SCAG Earthquake Preparedness Initiative

Regional Seminars
October 25 - November 9, 2016

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What is your earthquake risk?

Your Risk =
Probable Loss in lives & dollars =

What the Earth does X what you do
What is your earthquake risk?

Risk = Hazard × Exposure × Fragility ÷ Response ÷ Recovery

Faulting, shaking, landsliding, liquefaction

Extent & density of built environment

Structural weaknesses

Ability to respond

Will to recover
Preparedness Now

- Available on YouTube
- From SCEC - Southern California Earthquake Center
What is an earthquake?
Earthquake Surface

A bigger fault means a bigger earthquake
Bigger Faults Make Bigger Earthquakes
What Controls the Level of Shaking?

- **Magnitude**
  - More energy released
- **Distance**
  - Shaking decays with distance
Shaking with distance

Easter 2010
El Mayor Cucaipa

January 1994
Northridge
What Controls the Level of Shaking?

- **Magnitude**
  - More energy released

- **Distance**
  - Shaking decays with distance

- **Soil conditions**
  - Soft soils amplify shaking
Site Effects

- 30 m velocities
- Basin depth
- Amplify the shaking by up to 7x
What is your earthquake risk?

Risk = Hazard × Exposure × Fragility ÷ Response ÷ Recovery

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Will to recover
Our Hazard

San Francisco Bay

Sierra Nevada Mountains

San Gabriel Mountains
San Andreas Fault
San Andreas Earthquake History

- 1906 M7.8
- 1857 M7.8
- 1680 M7.7

Creeping Segment (no large earthquakes)
Paleoseismology

- Cut into the fault
- Find evidence of earthquake
- Date sediments above and below

- 6 earthquakes on San Andreas fault in Coachella between 800-1680
ShakeOut Simulation of M7.8 on San Andreas
Our Urban Society Is At Risk

Urban Disaster Resilience is having a society that functions after the disaster.
A System of Systems
ShakeOut Damage to Buildings

- Concrete buildings:
  - Commercial buildings from 1950s and 1960s
  - In highest shaking areas, 10% collapse
  - Biggest life loss in scenario
- Unreinforced masonry
  - Collapse of 300+ buildings
  - Complete financial loss for 90% within 30 km of fault
- Pre-1994 steel frame high rises could collapse
- 300,000 buildings with loss >10% of value
Building Damage and Destruction

- DAMAGED BUILDINGS
  - EMOTIONAL HARDSHIP
  - LIFE LOSS
  - BUSINESS CLOSURE
  - LOSS OF SHELTER
- SHORT-TERM CONSEQUENCES
  - BUSINESS DISRUPTION
  - DAMAGE TO ADJACENT BUILDING PROPERTY $
- LONG REPAIR TIME CONSEQUENCES
  - NEEDED FOR REPAIRS
    - POWER
    - TRANSPORTATION
    - MANPOWER
    - DEBRIS REMOVAL
- CAUSES
  - EARTHQUAKE SHAKING
  - FIRE
  - WATER PIPE BREAKAGE
Water and the San Andreas Fault

MAJOR WATER CONVEYANCE & EARTHQUAKE FAULTS
IN THE SCAG REGION

WATER SYSTEMS
- Major Water Conveyance
- Nature Water Features

EARTHQUAKE FAULTS
- Historic
- Late Quaternary
- Holocene & Latest Pleistocene

Source: California Department of Water Resources, State of California Geoportal | Date: 10/10/2016 | P:\Feiyang Zhang\California Aqueduct\Map
Damaged Water Supply Network

- All aqueducts cross the San Andreas to get to southern California and will be broken.
  - 18 months to repair
- Widespread damage to pipes in the ground
  - 6 months to restore all service
Damaged Water Supply Network

**Causes**
- Earthquake shaking
- Fault offset
- Chemical accidents

**Short-term Consequences**
- Life loss
- Impaired medical response
- Loss of shelter

**Long-term Consequences**
- Damage to buildings and property
- Business closure
- Business disruption

**Needed for Repairs**
- Transportation
- Purification systems
- Internet for water companies
- Manpower

**Damaged Water Supply**
- Causes
- Short-term consequences
- Long-term consequences
- Needed for repairs
Fire Following the Earthquake

- 1,600 ignitions requiring a fire engine
- 1,200 exceed capability of 1st engine
- 200 million square feet burnt
  \[\approx 133,000 \text{ single family dwellings}\]
- \(\sim 1.5\%\) of total building stock
- Property loss: $65 billion
Communication disruption

