Natural Hazard Risk Management for Critical Infrastructure

M. Lehmann
ABS Consulting/ EQECAT
Summary of Presentation

- Overview ABS Consulting
- Methodology for Managing Natural Hazards
  - Global Risk Modelling
  - Onsite Risk Assessment
  - Mitigation
- Projects Examples
  - Telecommunications
  - Electrical Power (Transmission & Distribution)
  - Water Distribution
  - Transport Infrastructure
Worldwide:

- $340+ Million revenue
- 2,200+ employees
- 58 Offices
- 32 countries
ABSC Core Competency

MANAGING RISK

Identify

Natural Hazards
- Earthquakes
- Hurricane/Windstorms
- Flood
- Tornado/Hail/Ice
- Wildfire

Man-Made Hazards
- Sabotage
- Human error
- Equipment Failures
- Process Failures
- Fire/Explosions
- HAZMAT release
- Terrorism

Evaluate

Property Damage:
- Buildings
- Equipment
- Inventory

Business Interruption

Environmental Impacts

Non-Owned Assets
- Supply Chain Analysis
- Suppliers
- Infrastructure
- Customers

Manage

Financial
- Insurance
- Insurance Captives
- Retention
- Securitization

Operational
- Improve Procedures
- Risk Mitigation
- Cost/Benefit Analysis
- Retrofit Design
- Emergency Recovery
- Training

ABSC Consulting

EQECACT
ABS Methodology
Natural Hazard Risk Reduction

Analysis of Global/Regional Portfolio
The EQECAT models cover over 88 countries worldwide.

Single Site Risk Assessment
On-site risk survey; evaluation of hazard level and physical and operational vulnerabilities.

Cost/ Benefit Analysis
• Detailed study of Options
• Feasibility Study
• Cost/benefit Analysis

Implementation
Selection of preferred option. Implementation of Risk Reduction Plan.

Phase 1 Report
Estimate of Potential Loss (PML & BI). Recommendations to reduce the risk

Phase 2 Report
Estimate of costs for proposed Risk Reduction measures.

Phase 1
Phase 2
Phase 3

Phase 1

Phase 2

Phase 3

Abs Consulting

Analysis and optimisation of portfolio
The EQECAT models cover over 88 countries worldwide.
“State of the Art” catastrophe models comprise key scientific/engineering components to develop expected damage:

- **Hazard Module**
- **Portfolio of assets dataset**
- **Vulnerability Module**
  - Engineering judgment
  - Historical asset damage
  - Asset response analyses
  - Secondary Features
- **Financial Loss Module**

---

**Unreinforced Masonry (URM)**

**Description**: Steel or concrete frame, with unreinforced brick, concrete block, or hollow clay tile walls; may be low-rise to high-rise, and serve commercial, institutional, or residential tenants; floors generally concrete or steel.

**Key Identifiers**: Visible brick, concrete block, or hollow clay tile walls; no reinforced concrete walls; may have exposed concrete beams and columns; beams and columns in grid pattern; may have large window area on all sides.

**Common Defects**:
- Tall parapets
- Large wall openings
- Large areas with unreinforced infill

**Wind Performance**: Typically moderate to high risk to structural system. However, infill is generally lost and poses life safety concerns.
**Global Portfolio Analysis**

**Flood**
Water depth at each point for different scenarios

**Earthquake**
For each location
PGA = f(M, d, local geology)
MMI = f(PGA, soil)

**Windstorm**
For each location
\( V_w = f(P_c, d, \text{topography}) \)
Understanding Vulnerability - Developing Damage Functions

- Earthquake
- Windstorm
- Flood
- Tsunami

Vulnerability Functions
Calculated damage for each Location

DMG

<table>
<thead>
<tr>
<th>Const 1</th>
<th>Const 2</th>
<th>Const 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>30%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>70%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>80%</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>90%</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Damage Losses can be grouped by:

