Procedure of Risk Estimation and Cost-benefit Analysis of Road Disaster Risk Reduction Investment for Both Non-seismic and Seismic Events

Mikihiro MORI[1*], Emilio VENTURA[2], Aleyda MONTOYA[2], Alonso ALFARO[2], William GUZMÁN[2], Juan GARCÍA[2], Deyman PASTORA[2], Mónica GUTIÉRREZ[2], Jaime JUÁREZ[2] and Brenda CALERO[2]

[1] Geosphere Engineering & Disaster Management Office Overseas Consulting Administration, Nippon Koei. Co. Ltd. Japan
[2] Department of Climate Change Adaptation and Strategic Risk Management, Ministry of Public Works, Transportation, Housing and Urban Development, El Salvador
*Corresponding author. E-mail: mori-mk@n-koei.jp

INTRODUCTION

The Japan International Cooperation Agency (JICA) has provided technical assistance on road disaster risk management to the Government of El Salvador. The project has begun developing the estimation tools to measure the risks, benefits, and cost-benefit analysis of road disaster risk reduction investments for seismic and non-seismic caused road disaster events from 2016. Non-seismic road damage events occur mostly due to a storm, but may also include non-hydrological events such as rockfall due to the deterioration and loosing of slope ground due to gravity and weather. The target is the whole length of the national roads in the country, and disaster –prone road locations with slopes, crossing streams, and bridges.

The purpose of the methodology is to promote investments in road disaster risk reduction by providing an efficient cost-benefit index.

STUDY FLOW OF RISK AND COST-BENEFIT ANALYSIS

The study of risk and cost-benefit analysis of each road location is undertaken in the sequence shown in **Fig. 1**.

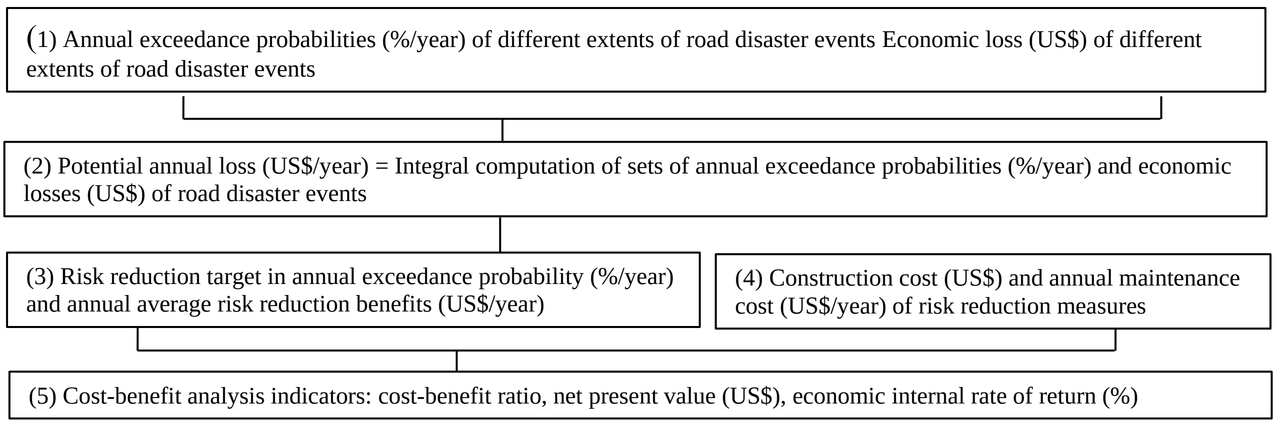

Fig. 1 Study flow of Risk and Cost-Benefit Analysis

RATING CHECKLIST OF OCCURRENCE PROBABILITY OF ROAD DISASTER

In the chart, annual exceedance probability (%/year) is the inverse value of the return period or occurrence probability in years of a road disaster event. Potential annual loss and annual average risk reduction benefits are estimated separately for seismic and non-seismic road disaster events for a road location and summed. Then, cost-benefit analysis for a road location can be conducted.

The procedure is applied for road locations with mountainside slope, with valley-side slope, stream crossing; and set of bridge piers, abutments, and superstructures. The rating checklists are developed and have the same check items to select or identify categories for seismic and non-seismic events. An example item is 'roadside slope angle,' and its category is 'steeper than 40 degree'. Each category has a score of occurrence probability in years for non-seismic disaster risks and critical horizontal seismic accretion (gal) for seismic disaster risks. The rating is determined by summing up the scores selected or the identified categories. The occurrence probability is rated for three damage extents of roadside damage: one-lane road closing and two-lane road closing for non-seismic damage. For seismic or bridge damage, the check sheet can rate the horizontal seismic accretion critical for slope or bridge destruction.

The rating tool is calibrated using the database of actual road damage events (return period of the rainfall or seismic intensity of historical events, or recurrent damage intervals) using multivariate analysis to minimize residual sum of squares between rated and actual values. The occurrence probability in years or critical horizontal seismic acceleration can be estimated using the numerical model calculation of disaster events such as slope failure and can be treated as actual data.

Items in the rating checklists are applied with reference to Japanese road disaster stability rating checklists for non-seismic, adding some items which may contribute to vulnerability with seismic as an initial setting. The probability year of the road/bridge seismic damage is determined by the return period of the rated horizontal seismic acceleration of the location.

ESTIMATION PROCEDURE OF COSTS AND BENEFITS

Cost can be estimated using unit construction cost with the productivity of labor-day, machinery-day, and material quantities.

The benefits of annual risk reduction are the potential annual loss (US$) without measures minus potential annual loss with measures. Risk reduction target in annual exceedance probability (%/year) or its invers occurrence probability in years (year) should be determined to estimate the potential annual loss with measures. For hydrological, hydraulic or seismic hazard, it can be determined as the target return period of the measures. For road slope disaster, it is proposed to be experimentally set. The project proposes the equation, RRT = 500(DSF-1) (unit：year), where
RRT = risk reduction target of the occurrence probability in years of a road location (unit: year)
DSF = design safety factor of slope stability (resistance force against slope failure force)

CONCLUSIONS

The tools would be used for decision-making on road disaster risk reduction investments for seismic and non-seismic disaster risks. In many cases for geohazards, the investments contribute to risk reduction for seismic and non-seismic hazards. For example, drainage for slope stability reduce the slope failure risk induced by both of heavy rains and earthquake. The applicability of items and categories of the rating checklist can be verified during the rating tool calibration.

Keywords: Risk Reduction, Risk Estimate, Cost-Benefit Analysis