Earthquake Resilience: Building Resilient Communities

Oregon Seismic Safety Policy Advisory Commission

Chris D. Poland, SE, FSEAOCC, NAE
Chairman & Sr. Principal, Degenkolb Engineers
September 20, 2011
Healthy Cities

Require jobs, heritage, urban planning, progressive governance, sustainability and disaster resilience

Oregon Seismic Safety Policy Advisory Commission
September 20, 2011
Resilience: the ability to prepare for, withstand, and rapidly recover from a disruption, and adapt to changing conditions (White House 2010)
Directs actions to

- strengthen security and resilience through built and sustained capabilities
- to prevent, protect against, mitigate the effects of, respond to, and recover from those threats that pose the greatest risk
- Report goals within 180 days
- Report systems within 240 days
- Annually report progress
Vision:

A nation that is earthquake-resilient in public safety, economic strength, and national security
Earthquake Resilient Communities

Requires a Holistic Approach

- **Physical Resilience** is the foundation
- Environmental sustainability is a parallel goal – eliminate the deconstruct/reconstruct cycle.
- Integrated with urban design
- Supportive of Social issues
- Conscience of Institutional and governance constraints
- Supported by new financial mechanism and incentives
Earthquake Resilient Communities

Physical Resilience

- Credible Disaster Response Plan that includes continuity of operations
- A place, ability and procedures to govern
- Building and lifeline design standards that support continuity and recovery
- Repair standards for reconstruction
How Much Damage Can a City Endure?

Haiti - 2010

Katrina - 2005

Chile - 2010

L’Aquila - 2009

Oregon Seismic Safety Policy Advisory Commission
September 20, 2011
The Resilient City:

Defining what San Francisco needs from its seismic mitigation policies for three phases

Before the Disaster, Response, Recovery

Oregon Seismic Safety Policy Advisory Commission
September 20, 2011
Seismic Mitigation Task Force

Urban Planners: Laurie Johnson, George Williams
City Officials: Laurence Kornfield, Hanson Tom, Debra Walker
Public Policy Makers: Sarah Karlinsky, Laura Dwelley-Samant, Tom Tobin
Engineers: Chris Barkley, David Bonowitz, Joe Maffei, Jack Moehle, Robert Pekelnicky, Chris Poland
Labor: Michael Theriault
Developers: John Paxton, Ross Asselstine
Economist: Jessica Zenk
Contractor: Jes Penderson
PG&E: Kent Ferre

A unique gathering of Earthquake professionals and Stakeholders
Approach:

- Define concept of *resilience* in the context of disaster planning and recovery, not a measure of the status

- Establish *performance goals* for the physical infrastructure for the “expected” earthquake that supports the definition of resilience

- Define transparent *performance measures* that help reach the performance goals
Performance Goals for the “Expected” Earthquake

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time Frame</th>
<th>Condition of the built environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1 to 7 days</td>
<td>Initial response and staging for reconstruction</td>
</tr>
<tr>
<td>II</td>
<td>7 to 60 days</td>
<td>Workforce housing restored – ongoing social needs met</td>
</tr>
<tr>
<td>III</td>
<td>2 to 36 months</td>
<td>Long term reconstruction</td>
</tr>
</tbody>
</table>

_Lifelines and workforce are the key elements_
## Transparent Hazard Definitions

<table>
<thead>
<tr>
<th>Category</th>
<th>Hazard Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>Likely to occur routinely in San Francisco (M = 5.0, 50/50)</td>
</tr>
<tr>
<td>Expected</td>
<td>Reasonably expected to occur once during the useful life of a structure or system (M= 7.2, 10/50, 500)</td>
</tr>
<tr>
<td>Extreme</td>
<td>Reasonably be expected to occur on a nearby fault (M=7.9, 2/50, 2500)</td>
</tr>
</tbody>
</table>
# Transparent Performance Measures for Buildings

