# Building Disaster Resilient Communities

*By Chris D. Poland, S.E.*

Healthy cities continuously grow by driving economic development while protecting cultural heritage. Success, in part, depends on a healthy built environment that is rooted in contemporary urban planning, sustainability and disaster resilience. Our job, as design professionals, is to provide a built environment that supports all of those goals. Our designs need to be efficient, economical, adaptive, sustainable, and disaster resilient. We are doing well on all fronts except for the last. We need to develop, and include in the code, provisions that will provide the buildings and lifelines needed to support disaster resilience.

Resilient communities have a credible disaster response plan that assures a place and ability to govern after a disaster has struck. Their power, water, and communication networks begin operating again shortly after a disaster and people can stay in their homes, travel to where they need to be, and resume a fairly normal living routine within weeks. The return to a "new" normal can then occur within a few years. While every building should protect its occupants from harm, a select few buildings need to remain operational and a larger group needs to be at least usable during repair. Lifeline systems must be restored quickly to support response and reconstruction.

San Francisco is already moving in this direction. The San Francisco Planning and Urban Research Association (SPUR at **www.spur.org**) recently published four policy papers related to what San Francisco needs from its seismic mitigation policies. Called the *Resilient City Initiative*, these papers define resiliency in a deterministic manner based on what the city needs from its buildings and lifelines to support response, recovery and rebuilding post-disaster. It is a set of goals that can be applied to any community facing any natural disaster. At the heart of the recommendations are the need for clarity in the hazard level and the expected damage from a disaster.

Engineers have used a variety of measures to define the size of earthquakes they design to. The first, and one held in high regard by the media, is the Richter Magnitude. Unfortunately, it means little to earthquake engineers and is not referenced in the code. These days, we prefer to talk about earthquakes in terms

*Table 1: Performance Measures that Support Disaster Resilient Cities.*

| CATEGORY | BUILDINGS |
|---|---|
| A | **Safe and Operational.** This describes the performance now expected of new essential facilities such as hospitals and emergency operations centers. Buildings will experience only very minor damage and have energy, water, wastewater, and telecommunications systems to back up any disruption to the normal utility services. |
| B | **Safe and usable during repair.** This describes performance for buildings that will be used to shelter in place and for some emergency operations. These will experience damage and disruption to their utility services, but no significant damage to the structure. They may be occupied without restriction and are expected to receive a green tag after the expected earthquake. |
| C | **Safe and usable after repair.** This describes the current expectation for new, non-essential buildings. Buildings may experience significant structural damage that will require repairs prior to resuming unrestricted occupancy, and therefore are expected to receive a yellow tag after the expected earthquake. Time required for repair will vary from four months to three years or more. |
| D | **Safe but not repairable**. This level of performance represents the low end of acceptability for new, non-essential buildings, and is often used as a performance goal for existing buildings undergoing rehabilitation. Buildings may experience extensive structural damage and may be near collapse. Even if repair is technically feasible, it might not be financially justifiable. Many buildings performing at this level are expected to receive a red tag after the expected earthquake. |
| E | **Unsafe.** Partial or complete collapse. Damage that will likely lead to significant casualties in the event of an expected earthquake. These are the "killer" buildings that need to be addressed most urgently by new mitigation policies. |
| | **LIFELINES** |
| I | **Resume 100% of service levels within 4 hours**. Critical response facilities, including evacuation centers and shelters, need to be supported by utility and transportation systems. This level of performance requires a combination of well built buildings and systems, provisions for making immediate repairs or activating back-up systems as needed, and redundancy within the networks that allows troubled spots to be isolated. |
| II | **Resume 90% service within 72 hours, 95% within 30 days, and 100% within four months.** Housing and residential neighborhoods require that utility and transportation systems be restored quickly so that these areas can be brought back to livable conditions. There is time to make repairs to lightly damaged buildings and replace isolated portions of the networks or create alternate paths for bridging around the damage. There is time for parts and materials needed for repairs to be imported into damaged areas. These systems need to have a higher level or resilience and redundancy than the systems that support the rest of the city. |
| III | **Resume 90% service within 72 hours, 95% within 30 days, and 100% within three years.** The balance of the city needs to have its systems restored as buildings are repaired and returned to operation. There is time to repair and replace older vulnerable systems. Temporary systems can be installed as needed. Most existing lifeline systems will qualify for Category III performance. |

