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THE RESILIENCE OF SPECIAL AND ORDINARY MOMENT RESISTING FRAMES

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The extent of damage after major earthquakes and a significant increase in the demand of organizational, social and structural recovery result in a new design method. For this reason, resilience-based design (RBD) as an advanced form of performance-based design (PBD) has been proposed. This method mostly concentrates on the factors such as recovery time of buildings aftershock, direct and indirect losses, life safety and social preparedness. In this methodology, recovery time is the most difficult parameter to obtain because there are a lot of uncertainties which affect downtime (Serban, 2015). Cimellareo (2008) firstly suggested the analytical recovery functions in his thesis which were related to the community preparedness. For instance, a city with a high intelligent society, good infrastructures, and the cautiousness has shorter recovery time in comparison with other societies. To do so, choosing a recovery function should be done accurately to make it compatible with the type of the society. Three common recovery functions in an engineering manner are linear, exponential and trigonometric which are shown in Equations 1 to 3 (Cimellareo, 2008).

$$f_{rec}(t.T_{RE}) = \left(1 - \frac{t - t_{0E}}{T_{RE}}\right); \tag{1}$$

$$f_{rec}(t) = \exp[-(t - t_{0E}) * (\ln 200)/T_{RE}]; \tag{2}$$

$$f_{rec}(t) = 0.5 * \left[1 + \cos\left[\frac{\pi(t - t_{0E})}{T_{RE}}\right]\right]; \tag{3}$$

For estimating the amount of the losses which depends on different factors such as the occupancy class of structures, hazard levels of regions and damage states HAZUS methodology is used. Moreover, a relative parameter which converts damage probabilities that are calculated from fragility curves to a non-dimensional variable is utilized in the loss assessment procedure (HAZUS-MR4, 2003).

The resilience is calculated with the integral of the functionality (Q(t)) in Equation 4. Finally, the resilience set equal to the normalized area under the functionality-time curve over the defined period of time (Tlc).

$$R_{Resi} = \frac{1}{T_{lc}} \int_{t_0}^{t_0+T_r} Q(t)dt \tag{4}$$

$$Q(t) = 1 - [L(I, T_{re})(H(t - t_{0E}) - H(t - (t_{0E} + T_{RE}))) \times f_{REC}(t, T_{0E}, T_{RE})] \tag{5}$$

In Equation 5, T_{re} is the recovery time of the structure, t_{oE} is the occurance time of the incident, H is the Heaviside function which is zero for non-positive data and is one for positive data, and f_{REC} is the function of time (Bruneau et al., 2007).

For assessing the seismic resilience of steel frames, the special and ordinary moment resisting frames are designed and modelled with ETABS and OpenSEES, respectively. Following this, the incremental dynamic analyses and fragility curves are derived based on the far-field records. Furthermore, the resilience of frames is calculated for three different recovery times for the intensity of 2%/50 years which are depicted in Figures 1 and 2.

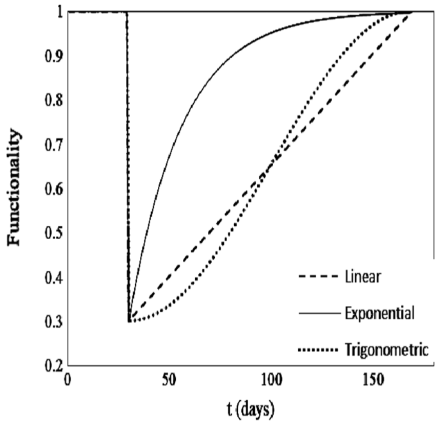

Figure 1. The effect of recovery functions on the SMF based on the far-field records for intensity 2%/50 years.

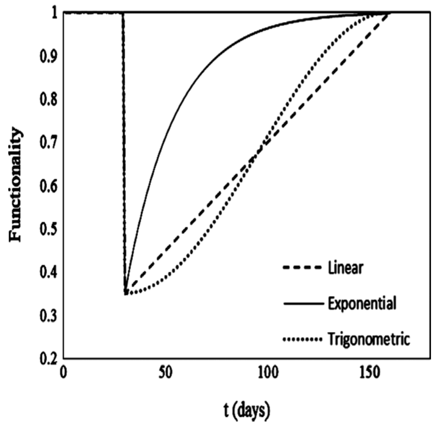

Figure 2. The effect of recovery functions on the OMF based on the far-field records for intensity 2%/50 years.

In result, based on the differences between the underneath normalized area of recovery functions, exponential recovery time can increase the resilience around 20 percent which is significant. Therefore, besides all elements and factors that are taken into consideration in the design of the structures, the facilities that are available in the cities, appropriate infrastructures and preparedness of the society can increase the resilience of the buildings remarkably.

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