Resilience of a complex of six hospitals

Gian Paolo CIMELLARO1, Andrei M. REINHORN2 & Michel BRUNEAU3

1 Grad. Res. Asst. Department of Civil, Structural & Environmental Engineering, University at Buffalo. e-mail: gpc2@buffalo.edu
2 Clifford C Furnas Eminent Professor, Department of Civil, Structural & Environmental Engineering, University at Buffalo.
3 Director of MCEER, Prof. Department of Civil, Structural & Environmental Engineering, University at Buffalo.

ABSTRACT

As the idea of building disaster-resilient communities gains acceptance, new methods are needed that go beyond estimating monetary losses and that address the complex, multiple dimensions of resilience. This research demonstrates the concept of seismic resilience through the development and application of quantitative measures to a complex of 6 hospitals located in Memphis, Tennessee. It explains the fundamental concepts of resilience proposing a unified terminology and establishing a common frame of reference and it gives a quantitative definition of it through the use of an analytical function that allows giving any quantitative measures of resilience.

An application to health care facilities is presented (West Coast MCEER demonstration hospital) and comparisons are done in term of resilience curve among different retrofit strategies considered: No action, Rehabilitation to Life Safety, Rehabilitation to Immediate Occupancy, Rebuild. The example demonstrates that the resilience framework can be valuable for guiding mitigation and preparedness efforts.

BACKGROUND

Resilience is defined graphically as the normalized shaded area in the functionality plot shown in Figure 1. On the x-axis there is the time range considered for system recovery while in the y-axis there is the functionality Q(t) of the system measured as a non-dimensional quantity in percentage. The methodology to calculate resilience is summarized mathematically in the following framing Equation (1):

\[ \Pi = \frac{1}{N} \sum_{n=1}^{N} \int_0^T \left[ H(t_{\text{eq}}) - H(t_{\text{eq}} + \theta) \right] \alpha_n(t_{\text{eq}}) \left( t_{\text{eq}} + \theta \right) \, dt \times p_1(t_{\text{eq}}) \times f(t) \]  

OBJECTIVES

The objectives of this research are:

- to provide a quantitative definition of resilience in a rational way through the use of an analytical function that may fit both technical and organizational issues;
- to analyze the fundamental concepts of seismic resilience, establishing a common frame of reference;
- to present an application to a group of six hospitals. The hospitals are located in Memphis, Tennessee. Comparisons are made for the evaluation of resilience when using different retrofit strategies.

Damage Assessment

The losses and costs considered in this case study are listed in the following tables:

<table>
<thead>
<tr>
<th>Table 1 Losses of the case study</th>
<th>Table 2 Expected equivalent costs for diff. rehab strategies</th>
</tr>
</thead>
</table>

RESULTS

It is assumed that losses are independent

CONCLUSIONS

The definition of seismic resilience combines information from technical and organizational fields, from seismology and earthquake engineering to social science and economy. So it is clear that many assumptions and interpretations are made during the study of seismic resilience, but the final goal is to integrate the information from these fields in a unique function that reach results that are unbiased by uninformmed intuitions or preconceived notions of how large or how small the risk is. An application to a system of six hospitals is presented and different rehabilitation strategies are compared. However, it is important to mention that the assumptions that are made for the case presented are only representative to illustrate the definitions; for other problems users calculating resilience should focus on the assumptions that most influence the problem at hand.

ACKNOWLEDGEMENTS

Program area: Thrust area #2: Seismic Retrofit of Acute Care Facilities; Task numbers: 040002c, 042004, 04101: Principal investigator and/or faculty advisor: A. M Reinhorn and M. Bruneau. This work is supported by the MCEER program of the National Science Foundation.