- Country
- Region, Division, Postcode etc
- Loss Type (Annual Gross, Ground Up, Aggregate..)
- Single or Combined Perils
- Multiple Return Periods (100, 250, 500 year..)
Phase 1 – On-Site Risk Assessments
Key Recommendations to help Reduce the Risk (Action Plan):

- Strengthening of vulnerable assets (buildings/equipment/tanks/pipelines etc) to better resist against Earthquake or Windstorm loading.
- Flood protection systems for below and above ground assets.
- Anchorage of Back-up power supplies, utilities and communication systems essential for production.
- Identification of alternative transport routes into and out of the site.
- Training of Local Site Staff.
Phase 1 - On-Site Risk Assessment

Site Risk Analysis for the Key Contributing Facilities in the Portfolio:

- Detailed Quantification of the Local Site Hazard for single or multiple perils (Earthquake, Flood, Windstorm,..)
- Start Up Meeting with local Site Staff and Facility Management to discuss key operations at the site and dependencies on local infrastructure and business-critical lifelines (power, water, communication systems etc).
- Survey of the facility by ABS Consulting Engineers to identify the critical Vulnerabilities of key assets including:
  - Buildings
  - Equipment
  - Stock
  - Tanking & Pipe work
- Evaluation of the Financial Loss Expectancy based on the findings from the site visit.
Phase 2 – Cost/Benefit Analysis
Phase 2 – Cost/Benefit Analysis

For the Selected Recommendations:

- Detailed Assessment of the Costs required to undertake the proposed improvement measure(s).
- Re-evaluation of the Financial Loss Expectancy for the facility assuming the measures are in place.
- Cost-Benefit Analysis of the proposed options to assist in identifying most economic solutions and to optimise the risk management program.

<table>
<thead>
<tr>
<th>Option</th>
<th>Loss Estimate Before Strengthening</th>
<th>Loss Estimate After Strengthening</th>
<th>Estimate Cost of Strengthening</th>
<th>Cost/Benefit Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Property Damage (PD)</td>
<td>Business Interruption (BI)</td>
<td>Property Damage (PD)</td>
<td>Business Interruption (BI)</td>
</tr>
<tr>
<td>1</td>
<td>$7,800,000</td>
<td>$25,000,000</td>
<td>$3,500,000</td>
<td>$15,400,000</td>
</tr>
<tr>
<td>2</td>
<td>$12,350,000</td>
<td>$42,550,000</td>
<td>$5,580,000</td>
<td>$23,550,000</td>
</tr>
</tbody>
</table>
Phase 3 – Implementation of Recommendations
To execute the proposed recommendations ABS Consulting Engineers can provide:

- Detailed engineering analysis
- Production of technical drawings and specifications where required
- Assistance in the tendering process for selecting contractors
- Supervision of installation works on site
- Guidance manual on future maintenance
Selected Examples
Power/ Telecommunications

Major UK Power Distributor - All Hazard Risk Assessment

MFL, NLE and BI loss estimates due to catastrophe events for a major UK utility provider. This also covered employer, public and third party liability exposures.

UK Telecommunications Client- Windstorm Loss Exposure

Quantification of windstorm loss exposure of the Radio Mast network, currently estimated at a capital value of £100 million.
Water Utilities

Water Utility – Europe
Earthquake Risk Assessment

Detailed assessment of the local seismic hazard and on-site engineering surveys to determine key asset vulnerabilities. Estimation of property damage and business interruption losses / provision of recommendations.

Water Utility – UK
Multi-Hard Risk Assessment

Loss evaluations for Fire/Explosion/Terrorism/Earthquake/Windstorm and Flood exposures at key production facilities in support of the clients insurance renewal program. Proposal of improvement measures to reduce the risk.
Transport

Roadway Bridges - Seismic Retrofit Program

Focus: Preliminary seismic assessment of 26 bridge structures located in five Northern California counties. Proposal of Retrofit Strategies to minimize potential.

Rail - Earthquake Insurance Study

Focus: Detailed Risk Assessment during the construction of the new Tramway System to evaluate the Earthquake risk exposure (PD and BI) as part of the insurance policy requirements, South of the Tagus, Portugal.