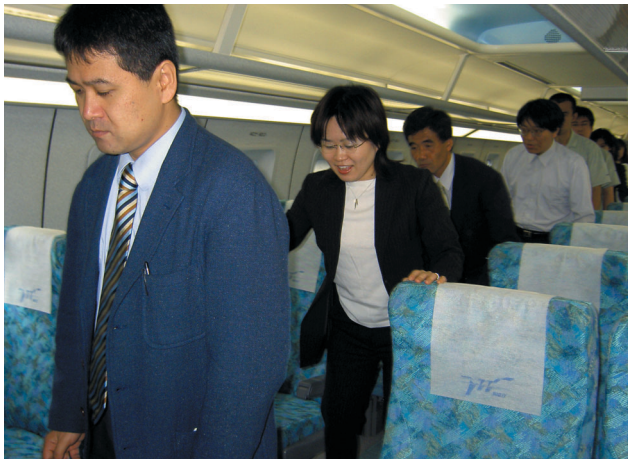

Fig. 1 Ride Comfort evaluation test during braking

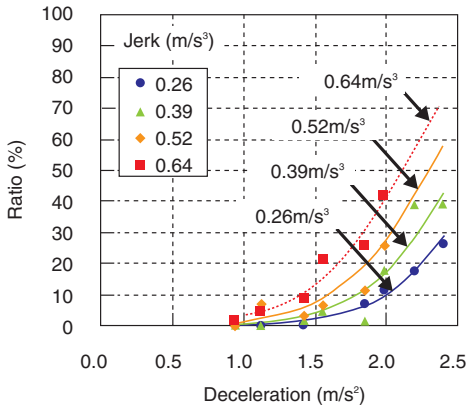

Fig. 2 Ratio of passengers unable to adequately adjust to braking patterns

Index for ride comfort during braking

$$z = \frac{1}{1 + exp(a\beta + bj + c)}$$

β: Deceleration, j: Jerk
a,b,c: Constants

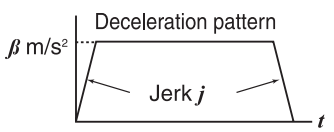

Fig. 3 Index for ride comfort during braking
The greater the value, the poorer the ride comfort