<table>
<thead>
<tr>
<th>Category</th>
<th>Performance Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category A</td>
<td><strong>Safe and operational</strong>: Essential facilities such as hospitals and emergency operations centers</td>
</tr>
<tr>
<td>Category B</td>
<td><strong>Safe and usable during repair</strong>: “shelter-in-place” residential buildings and buildings needed for emergency operations</td>
</tr>
<tr>
<td>Category C</td>
<td><strong>Safe and usable after repair</strong>: current minimum design standard for new, non-essential buildings</td>
</tr>
<tr>
<td>Category D</td>
<td><strong>Safe but not repairable</strong>: below standard for new, non-essential buildings. Often used as a performance goal for existing buildings.</td>
</tr>
<tr>
<td>Category E</td>
<td><strong>Unsafe – partial or complete collapse</strong>: damage that will lead to casualties in the event of the “expected” earthquake - the killer buildings</td>
</tr>
</tbody>
</table>
What is Safe?
What is Useable?

Observed Damage
L’Aquila, Italy
May 2009
ATC 20 Tagging

Green tag – May be used for continuous occupancy

Yellow tag – Safe enough to remove contents and do repair work

Red tag – Unsafe for entry during aftershock sequence
ATC 20 Criteria for Continued Occupancy

Noticeable leaning

Beams or girders shifted on their supports

Floors and roofs pulled away from their supports

Lateral loads system badly damaged

Nails on plywood walls withdrawn

Severe concrete damage – cracks over 3/8", rebar exposed, concrete fallen away

Braced steel frames buckled

Exterior facade unstable – falling away
### Transparent Performance Measures for Lifelines

<table>
<thead>
<tr>
<th>Category</th>
<th>Performance Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category I</td>
<td>Resume 100% service within 4 hours</td>
</tr>
</tbody>
</table>
| Category II | Resume 90% service within 72 hours  
 95% within 30 days  
 100% within 4 months |
| Category III | Resume 90% service within 72 hours  
 95% within 30 days  
 100% within 3 years |
## Target States of Recovery for Building & Infrastructure

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time Frame</th>
<th>Focus of Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>1 to 7 days</td>
<td>Initial response and staging for reconstruction</td>
</tr>
</tbody>
</table>

*EOC’s,*  
*City Buildings,*  
*Hospitals,*  
*Police and Fire Stations,*  
*Shelters*

### Peter O Kohler Pavilion

**Building Category A:** “Safe and Operational”  
**Life Line Category I:** “Resume essential service in 4 hours”
## Target States of Recovery for Building & Infrastructure

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time Frame</th>
<th>Focus of Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>7 to 30 days</td>
<td>Workforce housing restored – ongoing social needs met</td>
</tr>
</tbody>
</table>

*Residential structures,*

*Schools,*

*Community retail centers,*

*Doctors offices*

**Building Category B:** “Safe and usable while being repaired”

**Life Line Category II:** “Resume 100% workforce service within 4 months”
## Target States of Recovery for Building & Infrastructure

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time Frame</th>
<th>Focus of Attention</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>2 to 36 months</td>
<td>Long term reconstruction</td>
</tr>
</tbody>
</table>

- **Industrial Buildings**
- **Commercial buildings**
- **Historic buildings**

*Building Category C: “Safe and usable after repair”*

*Life Line Category III: “Resume 100% commercial service within 36 months”*
## Target States of Recovery for San Francisco’s Building & Infrastructure

### Phase I

<table>
<thead>
<tr>
<th>INFRASTRUCTURE CLUSTER FACILITIES</th>
<th>Event occurs</th>
<th>Phase 1 Hours</th>
<th>Phase 2 Days</th>
<th>Phase 3 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CRITICAL RESPONSE FACILITIES AND SUPPORT SYSTEMS</strong></td>
<td></td>
<td>4</td>
<td>24</td>
<td>72</td>
</tr>
<tr>
<td>Hospitals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Police and fire stations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency Operations Center</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Related utilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roads and ports for emergency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CalTrain for emergency traffic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airport for emergency traffic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EMERGENCY HOUSING AND SUPPORT SYSTEMS</strong></td>
<td></td>
<td>30</td>
<td>60</td>
<td>36</td>
</tr>
<tr>
<td>95% residence shelter-in-place</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency responder housing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public shelters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% related utilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% roads, port facilities and public transit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% Muni and BART capacity</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Target States of Recovery

