APPLYING VALUE ANALYSIS IN DESIGN OF ISOLATED STRUCTURES

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The cost-benefit analysis is an efficient tool for the value assessment in a structural design problem. In the recent years, various frameworks have been proposed to evaluate the performance of a structural design under seismic loads from cost or cost-benefit point of view (e.g. Wen and Kang, 2001; Sanchez-Silva and Rackwitz, 2004; Goda and Hong, 2005; Taflanidis and Beck, 2009). Despite the general similarities between the existing frameworks, most of them are merely based on cost analysis methods and role of benefit as the inherent part of the value analysis has not been considered. Moreover, in the carried out studies, comprehensive approaches are not often applied to account for all the influential variables in cost-benefit analysis. For instance, the effect of the design life period and economic environment as the important variables in cost-benefit analysis has been considered in only few studies (Wen and Kang, 2001; Sanchez-Silva and Rackwitz, 2004). To account all the main variables in cost-benefit analysis, development of a comprehensive framework is needed.

The employment of the value analysis becomes more important in relation to design of modern structural systems such as base isolation. In the base isolation technique, the performance of the structure is significantly improved, but the cost of construction increases in comparison with cost of the conventional systems. To find the optimal performance for the isolation system, different cost aspects such as the construction and life cycle costs should be integrated into a cost-benefit analysis. However, only few of studies have considered the cost-benefit issues related to the analysis and design of isolation system (Goda and Hong, 2010; Wang et al., 2013). On the other hand, the aim in the existing method for design of isolated structures is to provide a high-level of the structural performance (Naeim and Kelly, 1999), while the high performance level may not be necessarily the optimal solution for the design of isolated structures from the value-based point of view.

In the present research, a comprehensive framework based on the cost-benefit analysis is proposed in which the most influential variables are incorporated. These variables are structural performance, occupancy type, design life period and discount rate. In the proposed framework, the value measure of a structural design is defined as the ratio of the benefit, B, to cost, C.

$$V = \frac{B}{C} \qquad (1)$$

Applying the proposed framework in three case studies, a four-story building structure of five different configurations in superstructure with and without base isolation is analysed under various design situations. The same structure with fixed base is also studied in order to find the cases where the employment of the base isolation system has more justification than the conventional fixed-based system. The structural configurations are selected such that to span a wide performance range from very low to very high. For cost-benefit analysis of both fixed and isolated structures, two occupancy types of residential and hospital are selected to represent respectively the ordinary and special applications. Also, three design life periods of 2, 50 and 100 years are considered respectively as short, medium and long term operational durations; as well as four discount rates of 1%, 2%, 3% and 4% to represent economical environments with slow to rapid growths.

From the results obtained through the parametric study in the first case, it is shown that for the residential occupancy, applying the fixed-based structures provides higher value measures to the owner despite that the fixed structures have lower performance compared to the isolated ones (Figure 1). In contrast, the use of isolation system provides more value in the case of hospital occupancy. In addition, it is found that the optimal performance range for the isolated structures is lower than the one for the fixed structure.

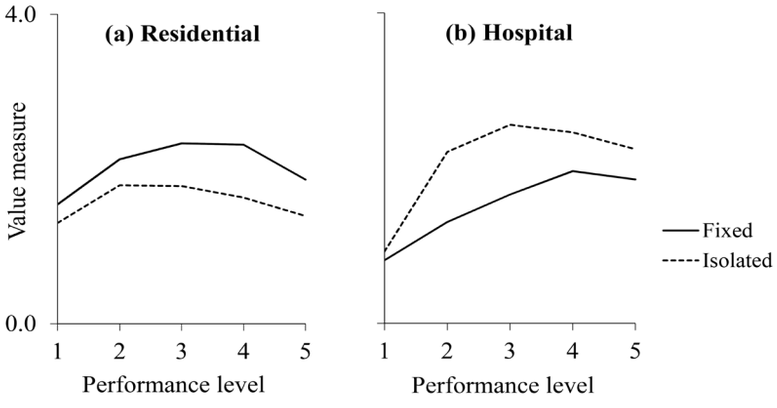

Figure 1. The obtained value measures for design life period of 50 years and discount rate of 2% with the residential and hospital occupancies

The findings from the three case studies confirm that, first, the structural design problem is not only related to the structural performance but also to the variables such as design life period, occupancy type and economic environment of the society, and second, improvement in structural performance by the isolation system may not result in improvement in the value of the design.

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