Determining Priorities for Seismic Countermeasures on the Basis of Costs and Benefits

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Railway systems include a variety of facilities and components such as railway structures, tracks, electrification masts, and vehicles. While measures against seismic disaster have been actively applied to various facilities and to prevent derailments since the Hyogo-Ken Nanbu Earthquake (1995) and the Niigata-Ken Chuetsu Earthquake (2004), they have actually been conducted independently from each other. The aseismic capability that individual equipment possesses may therefore vary.

To achieve the objective of an improvement in safety for the whole railway system against earthquakes, aseismic capability and the effect of seismic countermeasures for each facility have to be evaluated using a common standard. In addition, to put effective countermeasures into practice within a limited budget, priorities in reinforcement and the selection of construction methods have to be determined on the basis of a rational principle. Given these circumstances, we calculated the earthquake risk for each railway system, and we proposed an evaluation index to determine the required seismic countermeasures in terms of life-cycle cost derived from the earthquake risk (Fig. 1).

On the basis of the results of recent studies of major earthquakes and active faults, it is possible to stochastically evaluate earthquake motions estimated at a target location by means of a stochastic seismic hazard analysis. By dynamically simulating the ground motion based on the probability of an earthquake occurring and the ground condition of the target point, it is possible to evaluate a surface earthquake motion at a particular location. Further, the seismic risk and the life-cycle cost for each facility can be calculated to give an each facility the seismic vibrations assumed at the ground surface. Finally, the effectiveness of the measure is evaluated by calculating the difference in the life-cycle costs, or DLCC, on each condition before and after a seismic countermeasure has been implemented. Ranking of the effectiveness of each seismic countermeasure can be numerically determined by calculating the DLCC for each location and the construction method of the measure.

Figure 2 shows an outline of how priority is determined for application of seismic countermeasures using this proposed method. Suppose that the DLCC for each location is calculated for each of the three locations A, B and C (for example, embankment, viaduct, and mast). Since location B in the figure shows the highest DLCC resulting from the seismic countermeasure, it was selected as the measure to be taken with the highest priority.

The studies also clarified that the priority varies depending on the seismic activity. In other words, this method allows the most appropriate countermeasures to be chosen for each target line by taking into account the seismicity, ground condition, structural conditions, and the level of traffic at that point.

This method is also applicable for determining the priorities for measures to be taken on different routes, and it is thus expected to be widely utilized when considering the priorities for implementation of seismic countermeasures.

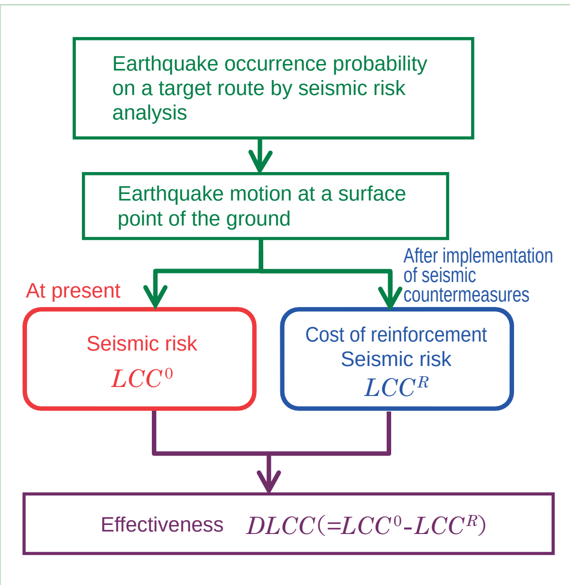

Fig. 1 Flow chart for estimating DLCC

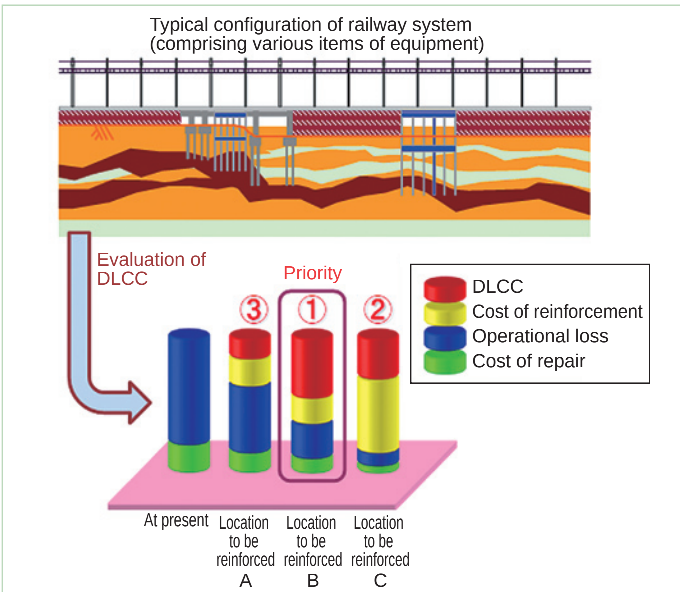

Fig. 2 Outline of determination of priorities for implementing seismic countermeasures