<table>
<thead>
<tr>
<th>PERFORMANCE MEASURE</th>
<th>DESCRIPTION OF USABILITY AFTER EXPECTED EVENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDINGS</td>
<td></td>
</tr>
<tr>
<td>Category A:</td>
<td>Safe and operational</td>
</tr>
<tr>
<td>Category B:</td>
<td>100% restored in 4 hours</td>
</tr>
<tr>
<td>Category C:</td>
<td>100% restored in 4 months</td>
</tr>
<tr>
<td>Category D:</td>
<td>100% restored in 3 years</td>
</tr>
</tbody>
</table>

Note: Categories A–D are defined on page 10.
# Target States of Recovery for San Francisco’s Building & Infrastructure

## Phase II

### Target States of Recovery for San Francisco’s Buildings and Infrastructure

<table>
<thead>
<tr>
<th>Infrastructure Cluster Facilities</th>
<th>Event occurs</th>
<th>Phase 1 Hours</th>
<th>Phase 2 Days</th>
<th>Phase 3 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential City Service Facilities</td>
<td>4</td>
<td>24</td>
<td>72</td>
<td>30</td>
</tr>
<tr>
<td>Schools</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical Provider Offices</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% Neighborhood Retail Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95% of All Utilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% Roads and Highways</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% Transit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90% Railroads</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airport for Commercial Traffic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95% Transit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Performance Measure

- **Buildings**:
  - **Category A**: Safe and operational
  - **Category B**: Safe and usable during repairs
  - **Category C**: Safe and usable after moderate repairs
  - **Category D**: Safe and usable after major repairs

- **Lifelines**: Expected current status

**Description of Usability after Expected Events**

**Note**: Categories A–D are defined on page 10.
## Target States of Recovery for San Francisco’s Buildings and Infrastructure

### Phase III

<table>
<thead>
<tr>
<th>Infrastructural Cluster Facilities</th>
<th>Event Occurs</th>
<th>Phase 1 (Hours)</th>
<th>Phase 2 (Days)</th>
<th>Phase 3 (Months)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Community Recovery</strong></td>
<td></td>
<td>4</td>
<td>24</td>
<td>72</td>
</tr>
<tr>
<td>All residences repaired, replaced or relocated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>95% neighborhood retail businesses open</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50% offices and workplaces open</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-emergency city service facilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All businesses open</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% utilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% roads and highways</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% travel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Performance Measure**

- **Buildings**
  - Category A: Safe and operational
  - Category B: Safe and usable during repairs (100% restored in 4 hours)
  - Category C: Safe and usable after moderate repairs (100% restored in 4 months)
  - Category D: Safe and usable after major repairs (100% restored in 3 years)

**Lifelines**

Expected current status

Note: Categories A–D are defined on page 10.
Achieving Resilience

New Buildings

• Establish seismic performance targets for new buildings that allow us to recover quickly.

• Make improvements to the Building Code to provide cost-effective improvements in seismic performance.

• Declare the expected seismic performance that will be achieved by the current Building Code.

• Develop optional code provisions for Seismic Silver and Gold to quantify improved seismic performance.

