RAPID POST-EARTHQUAKE DAMAGE EVALUATIONS

MRP Engineering Newsletter **August 2012**

In the event of an earthquake, a rapid damage assessment program is vital for making decisions on resuming occupancy and operations. The cornerstone of this approach is a post-earthquake damage evaluation program including building-specific forms that can be utilized by qualified facility staff immediately after an event. When coupled with training in safety and emergency response, this post-event program is an effective tool for facility teams to perform the initial rapid damage evaluations, determine the level of structural and nonstructural damage, and initiate follow-on actions. MRP Engineering's observations of post-earthquake recovery following earthquakes clearly indicate that organizations with well-organized post-event emergency response can efficiently proceed with recovery of operations. This newsletter describes MRP Engineering's post-earthquake damage evaluation program that has been implemented by our clients to assist in recovery after a significant earthquake.

EARTHQUAKE DAMAGE EXAMPLES

The following photographs from recent MRP Engineering post-earthquake investigations illustrate general types of damage and its significance.

Lateral soil spreading near a community center near Tokyo, Japan, 2011; the pile-supported building survived

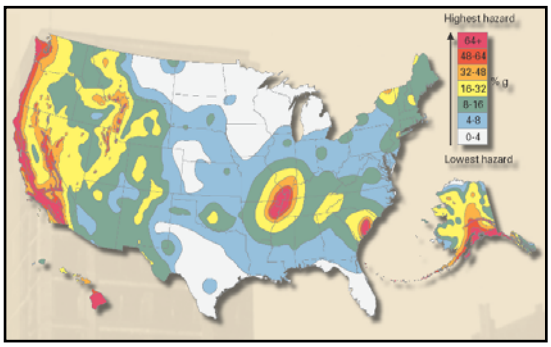
Extensive wall damage in office building in Port-au-Prince, Haiti, 2010, requiring extensive repairs before re-occupancy

Damaged high-rise residential tower in Santiago, Chile, 2010, requiring substantial structural repairs

Damaged elevated walkway at Santiago International Airport, Chile, 2010; until repaired the area was off limits

POST-EVENT DAMAGE EVALUATION PROCEDURES

A post-earthquake evaluation program is crucial to allow a business to rapidly assess impacts and make informed decisions to speed up recovery. Organizations with facilities located in moderate or high earthquake hazard areas should maintain an emergency response program that considers earthquake scenarios. The adjacent map indicates earthquake-prone areas in the United States.



Seismic Hazard Map of U.S. showing 2,475-year ground motions (Source: USGS)

The post-earthquake rapid evaluations are performed using building-specific forms based on the structure's lateral-load-resisting system. The forms include building floor layouts to aid in damage assessment. The procedure is based on systematic damage evaluation steps beginning with the building exterior to review safety and hazards at the perimeter. Damage evaluation teams conduct the initial evaluations by walking around and (if deemed safe) through the building, completing the forms, determining the appropriate placards, consulting with the Incident Commander, and posting the building using the appropriate colored placard at all access points. The system is based on ATC-20 approach and includes three color-coded placards that are used for the initial posting of buildings (at all entrances and exits):

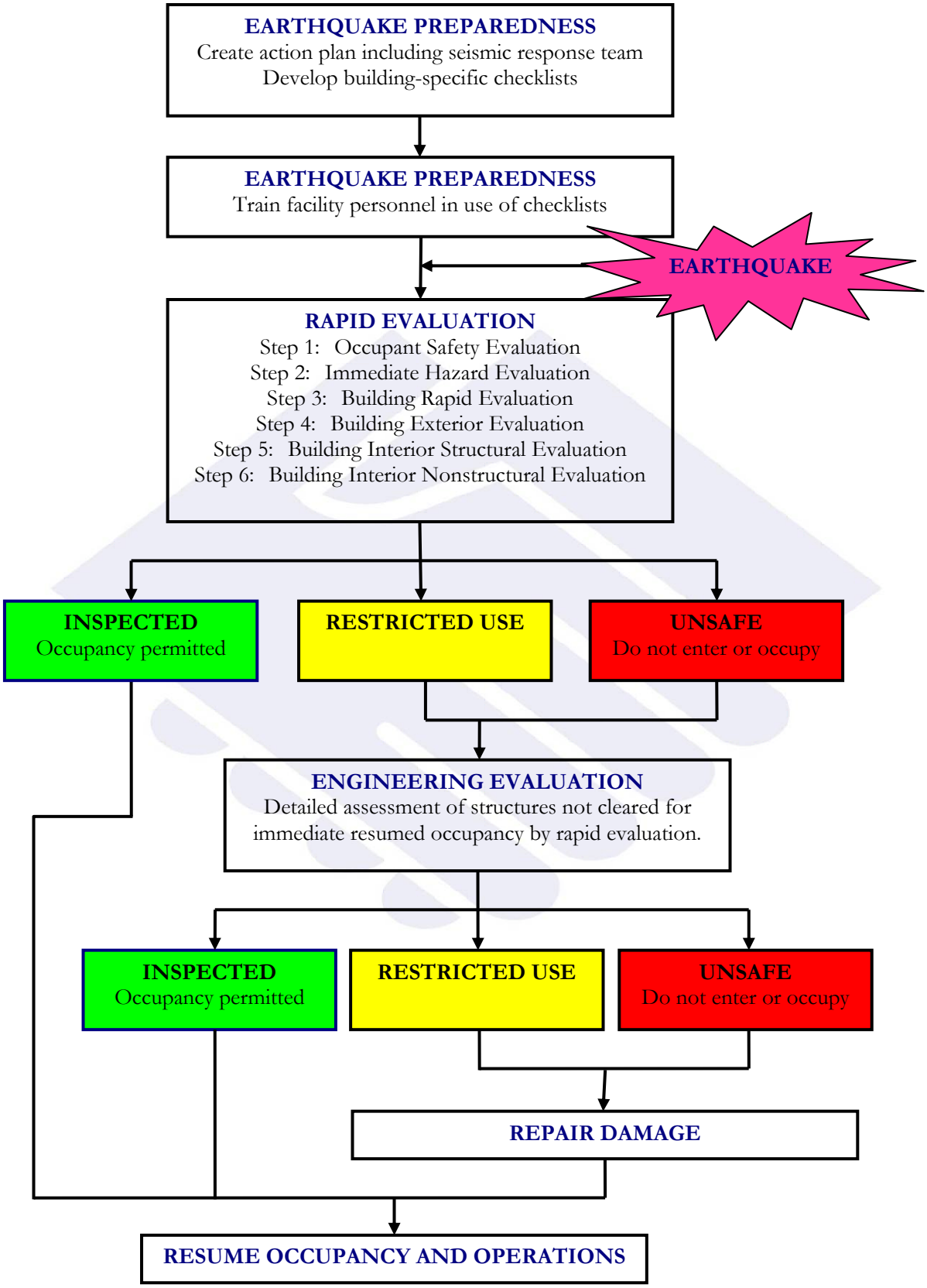
Placard Color	Posting	Description
Green	INSPECTED—OCCUPANCY PERMITTED	The building has no apparent structural hazard. Cleanup, minor repairs, and additional evaluations may still be required.
Yellow	RESTRICTED USE	The building should not be occupied until further evaluation or repairs are completed by qualified personnel.
Red	UNSAFE—DO NOT ENTER OR OCCUPY	The structure has been seriously damaged and is unsafe.