- Electricity could be out for weeks
- Cell tower backup power lasts 4 hours
- Two-thirds of Internet bandwidth in fiber cables across the San Andreas
Communication disruption

CAUSES
- Earthquake shaking
- Fault offset
- Fire

SHORT-TERM CONSEQUENCES
- Business disruption
- Emotional hardship
- Transportation
- Manpower
- Needed for repairs

LONG REPAIR TIME CONSEQUENCES
- Impaired emergency response
- Impaired medical response
- Severe fiber optics
- Damage to communications networks
- Damaged cell towers
- Phone lines overloaded
- Impaired fire response
- Business closure

COMMUNICATION DISRUPTION

FAULT OFFSET

EARTHQUAKE SHAKING

FIRE
Damaged Transportation

Maule, Chile, M8.8
February 27, 2010
Damaged Transportation

Causes:
- Earthquake shaking
- Landslides
- Fault offset
- Damaged power system
- Fire
- Debris in roads
- Water pipe breakage

Short-term Consequences:
- Impaired emergency response
- Traffic jams and accidents
- No debris removal
- Loss of food supply

Business interruption

Needed for repairs:
- Debris removal
- Power
- Internet for Caltrans
- Manpower

Long repair time consequences:
- Impeded reconstruction

Supplies chain disruption

Damage to transportation systems

Disruptions
- Supply chain disruption
- Impeded reconstruction
- Impaired emergency response
- Impaired medical response
- Traffic jams and accidents
- No debris removal
- Loss of food supply

Damages
- Fire
- Water pipe breakage
- Earthquake shaking
- Landslides
- Fault offset
- Damaged power system

System integrity

Short-term consequences

Reconstruction

Interdependencies
- System
- Supply chain
- Emergency response
- Medical response
- Traffic

Impacted areas
- Transportation systems
- Debris removal
- Food supply
- Emergency response
- Medical response

Advanced response
- Business interruption
- Interdependencies
- Impacted areas

Energy infrastructure
- Power
- Internet

Critical infrastructure
- Transportation
- Emergency response
- Medical response

Infrastructure resilience
- Energy infrastructure
- Critical infrastructure
- Advanced response

Critical infrastructure systems
- Transportation systems
- Emergency response systems
- Medical response systems

Critical infrastructure performance
- System integrity
- Energy infrastructure performance
- Critical infrastructure performance

Critical infrastructure resilience
- System resilience
- Energy infrastructure resilience
- Critical infrastructure resilience

Critical infrastructure impact
- Business interruption
- Interdependencies
- Impacted areas

Critical infrastructure recovery
- Energy infrastructure recovery
- Critical infrastructure recovery

Critical infrastructure response
- System response
- Energy infrastructure response
- Critical infrastructure response

Critical infrastructure performance resilience
- System performance resilience
- Energy infrastructure performance resilience
- Critical infrastructure performance resilience

Critical infrastructure impact resilience
- System impact resilience
- Energy infrastructure impact resilience
- Critical infrastructure impact resilience

Critical infrastructure effectiveness
- System effectiveness
- Energy infrastructure effectiveness
- Critical infrastructure effectiveness
San Andreas Fault at Cajon Pass

- Co-located lifelines
- Loss of gas, petroleum, electricity, transportation, supply chain
- Potential for uncontrolled fire
Biggest Issues from San Andreas

- Life loss in old buildings
- Fire following earthquake
- Loss of housing
- Business disruption
  - Unusable commercial properties
  - Transportation disruption
  - Utility outages
- Region-wide disruption
The other faults of southern California
Big Earthquakes of California

Courtesy:
T. Rockwell
SDSU
The other faults of southern California

1. San Andreas Fault
2. San Jacinto Fault
3. Elsinore Fault
4. Imperial Fault
January 9, 1857 M7.9

Twenty-five Northridge-sized faults laid end to end.
WHAT’S AT STAKE?

NEW ORLEANS VS NASHVILLE ECONOMIC GROWTH

REAL GROSS DOMESTIC PRODUCT (in Billions of Dollars)

YEAR


NEW ORLEANS

NASHVILLE

$80 BILLION

-$105 BILLION

36
SOCIAL REPERCUSSIONS
SOCIAL REPERCUSSIONS

NEW ORLEANS
POPULATION GROWTH

YEAR

POPULATION

500,000 420,000 340,000 260,000 180,000
Which of these is the worst problem for your city?

