2011 HAZUS Scenario Study
San Diego Region

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Presentation Outline

1. HAZUS – Loss Estimation Methodology - Overview
2. Regional Study of San Diego(-Tijuana) area for a Rose Canyon M7.2 Scenario event (HAZUS default data)
3. Enhanced AEBM Study - Census Tract 53 in downtown San Diego (enhanced Sanborn data)
4. Comparison of HAZUS default data to Sanborn & other local data
5. Conclusions & Recommendations
HAZUS-MH Methodology

Scenario Earthquake Hazard:
- USGS or User Defined earthquake
- Ground shaking intensity data & distribution
- Surface rupture, liquefaction, landslides

Building (B-L-I) Inventory:
- Building type, location, number, square footage, and occupancy of all buildings, lifelines & infrastructure.
- Structural systems & damageability characteristics.

Damage & Consequences
- Damage severity & distribution
- Consequences:
  - Casualties (injuries & fatalities)
  - Damage Repair Cost ($$$)
  - Downtime – loss of building service
  - Lifeline & infrastructure losses
  - Economic disruption
  - Social Consequences

A. B. Court & Assoc. EERI 2011-15
HAZUS Study No. 1

- Scenario – Rose Canyon M7.2
  - USGS shakemap for the Newport-Inglewood-Rose Canyon Fault
- Regional Study of San Diego County—(Not Tijuana or LA area)
- Building Inventory – HAZUS default data
- Fragility relationships – HAZUS default functions
- “push button” analysis
HAZUS Study Area - Rose Canyon M7.2 – San Diego County
HAZUS Study - Rose Canyon M7.2 - Contour Map PSA-03
# Regional Statistical Overview

<table>
<thead>
<tr>
<th>San Diego (HAZUS Data)</th>
<th>Tijuana (Guestimates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 million residents</td>
<td>1.5M to 3.5M residents??</td>
</tr>
<tr>
<td>4237 (1200) sq miles</td>
<td>246 sq miles??</td>
</tr>
<tr>
<td>822,000 buildings</td>
<td>300k-500k bldgs??</td>
</tr>
<tr>
<td>$225 B replacement value (92% of B.E.)</td>
<td>$75B-$125B ?? replacement value</td>
</tr>
<tr>
<td>$17 B transportation systems</td>
<td>$5B to $10B ?? transportation systems</td>
</tr>
<tr>
<td>$3 B infrastructure value</td>
<td>$1B to $1.5B ?? infrastructure</td>
</tr>
</tbody>
</table>

*EERI 2011-15*
Building Inventories

San Diego Area:
• 822,000 bldgs
• 1500 to 2000 URM?
• Non-ductile concrete?
• Infill frame?
• Concrete & masonry shear wall buildings?
• Steel frame?
• Wood frame – 85%

Tijuana Area:
• 300,000-500,000 bldgs??
• Many URM
• Many non-ductile concrete
• Many infill frame
• Many shear wall bldgs
• Not-many wood frame?
• Not-many steel frame?
Building Values - HAZUS

Appendix B: Regional Population and Building Value Data

<table>
<thead>
<tr>
<th>State</th>
<th>County Name</th>
<th>Population</th>
<th>Building Value (millions of dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Residential</td>
</tr>
<tr>
<td>California</td>
<td>San Diego</td>
<td>2,813,833</td>
<td>179,258</td>
</tr>
<tr>
<td>Total State</td>
<td></td>
<td>2,813,833</td>
<td>179,258</td>
</tr>
<tr>
<td>Total Region</td>
<td></td>
<td>2,813,833</td>
<td>179,258</td>
</tr>
</tbody>
</table>

$224B in building value. 80% in residential buildings. (2000 data)
Critical Facility Inventory
San Diego County

• Essential Facilities
  • Hospitals: 27 facilities, 6574 beds
  • Schools: 993
  • Police Stations: 73
  • Fire Stations: 62
  • Emergency Operations Center: 2

• High Potential Loss Facilities
  • 54 Dams
  • 228 hazardous materials sites
  • 1 nuclear facilities
Transportation & Lifeline Utilities ($21 B replacement value)

- Transportation Systems (7-types)
  - Highways, rail, light rail, buses, ports, ferries, airports

- Lifeline Utility Systems
  - Potable water, wastewater, natural gas, crude & refined oil, electric power and communications
HAZUS default data assessment for Rose Canyon M7.2

Wood frame bldgs with at least moderate damage.
HAZUS default data assessment for Rose Canyon M7.2
M-C **Steel frame bldgs** with at least moderate damage
HAZUS default data assessment for Rose Canyon M7.2