*Table 2: Resilient performance requirements for the built Environment.*

| Phase | Time Frame | Condition of the Built Environment |
|---|---|---|
| 1 | ***1 – 7 days*** | ***Initial Response and staging for reconstruction*** |
| | Immediate | Mayor proclaims a local emergency and the City activates its Emergency Operations Center. Hospitals, police stations, fire stations and City Department operations centers are operational. |
| | Within 4 hours | People who leave or return to the city in order to get home are able to do so. Lifeline systems that support critical response facilities are operational. |
| | Within 24 hours | Emergency response workers are able to activate and their operations are fully mobilized. Hotels designated to house emergency response workers are safe and usable. Shelters are open. All occupied households are inspected by their occupants, and less than 5% of all dwelling units are found unsafe to be occupied. Residents can shelter in place in superficially damaged buildings even if utility services are not functioning. |
| | Within 72 hours | 90% of the utility systems (power, water, wastewater, natural gas and communication systems) are operational and serving the facilities supporting emergency operations and neighborhoods. 90% of the major transportation systems routes, including Bay crossings and airports, are open at least for emergency response. The initial recovery and reconstruction efforts will be focused on repairing residences and schools to a usable condition, and providing the utilities they need to function. Essential City services are fully restored. |
| **2** | ***30 to 60 days*** | ***Housing restored – ongoing social needs met*** |
| | Within 30 days | All utility systems and transportation routes serving neighborhoods are restored to 95% of pre-event service levels, public transportation is running at 90% capacity. Public schools are open and in session. 90% of the neighborhood businesses are open and serving the workforce. Medical provider offices are usable again. |
| | Within 60 days | Airports are open for general use, public transportation is running at 95% capacity, minor transportation routes are repaired and reopened. |
| **3** | ***Several Years*** | ***Long-term reconstruction*** |
| | Within 4 months | Temporary shelters are closed, with all displaced households returned home or permanently relocated. 95% percent of the community retail services are reopened. 50% of the non-workforce support businesses are reopened. |
| | Within 3 years | All business operations, including all City services not related to emergency response or reconstruction, are restored to pre-earthquake levels. |

of their probabilities of occurrence. The favorites are the 10/50 and 2/50. That is an earthquake that will have a 10% or 2% chance of exceedence in 50 years. In the SPUR Initiative, a combined track was taken by suggesting that every city faced three characteristic sizes of earthquakes, (routine, expected, and extreme), and that the design for disaster resilience should accommodate the expected earthquake defined as the event that could occur once in the life of the building under consideration. Urban planners and city policy makers are more comfortable planning for "expected" events rather than "extreme" events in all aspects of their work. For San Francisco's buildings, it's an M=7.2 on San Andreas Fault located as close to the city as possible. For lifelines, other scenario events need to be defined.

Earthquake Professionals are rarely clear about the level of damage that can occur to their buildings and lifeline systems in the expected earthquakes they are designing for. While this is a comfortable position to take because of the concern about liability, it has led to a significant misconception on the part of the public. Because they are generally not told that their building was only designed to keep the people safe and may actually be seriously damaged, they believe that their buildings are "earthquake proof". SPUR decided to tackle that misconception head on and defined eight states of damage that clearly state whether people are safe inside and how soon the building can be used after the shaking stops. *Table 1 (page 33)*, taken from the SPUR Urbanist, defines these transparent performance measures that are key to the public's understanding of the problem and interest in the proposed solution. These categories of damage need to become part of the design and construction vocabulary.

Cities do not need to resist disaster without damage. In fact, history shows that, most often, recovery can occur even though significant damage occurs. The key to success is at the heart of disaster resilience. SPUR defines response and recovery in three phases, the same often used by emergency planners. *Table 2* defines the needed condition of the built environment to properly support the recovery. In the first phase, the weeklong response and rescue period, only the emergency response centers are needed. These buildings need to be capable of Category A performance, Safe and Operational, and the supporting lifelines capable of Category I performance. These are the Occupancy Category IV buildings specified in the *2006 International Building Code* (IBC), though there is no code requirement for the lifelines.

The second phase of recovery focuses on restoring the neighborhoods within 30 to 60 days so that the workforce can be reestablished, their communities restored, and people are able to return to a normal life style and back to work. This is a new idea that grew out of the Katrina experience. People need to have a place to live, send their kids to school, do their shopping, and create community if they are to participate in the cities economic recovery. The buildings they depend on need to be capable of Category B performance, safe and usable during repairs, and the lifelines that serve them capable of Category II performance. This is a new performance level, not covered by the IBC today, though it does look a lot like the requirements for Occupancy III buildings. There are no such requirements for lifelines.

The third phase of recovery covers the repair and reconstruction of the affected area. Buildings need only be safe while they are repaired or replaced within the target period. The current IBC requirements for Occupancy I and II buildings should meet this goal, although the extent and cost of repair needs to be planned for if the 3 year time frame is to be achieved. Funding for the repairs is a key consideration, as are the standards that the repair needs to follow. Pre-event planning and insurance should be given serious consideration.

In many ways, we have the tools and procedures to create disaster resilient cities. It will require some modification to the current IBC, significant alignment of the lifeline systems around common performance objectives, and strong community support for adopting the policies needed to mitigate the deficient buildings, build new buildings to the performance levels needed, and insist that the lifeline systems they depend on can deliver as needed. Making such a shift to updated codes, and generating community support for new policies, is not possible without solid, unified support from the science and engineering communities that support design. We as design professionals need to take the time to understand this issue, join the conversation about how to achieve resiliency, build it into our research programs, convince our owners to incorporate it in their projects, and be a part of the common voice from our profession on how to change the codes. We need to do this.▪

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