MANAGING EARTHQUAKE RISKS FOR A RAPID FUNCTIONAL RECOVERY

MRP Engineering Newsletter **June 2020**

Today, more than ever, private enterprises and public organizations understand that in addition to protecting their employees, a timely recovery of basic operations is necessary for economic survival, as illustrated by the 2020 pandemic and ensuing health and economic crises. However, once in the midst of a crisis, choices are constrained by the resources at hand. Consequently, pre-disaster preparedness and mitigation actions focused on safety and functional recovery can reduce a potential disaster into a manageable emergency. Functional recovery means that a building is not only occupiable, but it has also resumed its basic function. There is never a convenient time to address risks from rare events, such as earthquakes. Since they can occur anytime, now the time to prepare is. This newsletter discusses development of a practical safety and functional recovery action plan that addresses potential earthquake risks for your organization. An example case study is included to illustrate risk results and associated action plan.

Why manage earthquake risk?

Identifying and mitigating unacceptable existing exposures is vital for business enterprises and communities located in earthquake country. Existing buildings, including equipment systems, were designed to past editions of building codes that focused on occupant safety and not on damage protection. Building codes change reflecting lessons learned from recent earthquakes. Due to evolving building standards, some pre-existing structures may not meet the safety goals or be functional as soon as desired following a major earthquake. Current building codes for new construction intend "collapse prevention" in a major earthquake and usability in a minor event. Future codes and design standards addressing functional recovery goals for new construction are still some years away.

Risk transfer via property insurance is often considered, as it provides a payment in exchange for an annual premium in the event of a covered loss. However, risk transfer alone does not prevent damage or disruption of operations. Insurers increasingly look for a record of loss-control activities before underwriting earthquake risks. Still, property insurance rates can be pricey and deductibles high in regions with the highest seismic hazard. Claim payouts may not be rapid enough or adequate enough to fund repairs immediately after an event. For example, earthquake aftershocks may occur in the weeks or months following the main shock resulting in additional damage, complicating claim processing, and delaying insurance payments, as was the case in 2010-11 in Christchurch, New Zealand (see below).

2010-2011 Earthquake Sequence, Christchurch, New Zealand: *Prior to 2010, a passive retrofit policy for seismically vulnerable buildings resulted in limited structural upgrades. The region was impacted in 2010 and 2011 by a sequence of damaging earthquakes. Following the M6.3 earthquake in 2011, Christchurch central business district (CBD) was cordoned off for many months affecting all CBD businesses, whether damaged or not. Attributing damage to specific earthquake events was complicated resulting in protracted claim processing and delayed payments to fund necessary repairs. The regional recovery continues to this day.*

How to manage earthquake risk to enhance rapid functional recovery?

Addressing safety concerns is the first risk management priority. Following that, the goal is to protect those assets that enable rapid recovery (buildings, equipment systems, and utilities) of operations and to mobilize sufficient post-event resources when they are most needed. For existing facilities, our approach involves:

- An earthquake risk assessment to understand existing exposures
- A safety and functional recovery action plan to prioritize risk mitigation tasks

A risk assessment involves evaluating the seismic hazard, assessing structural/equipment vulnerabilities, and quantifying the resulting exposures. The resulting damage projections can identify potential safety concerns. Probable maximum losses (PMLs) measure potential financial impacts. Repair time projections provide insight into potential business interruptions.

A safety and functional recovery action plan is needed to guide risk mitigation actions aimed at reducing lengthy disruptions. Addressing safety concerns alone, such as high-risk structures, may not be enough to enable a rapid recovery of function or use. As we observed following the 2010 M8.8 earthquake in Chile, some modern residential towers and industrial facilities experienced many months of downtime.

How to identify impediments to functional recovery?

MRP Engineering earthquake investigations and experience validate that the following elements are important for a rapid restoration of facility operations following a major earthquake:

- Stability of site soils and building foundations
- Very limited (readily repairable) damage to the structures
- Functionality of in-building equipment in utility systems
- Rapid restoration of offsite lifeline systems (electricity, water, communications, transportation)

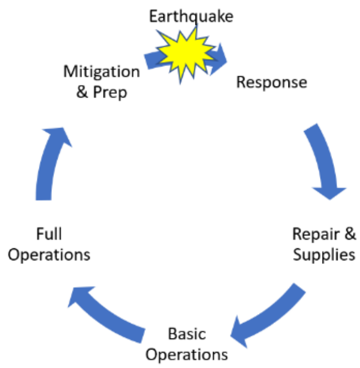
MRP Engineering's risk evaluation approach entails a site visit, a review of structural drawings for key buildings, and a review of site soils reports. The vulnerability assessment is based on engineering observations of building construction, in-building equipment restraints, and utility installations. The resulting risk report includes damage scenarios for the structures and equipment, associated PMLs, and potential repair times. This engineering-based method provides a more reliable vulnerability assessment than a solely a computer-based risk evaluation and leads to a prioritized action plan to enhance safety and recovery of operations. Recommended actions consider safety, loss of function, and property loss. "As-improved" PMLs provide a measure of financial benefit of mitigation. The findings can be integrated into a more effective emergency response and business recovery plan.