URM bldgs with at least moderate damage
HAZUS default data assessment for Rose Canyon M7.2
M-C Concrete Frame bldgs with at least moderate damage
HAZUS default data assessment with Rose Canyon M7.2
M-C Concrete Infill Frame Bldgs with at least moderate damage
HAZUS default data with Rose Canyon M7.2 Shakemap
Concrete Infill Frame Bldgs with moderate to severe damage
HAZUS default data assessment for Rose Canyon M7.2

Schools with at least moderate damage
HAZUS default data assessment for Rose Canyon M7.2

Hospitals with at least moderate damage.
HAZUS Building Damage Summary

- 96,066 buildings will be at least moderately damaged
- 12.00% of all buildings in the County
- 784 buildings will be damaged beyond repair
- High damage rates in multi-family residential & commercial buildings – large economic & housing impacts
- Heavy damage ratios in URM and non-ductile concrete, also in steel buildings
# HAZUS estimate of Casualties

## Table 10: Casualty Estimates

<table>
<thead>
<tr>
<th>Time</th>
<th>Category</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 PM</td>
<td>Commercial</td>
<td>2,138</td>
<td>391</td>
<td>45</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Commuting</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Educational</td>
<td>300</td>
<td>45</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Hotels</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>0</td>
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<tr>
<td></td>
<td>Industrial</td>
<td>203</td>
<td>30</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Other-Residential</td>
<td>163</td>
<td>23</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Single Family</td>
<td>120</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2,934</td>
<td>502</td>
<td>59</td>
<td>106</td>
</tr>
</tbody>
</table>

- **3600** injuries total, **106** at Level 4.
### Building Related Economic Losses

Table 11: Building-Related Economic Loss Estimates

(Millions of dollars)

<table>
<thead>
<tr>
<th>Category</th>
<th>Area</th>
<th>Single Family</th>
<th>Other Residential</th>
<th>Commercial</th>
<th>Industrial</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Income Losses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wage</td>
<td>0.00</td>
<td>59.89</td>
<td>462.01</td>
<td>11.61</td>
<td>21.86</td>
<td></td>
<td>555.38</td>
</tr>
<tr>
<td>Capital-Related</td>
<td>0.00</td>
<td>25.58</td>
<td>430.71</td>
<td>7.00</td>
<td>5.16</td>
<td></td>
<td>468.44</td>
</tr>
<tr>
<td>Rental</td>
<td>60.93</td>
<td>202.00</td>
<td>249.38</td>
<td>6.18</td>
<td>12.92</td>
<td></td>
<td>531.41</td>
</tr>
<tr>
<td>Relocation</td>
<td>224.05</td>
<td>142.72</td>
<td>378.07</td>
<td>31.81</td>
<td>83.92</td>
<td></td>
<td>860.57</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>284.98</strong></td>
<td><strong>430.19</strong></td>
<td><strong>1,520.18</strong></td>
<td><strong>56.59</strong></td>
<td><strong>123.86</strong></td>
<td></td>
<td><strong>2,415.80</strong></td>
</tr>
<tr>
<td><strong>Capital Stock Losses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural</td>
<td>450.44</td>
<td>316.14</td>
<td>439.19</td>
<td>70.89</td>
<td>75.13</td>
<td></td>
<td>1,351.80</td>
</tr>
<tr>
<td>Non_ Structural</td>
<td>2,678.00</td>
<td>2,068.64</td>
<td>1,466.61</td>
<td>258.01</td>
<td>264.71</td>
<td></td>
<td>6,735.98</td>
</tr>
<tr>
<td>Content</td>
<td>998.34</td>
<td>564.57</td>
<td>738.26</td>
<td>179.81</td>
<td>143.27</td>
<td></td>
<td>2,624.24</td>
</tr>
<tr>
<td>Inventory</td>
<td>0.00</td>
<td>0.00</td>
<td>15.74</td>
<td>31.48</td>
<td>2.27</td>
<td></td>
<td>49.49</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>4,126.78</strong></td>
<td><strong>2,949.36</strong></td>
<td><strong>2,659.80</strong></td>
<td><strong>540.19</strong></td>
<td><strong>485.37</strong></td>
<td></td>
<td><strong>10,761.50</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,411.76</strong></td>
<td><strong>3,379.55</strong></td>
<td><strong>4,179.98</strong></td>
<td><strong>596.78</strong></td>
<td><strong>609.24</strong></td>
<td></td>
<td><strong>13,177.30</strong></td>
</tr>
</tbody>
</table>

$13.2 \text{ B}$ in Capital Stock Losses. $2.4 \text{ B}$ in income losses.
Additional Losses

• Transportation Systems  $300 M of $17.2 B

• Utilities  $736 M of $3.9 B

• Additional indirect losses, induced damages, and social impacts (eg., tourism, fires, loss of shelter, etc.)
HAZUS Study – No. 2