- Life loss in old buildings
- Fire following earthquake
- Loss of housing
- Business disruption
  - Unusable commercial properties
  - Transportation disruption
  - Utility outages
What is your earthquake risk?

Risk = Hazard × Exposure × Fragility ÷ Response ÷ Recovery

Faulting, shaking, landsliding, liquefaction

Extent & density of built environment

Structural weaknesses

Ability to respond

Will to recover
Hazard

Use science to understand it
Exposure

Stay off the faults

Too late!
Response

We’ve got the best
Fragility

- Buildings are as good as the building code when they were built
  - Current building code protects lives, but not property
Recovery

Population

SF

LA

1906 earthquake

1890  1900  1910  1920

Year
NECESSARY SYSTEMS

- Transportation
- Supply Chain
- Emergency Services
- Health and Safety
- Business/Jobs
- Schools
- Banking/Finance
- Housing
- Internet
- Electricity
- Water
- Gas
- Cell Towers
- Phone Systems
CRITICAL INFRASTRUCTURE

- Water
- Electricity
- Gas
- Internet
- Buildings
- Cell Towers
- Phone Systems
Buildings that Can Kill

- Unreinforced masonry (pre-1935)
- Soft-first-story (pre-1980)
- Non-ductile concrete (pre-1980)
- Steel moment frames (pre-1997)
Retrofitting URMs has saved lives

- **In the Northridge earthquake:**
  - No one died in a URM
  - Only 19% of inspected URMs needed repairs compared to 33% of buildings overall

- **Statewide**
  - Jurisdictions have retrofitted or demolished 88% of URMs with mandatory programs
  - Only 22% with voluntary programs
Current building code

- In worst earthquake, 90% probability of not collapsing
- 10% probability of collapse = 10% of new buildings collapsing
Impaired buildings are economic loss
In California, many more buildings impaired

- Average of Loma Prieta & Northridge
- For each collapse
  + 13 red tags
- For each red tag,
  + 3.8 yellow tags
- = 63 impaired per collapse

Check: Napa 2014 had 57 impaired per collapse
CAN WE SURVIVE “THE “BIG ONE”?

49% USABLE BUILDINGS AFTER EARTHQUAKE

1% COLLAPSED

10% UNSAFE

40% LIMITED USE
Christchurch 2010
Christchurch, February 22, 2011 M6.3
Christchurch 2015
Most people don’t know what the code provides

What is the building code’s objective?

Survey of 814 people by Dr. Keith Porter, U. Colorado:
Most people want more than the code provides

What should it ensure?

- Occupiable: 41%
- Life safe: 22%
- Functional: 18%
- Do not know: 17%
- Other: 2%
Four example cities

- San Francisco
  - Community-driven
- Los Angeles
  - Mayoral leadership
- Santa Monica
  - Staff initiative
- West Hollywood
  - Council initiative
Community Action Plan For Seismic Safety (CAPSS)

- San Francisco’s seismic safety plan
- 2002 - 2013
- 30 year plan to address building deficiencies
• Los Angeles seismic safety plan
• 2014
Fortify Our Water System

- Water for fire fighters
- Protected fault crossings for the aqueducts
- Less dependence on imported water
- Seismic resistant pipes
- Resilience By Design Program
Enhance Reliable Telecommunications

- MOU with service providers to manage emergencies
- More resilient power
- Promote City-wide Wifi access
- Stronger towers

Cell tower in Tokyo after March 2011 M9
Strengthen Our Buildings

- Mandatory retrofit of soft-first story buildings
- Mandatory retrofit of concrete buildings
- Voluntary rating system
- “Back to Business” inspection program
- Excessive Damage ordinance
Santa Monica

- Initiated ordinances after Northridge
- City staff is working with City Council to develop new approaches
- Holding community meetings
- Several ordinances to be considered in winter
West Hollywood

- Started with survey to determine issues
- Soft first story
- Concrete
- Steel moment frame
West Hollywood

- Initiated by City Council
- Staff brought in consultants
- Established expert advisory committee
- Took about a year to come to Council
- Council asked for more outreach

weho.org/seismic
Where are you?

Self-evaluation form
What’s next?

- Take self-evaluation back to your jurisdiction
- Plan to attend all-day Workshop in SCAG’s Earthquake Preparedness Initiative*

* See Exit Survey
Contact
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