Post-earthquake building damage assessment and repairs may be lengthy. Japan points to a damage-reducing solution. Specifically, many data centers in Japan are built with structural protective systems such as dampers and/or base-isolation bearings. These systems are intended to preclude significant structural and contents damage by dissipating the ground-shaking energy thus reducing building movement. Most Tokyo area data centers resumed full operations within hours following the 2011 M9 earthquake.

What is meant by resilience and functional recovery?

Resilience is an attribute of an organization, not of a single building or asset. **Resilience** represents the ability of an organization to prepare for, absorb, and recover from an adverse event in an acceptable time. **Functional recovery** is achieved when a building or an asset has resumed its basic operation following a major event, thus contributing to the organization's resilience.

What is needed for rapid restoration of operations?



Functioning emergency response systems and adequate repair resources are critical following an earthquake and can mean weeks, not months, before resuming operations. MRP Engineering investigations of industrial facilities damaged in the 2010 Chile earthquake revealed a vast range of recovery times depending on their response capability and repair resources. This holds particularly true for industrial plants where specialized expertise is required to assess and repair equipment damage. The table below shows examples of what is needed and when during post-event recovery phases.

Post-event Phase	What is needed?	When needed?
Emergency Response	Monitoring sensors, Fire protection, control rooms, communications, backup power	Seconds to hours
Repair Resources	Maintenance, engineering, spare parts, supplies	Days to weeks
Basic Operations	Manufacturing machinery, or other core functions	About 2 months[1]
Full Operations	Warehousing, etc.	More than two months

1. Target recovery period can vary depending on industry and criticality of services.

Sample earthquake risk assessment results and a functional recovery action plan are presented next. The reward of implementing a risk mitigation program is improved safety and a more rapid functional recovery in the event of a major earthquake.

M8.8 February 27, 2010—Chile: *This subduction earthquake generated two minutes of strong ground shaking and tsunamis affecting central Chile, home to forest products, energy, and marine industries. Preparedness and communications dramatically enhanced response and recovery of operations. Primary electrical supply was disrupted and backup power was critical for rapid damage assessment, testing, and repairs. Protected control rooms equipment allowed safe shut down of industrial plants.*

Industrial plants in Talcahuano (Concepcion), Chile, experienced months of downtime following the 2010 M8.8 earthquake.

Sample earthquake risk assessment results and a functional recovery action plan:

Consider a hypothetical manufacturing campus of modern buildings. The risks of extensive structural (building) damage and related safety issues are relatively low for most buildings. However, equipment and other systems damage can still result in a significant downtime. The risk evaluation report includes a "loss summary" with probable maximum losses (PMLs), or costs to restore the facility to pre-earthquake condition, represented in terms of percentage of its replacement value or in dollars (when coupled with values at risk). The table below illustrates existing losses as well as potential reduced losses for a "retrofitted" case, assuming that loss-control recommendations are implemented. When reviewing the recommended action plan (see below), this information is very useful in assessing the benefits of seismic risk mitigation.

Example Loss Summary

Item	**Value**	**Existing**		**Retrofitted**	
Buildings	$100M	20%	$20M	15%	$15M
Equipment	$100M	30%	$30M	10%	$10M
Time element	$150M	4 months	$50M	2 months	$25M
Total	**$350M**		**$100M**		**$50M**

The following table presents a functional recovery action plan for the example facility, with recommendations aligned with post-event timeline and recovery phases. Comparing the timeline with "as-is repair times" points to actionable "gaps" for items not meeting their functional timeline.

Example Functional Recovery Action Plan

Post-event Timeline	**Recovery Phase**	**Building/System**	**As-is Repair Time**	**Recommendation**
Seconds to Minutes	Emergency Response	Natural gas	1 week	Install seismic sensor/shutoff valve
		Vibration-sensitive plant equipment	2 months	Install seismic sensor for safe equipment shutdown
		Fire protection pump	1 week	Anchor fuel tank
		Control room	1 month	Brace consoles, UPS, and servers
Days to Weeks	Repair Resources	Response plan	N/A	Develop damage assessment checklists and align resources
		Electrical substation	1 month	Store spares; provide backup generator
		Maintenance shop	1 month	Brace spare parts racks
Weeks to Months	Basic Operations	Manufacturing	4 months	Replace bracing; anchor production equipment
Months to Years	Full Operations	Warehouse	4 months	Anchor inventory racks
		Manufacturing expansion	N/A	Consider a structure with base-isolation or dampers

Begin with high benefit-to-cost activities, such as anchoring equipment near exits to preserve clear emergency egress routes or bracing critical IT and communications components. Relatively low-cost seismic shutoff sensors for natural gas or other flammables reduce fire-following-earthquake risk. Customized post-earthquake damage assessment checklists serve to expedite response and repairs to "bounce back stronger".