- Scenario – Rose Canyon M7.2
- Area – San Diego **Census Tract 53**
- **AEBM** (advanced engineering building module) analysis
- **Enhanced Building Inventory data** based on Sanborn data supplemented by **field observation** to record structural data
- Fragility relationships – HAZUS default functions **adapted slightly** to account for retrofitted URMs and soft story conditions
San Diego Census Tract 53 – Sanborn Map
Census Tract 53 – AEBM Analysis

Building Ages by Year Built

Layers
- CT53BuildingAEBMPoint_1
  - YearBuilt
    - 0.000000 - 1912.000000
    - 1912.000001 - 1940.000000
    - 1940.000001 - 1975.000000
    - 1975.000001 - 1994.000000
Census Tract 53 – AEBM Analysis

URM Buildings
Census Tract 53 – AEBM Analysis
Infill frames and Non-ductile Concrete Frame Bldgs
Census Tract 53 - AEBM Analysis
M-C Steel Moment Frame Bldgs
Census Tract 53 - AEBM Analysis

Wood Frame Bldgs
Census Tract 53 – AEBM Analysis

Structural Losses per Bldg (x $1,000?)
Census Tract 53 – AEBM Analysis – Total Building Losses

Structural, Non-structural & Contents (x $1,000?)

(Does not include business operations/relocation loses)
Occupancy

- COMMERCIAL
- EDU
- EDUCATION
- HOTEL
- INDUSTRIAL
- PARKING GARAGE
- PUBLIC/INSTITUTIONAL
- RESIDENTIAL
- UTILITY
Comparisons:

HAZUS default inventory data compared to Sanborn & other local inventory data
HAZUS data reflects approximately 1/3 the square footage and 3 times the number of buildings compared to current inventory in Tract 53.

Note: Similar types of discrepancies are reported in similar studies of Seattle (Maheshwari, 2007) and New York City (Nordenson et al, 1999).

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Hazus Default data</th>
<th>Local Tract 53 data</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sq ft x1000</td>
<td>Count</td>
<td>Sq ft x1000</td>
</tr>
<tr>
<td>Wood</td>
<td>3519</td>
<td>329</td>
<td>416</td>
</tr>
<tr>
<td>Steel</td>
<td>1225</td>
<td>147</td>
<td>12433</td>
</tr>
<tr>
<td>Reinforced Concrete</td>
<td>1571</td>
<td>126</td>
<td>9689</td>
</tr>
<tr>
<td>Precast Concrete</td>
<td>795</td>
<td>81</td>
<td>0</td>
</tr>
<tr>
<td>Reinforced Masonry</td>
<td>1655</td>
<td>152</td>
<td>1258</td>
</tr>
<tr>
<td>Unreinforced Masonry</td>
<td>362</td>
<td>33</td>
<td>1577</td>
</tr>
<tr>
<td>Mobile Homes</td>
<td>5</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9132</strong></td>
<td><strong>870</strong></td>
<td><strong>25373</strong></td>
</tr>
</tbody>
</table>
Conclusions & Suggestions

1. The San Diego-Tijuana building inventory has very significant vulnerability in a major event on the Rose Canyon fault.

2. HAZUS provides a powerful tool for assessing the risks and potential losses, but does not extend across the border --- no data for Tijuana.

3. The HAZUS US default inventory data captures a reasonable estimate seismic vulnerability on a regional basis, but not necessarily on a local or census tract level.
Conclusions & Suggestions

4. HAZUS inventory for redeveloping downtown areas can be particularly erroneous.

5. Local data bases such as Sanborn’s data, or assessor’s data, supplemented with local engineering insights can provide much more accurate inventory and seismic vulnerability accounting.

6. Sanborn’s data can provide a very good starting point. Their building footprint data and 3D imagery can provide powerful communication tools for emergency planners.
Conclusions & Suggestions

7. HAZUS studies particularly using enhanced data sets can provide City building officials and political leaders with useful insights to help develop appropriate seismic retrofit policies and seismic risk mitigation strategies.

8. Recommendation: San Diego should consider taking some more aggressive steps toward inventorying its vulnerable building stocks and toward protecting and preserving its architectural heritage, in particular: the Gaslamp Quarter and the Balboa Park’s historical monuments.
Conclusions & Suggestions

9. We know very little about the building inventory and seismic vulnerability across the boarder. Tijuana’s participation can help fill these knowledge gaps.

10. HAZUS and Sanborn type data bases for Tijuana could be very useful to Mexico’s planning and risk mitigation and can help ameliorate the cross boarder consequences of a major Rose Canyon event.
Gaslamp District
Gaslamp District
Gaslamp District
Balboa Park - MoA
Balboa Park - MoM
Thank you.