ESTIMATION OF ECONOMIC LOSSES DUE TO EARTHQUAKE IN LIFELINE SYSTEMS

Morteza BASTAMI
Assistant Professor, IIEES, Tehran, Iran
mbastami@iiees.ac.ir

Ali JAFARIFARD
Student, University of Kurdistan, Sanandaj, Iran
Alijafarifard1381@yahoo.com

Keywords: Direct Loss, Indirect Loss, Output-Input, Effect Ripple, Economic

In this research, we create a linear relationship between seismic time-history parameters and earthquake losses to obtain a model that is able to estimate economic losses of lifeline systems including transportation, telecommunication, potable water and wastewater, natural gas and electric power systems in earthquakes. The model is verified for economic losses data from the past Iran earthquakes such as Rudbar and Manjil 1990, Silakhoor 2006, East Durood 2010, Varzaghan 2012 and Borazjan 2013 earthquakes. Because of Iran's high inflation rate in last years that the earthquakes happened; the monetary value of the losses is different. So the monetary value of losses caused by an earthquake in the lifeline systems calculated according to the annual inflation rate. In this research, base year is considered 2007. Therefore, to estimate economic loss according to the annual inflation rate, we propose a model to estimate the economic losses of earthquakes.

In this research, we were considered economic losses of lifeline Systems as a dependent variable and seismic parameters as independent variables. Stepwise multiple linear regressions were used to create a linear equation between the monetary value of losses and the seismic parameters of Peak Ground Acceleration (PGA), Peak Ground Velocity (PGV) and Peak Ground Displacement (PGD) at various earthquakes; and established significant relationship between economic losses and seismic parameters PGA, PGV and PGD.

$$\mathrm{Loss}_n = [0.925(\mathrm{PGD})_s \pm \varepsilon_\alpha \sigma] \prod_{i=2006}^{n-1} \left(1 + \frac{N_{i+1}}{100}\right) \quad (1)$$

Earthquake damages are not necessarily restricted to such physical damages but may include much wider aspects, such as loss of production due to manufacture suspension, decrease of consumption due to abated social activities, etc. losses associated with such effects would be much greater and more widespread than those counted only from physical failures (Kawashima and Kanoh, 1990). Given the possibility of alternative damage patterns across various business sectors, linked business activities are potentially vulnerable beyond sustaining just direct damage. Thus, the term indirect damage means any loss other than that directly produced by a disaster. These potential losses are not confined to immediate customers or suppliers of damaged enterprises. All of the successive rounds of customers and suppliers of suppliers are impacted. In this way, even limited earthquake physical damage causes a chain reaction, or ripple effect, that is transmitted throughout the regional economy (Brookshire et al., 1997).

Such economic loss in i-th industry (For example electric power systems), decrease productions of other industries which depend on the products of i-th industry, even if their facilities suffered no direct damages by the earthquake. In this study, the ripple effects of direct economic losses is considered as indirect economic losses, and is analyzed through an inter-industry relation analysis (Kawashima and Kanoh,1990).

The most prevalent approach is Input-Output (I-O) impact analysis. I-O table is a summary accounting of all purchases and sales between sectors in a given region (Brookshire et al., 1997).

In this analysis, Iran is considered as a region. Thus, we use Iran's input-output table, the indirect losses due to damage of lifeline systems evaluated by the inter-industry relation.

Table-1 shows the direct loss and indirect loss in the lifeline systems (in terms of Percent). Because most of activities are dependent on Electric power, in that Electric power has the maximum amount of indirect loss (Nearly 52.35%).

Table 1. Share of direct losses and indirect losses (%)

Lifeline system	Indirect Economic loss	Direct Economic loss
Electric power	52.35	47.65
Potable and waste water	40.99	59.01
Communication	24.07	75.93
Natural gas	32.15	67.85

REFERENCES

Brookshire DS, Chang SE, Cochrane H, Olson RA, Rose A and Steen son J (1997) Direct and Indirect Economic Losses from Earthquake Damage, *Earthquake Spectra,* 13(4): 683-701

Kawashima K and Kanoh T (1990) Evaluation of Indirect Economic Effects Caused by the 1983 Nihonkai-chubu, Japan, Earthquake, *Earthquake Spectra*, 6(4): 739-756