

A Study on the Development of Seismic Fragility Function for Construction of Earthquake Damage Assessment System in Korea

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Summary

A study on earthquake damage assessment is very important for the government to manage the disaster, in particular to rapidly respond and judge the situation systematically according to damage scale. Thus the National Emergency Management Agency in Korea is building the Earthquake Disaster Management System. In so doing, the National Institute for Disaster Prevention in Korea has made the related research on seismic fragility functions since 2005. Since the earthquake damage is evaluated in large region, this paper classified each structure according to the status and characteristics of structures, developed fragility functions on the classified structures, and applied the functions to the system. Fragility functions for bridges and railroad systems and others have been developed so far. Also, various methods such as capacity spectrum analysis and inelastic dynamic analysis are used in development of applicable fragility functions to Korea.

Keywords: earthquake damage assessment; seismic fragility function; earthquake disaster management system; structure classification; damage state.

The earthquakes causing major damage are constantly occurring in neighboring countries - China, Japan, Taiwan and etc. Thus many feel fears of possible earthquake whose severe damages are increasing due to rapid urbanization in Korea, although it is on low and medium seismic regions. For effective earthquake prevention, the National Emergency Management Agency (NEMA) is constructing the Earthquake Damage Management System (EDMS) by assessing earthquake damage. The National Institute for Disaster Prevention (NIDP) in Korea is conducting researches on applicable seismic fragility functions to Korean seismic design code and structural characteristic.

It is necessary to classify structure into structural types as tendencies of similar damage and loss for earthquake damage assessment in large region. The EDMS 1st project sorted out the classification for buildings in Korea by 10 types – unreinforced masonry, concrete moment frame and others. Korean classification of buildings is adjusted as distribution status in comparison with HAZUS's classification of buildings. Also to classify Korean road bridges, structural types, sites, and the numbers of years are surveyed, and then suitable classification for bridges is presented. Electric system in HAZUS is different from that in Korea, so the paper surveyed the status of electric power system in Korea and then has sorted out the system by 3 types – transmission substation, generation power plants, distribution system. The Korean Railway Co. that manages railroad facilities in Korea has sorted out railroad systems by railway bridge, tunnel, building and etc. In order to develop seismic fragility functions for railroad system in this paper, the railroad system is classified into track/roadbeds, railway bridge, tunnel, and electric facility, but considering electrification of railroad, oil facility is disregarded in Korea.

The damage state is a qualitative degree about structural damage by earthquake and each damage state is individually defined with each structural property. The damage state of structure offers the preliminary data about instant damage scale, repair, and reinforcement work of damaged structure, and informs the political decision for a countermeasure about budget and relief supplies. To develop seismic fragility functions for building in Korea, the definition of HAZUS is used as qualitative damage state. Also, the quantitative definition uses HAZUS's value together with Korean damage estimation grade. In research result, the damage estimation grade in Korea is rational in some of building type such as unreinforced masonry. And to define the damage states for bridges in Korea, the paper compared the Korean seismic design code, dynamic analysis results of bridges, and others with those of USA, and then suggested the same value of displacement limits for bridges in HAZUS in case of non-seismic design and 80% level in case of seismic. The qualitative definition of damage states in HAZUS is applied to the damage states for the electric power system, but, regarding the properties of substation in Korea, fault tree and event tree are considered for computational analysis in the quantitative definition. And in railway system, the railway line maintenance prescription and the operation prescription are applied to the damage states for railway track/roadbeds. Since railway substations in Korea use not three-phase but two-phase electricity, the damage states for railway substation are defined as considering this condition.

The development of seismic fragility functions in Korea used various analysis methods concerning structure properties and damage state. Although it is necessary to make and verify the seismic fragility curves by earthquake disaster records, only analysis methods are used because the records are insufficient.

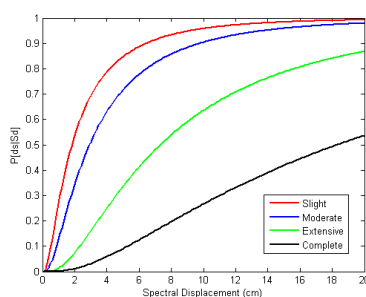


Fig. 1: Fragility Curves
of Low-Rise RC Building

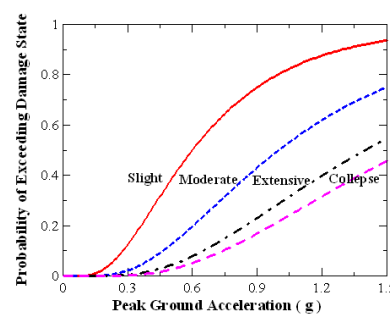


Fig. 2: Fragility Curves
of PSC Box Girder Bridge

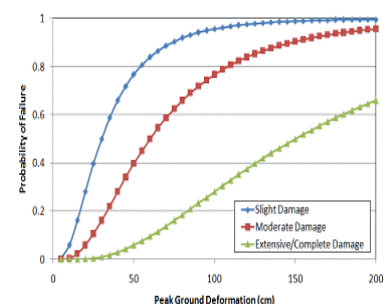


Fig. 3: Fragility Curves
of Railway track/roadbeds

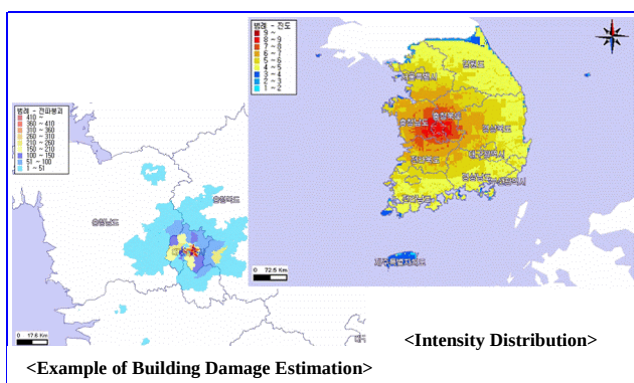


Fig. 4: Map of Building Damage Estimation
and Intensity Distribution

Korea has not been seriously damaged by earthquake recently because Korea is located in low and medium seismic regions, therefore the researches about earthquake damage assessment have not been quite satisfactory as of now in Korea. But, the base of earthquake damage assessment study in Korea is being expanded by research projects of the NIDP and the construction of the EDMS. So, we expect that the reliability of the system will be increased.

The fragility curve is represented through the mean and the standard deviation on cumulative probability distribution curve, so earthquake damage degree can be estimated through comparatively simple algorithms. The EDMS applied the seismic fragility function to assess earthquake damage, was constructed on a web-based the NDMS (Natural Disaster Management System), which includes GIS data of each structure