Upon completion of each building evaluation, the checklists are returned to the Incident Commander or designee. The Incident Commander collects all of the damage evaluation forms and initiates appropriate follow-on actions for structures that require detailed engineering evaluations or repairs. The overall post-earthquake damage evaluation program consists of these components:

1. Development of building-specific damage evaluation forms by MRP Engineering for use by qualified on-site personnel
2. Training of on-site facility personnel in use of the damage evaluation forms and instructions on how to recognize significant earthquake damage

The flowchart below outlines the process of evaluating facilities for damage after an earthquake, making initial occupancy decisions, communicating findings, and initiating follow-on actions. The overall program should also include external technical resources that may be required to perform detailed engineering damage assessments and repairs.

Post-Earthquake Damage Evaluation Flowchart



EARTHQUAKE PREPAREDNESS BENEFITS

A facility-specific damage assessment plan can make a significant difference in efficient re-occupancy and business recovery. The program results in:

- Early understanding of extent and significance of damage
- Communication of findings with management and initiation of follow-on actions
- Early access to external technical resources, if repairs are needed

Recent earthquake events have clearly demonstrated that efficient recovery following major earthquakes is possible when preparedness actions are taken. The alternative may result in prolonged downtime and lack of access to specialized resources that may be in demand immediately after the event.

MRP ENGINEERING TECHNICAL CORNER

The MRP Technical Corner is a newsletter feature that addresses timely earthquake-related questions.

Question: How do early earthquake warning systems work?

Answer: Earthquakes can originate from a variety of sources, such as along interfaces of tectonic plates (plate subduction as exemplified by mega-earthquakes in Chile, 2010, and Japan, 2011, or crustal spreading as in Iceland, 2000). Other earthquakes may occur at the earth's surface along crustal faults (such as in Haiti, 2010), or deep below the surface where the crust breaks apart (such as 2001 event near Olympia, WA). When an earthquake occurs, the ground-shaking energy is released in several wave forms, including P-waves (pressure) and S-waves (shear). The pressure waves generate an abrupt shock that radiates quickly from the earthquake's hypocenter. Shear waves that travel more slowly generate destructive lateral motions. The time lag between arrival of P-waves and damaging S-waves at a point of interest can allow communication of early warnings (from a few seconds to a couple minutes) before the onset of strong ground shaking.

Earthquake-warning systems are widely used in Japan, Taiwan, and Mexico, and in limited regions of California. The systems consist of arrays of seismic motion sensors distributed throughout a region. High-speed communications systems and computers collect and analyze the sensor readings. When a significant event is detected, warnings are dispersed throughout the region likely to be affected. Such warnings can be sufficient to allow people to move to safer areas or initiate a shutdown of critical operations.

Tsunami warning systems detect sea level changes and calculate potential tsunami arrival times. The systems are triggered by seismic activity occurring offshore. Sea-level height is monitored to verify the existence of a tsunami. Potential wave height and arrival times are then calculated, and notifications are sent to first responders, armed forces, and population centers with alert systems (sirens). Multiple communication lines are generally employed, such as email, radio, and text messaging.

MRP ENGINEERING

MRP Engineering is a structural engineering and risk analysis firm specializing in earthquake engineering. The firm was founded in 2002 and is located in metropolitan Seattle, Washington. Our technical staff actively contributes to the advancement of earthquake engineering standards and routinely investigates performance of structures and systems in actual earthquake events. We assist clients in protecting their business operations from risks to physical assets resulting from extreme events such as earthquakes and hurricanes. Our philosophy is to listen to your needs and then provide you with practical and cost-effective ***structural engineering-based risk reduction solutions****. For further information please visit us at our website or contact us at info@mrpengineering.com.*