Resilience

Resilience has to do with recovery after a shock. The term was used in the 1970s in the context of ecological systems subjected to adversity (Holling 1973). Figure 1 shows a "resilience curve," i.e., the functionality level of, say, a community after a shock, such as an earthquake. Curves like that are intuitive, but often it is necessary to dig deeper to understand the resilience of a system. Questions that quickly emerge include: What is the actual measure of functionality? What are the models that predict the drop in functionality? What are the models that predict the predict the recovery of the functionality?

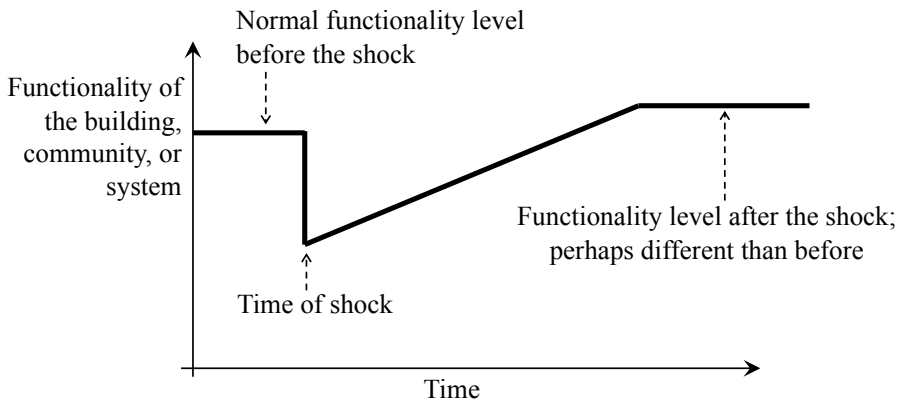

Figure 1: A resilience curve.

In the context of seismic resilience of communities an Earthquake Spectra paper from 2003 has been influential (Bruneau et al. 2003). That paper puts forward the following four Rs, which are also included in Figure 2:

- Robustness: Ability to withstand the shock
- Redundancy: Ability of secondary elements to carry the effects of the shock
- Resourcefulness: Availability of resources to recover after the shock
- Rapidity: Timeliness in making those recourses available after the shock

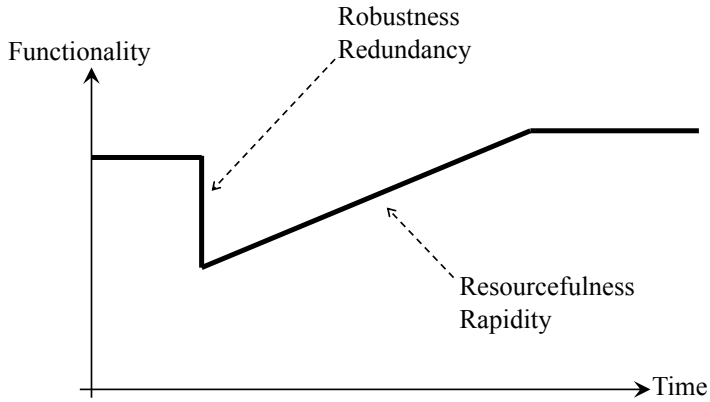

Figure 2: Definitions related to resilience.

Resilience also has to do with systems and communities. That means that the performance of a building is only one part of a bigger picture. The functionality of critical societal functions and critical infrastructure is a paramount concern in the resilience studies envisioned here. See for example the Action Plan for the Protection of Vital Societal Functions and Critical Infrastructure developed by the Swedish Civil Contingencies Agency. In several references, for example the NIST report on understanding societal needs, the following items are included as societal critical functions:

- Habitat
- Power
- Water
- Fuel
- Transportation
- Telecommunications
- Waste removal

Structural engineers influence several of those items. The design of buildings, i.e., habitat to withstand earthquakes is one example. The design of bridges in a transportation network is another example. Structures that are part of power grids and telecommunication grids are also within the scope of structural engineers. Several documents on this website are relevant for the repairability of such structures.

References

Bruneau, M., Chang, S. E., Eguchi, R. T., Lee, G. C., O'Rourke, T. D., Reinhorn, A. M., Shinozuka, M., Tierney, K., Wallace, W. A., and Von Winterfeldt, D. (2003). "A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities." *Earthquake Spectra*, 19(4), 733–752.

Holling, C. S. (1973). "Resilience and Stability of Ecological Systems." *Annu.Rev.Ecol.Syst.*, 4, 1–23.