• Develop strong incentives related to taxes, fees, zoning, or planning that encourage building to higher seismic standards.
Achieving Resilience

Existing Buildings

• Retrofit or redundancy for designated shelters.
• Mitigation program for essential city services.
• Mitigation program for un-reinforced masonry buildings
• Mitigation program for critical non-ductile concrete buildings.
Achieving Resilience

Lifelines

1. Establish a “Lifelines Council” to provide a mechanism for comprehensive planning.

2. Conduct a seismic performance audit of lifelines in the region and establish priorities for lifeline mitigation.

3. Establish partnerships with regional, state and private sector entities to address multi-jurisdictional and regional systems.
Need New Design Codes and Standards

Requires a Transparent Approach

- Next generation hazard definitions
  - Expected earthquake for building resilience
  - Extreme earthquake for lifelines and building safety
- New Vocabulary to describe damage in terms of response and recovery
  - Describe in terms of safety and usability
- Performance Objectives to support resilience
  - Add an intermediate “shelter-in-place” goal
- Mandatory mitigation, but only as needed
National Earthquake Hazards Reduction Program

2009-2013 Strategic Plan
Vision: A nation that is earthquake-resilient in public safety, economic strength, and national security

2011 NRC Report
National Earthquake Resilience, Research, Implementation, and Outreach
National Earthquake Hazards Reduction Program

Vision: A nation that is earthquake-resilient in public safety, economic strength, and national security

Advisory Committee on Earthquake Hazards Reduction

- Established in 2004 to assess
  - Trends and Developments
  - Effectiveness of NEHRP
  - Need to Revise NEHRP
  - The management, coordination, implementation activities
National Earthquake Hazards Reduction Program

Advisory Committee on Earthquake Hazards Reduction

Walter Arabasz
Jon Bray
Jim Harris
Mike Lindell
Chris Poland (Chair)
Anne vonWeller
Brent Woodworth

Jim Beavers
Richard Eisner
John Hooper
Tom O’Rourke
Susan Tubbesing
Yumei Wang
National Earthquake Hazards Reduction Program

Achieving National Disaster Resilience through Local, Regional, and National Activities

A White Paper for the White House Senior Director for Resilience Policy

www.nehrp.gov
Achieving National Disaster Resilience

- NEHRP has provided many tools
  - Seismic monitoring and mapping
  - Building code development
  - Risk mitigation
  - Emergency preparedness

- Serious gaps still exist
  - Existing physical infrastructure is inadequate
  - Building standards are not sufficient to achieve resilience
  - Critical lifelines will not provide needed services
Achieving National Disaster Resilience

- Current Status of the nation with regard to Resilience
  - Code adoption is neither universal nor comprehensive
  - Enormous diversity exists in how model codes are adopted and enforced
  - Even with full compliance, current codes would not provide resilience.
    - Codes are designed to safeguard life and support emergency response
    - Codes do not provide for post-disaster performance
  - There is no such thing as a fully compliant city
Achieving National Disaster Resilience

- Change is needed
  - Resilience starts locally and encompasses the built environment along with the socioeconomic and cultural needs
  - National Resilience can not be achieved without supporting local measures
  - Cities need to be empowered and funded to build resilience neighborhood by neighborhood
    - Develop human infrastructure for response and recovery
    - Plan for effective lifeline response
    - Advance building standards to a resilience level
    - Eliminate “killer buildings”
Achieving National Disaster Resilience

• Unified support is required from all levels of government
  • Federal Government
    • Set performance standards for all construction
    • Insist that states adopt and enforce the codes
    • Provide financial incentives to stimulate mitigation
    • Support research that leads to cost effective mitigation, response, and recovery
Achieving National Disaster Resilience

- Unified support is required from all levels of government
  - State and local governments
    - Identify and mitigate regional lifeline system vulnerabilities
  - Local Governments
    - Adopt and enforce appropriate Building codes
    - Current Expand preparedness planning
    - Develop mandatory mitigation programs
Creating Earthquake Resilience

• **Craft a Mitigation Program**
  • New generation of national codes and standards based on expanded research
  • Develop mandatory, incentive driven, encouraged, and voluntary rehabilitation programs based on resilience.
  • Development of resilient state and national networks of lifelines.
  • Strengthen adoption and enforcement

• **Refine Emergency Response planning**
  • Add neighborhood response ability including posting.

• **Plan for Recovery**
  • Set goals for livable-sustainable cities.
  • Develop plans for governance