EXPECTED PERFORMANCE OF URM’S IN MEMPHIS, TN

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EXPECTED PERFORMANCE OF URM’S IN MEMPHIS
Expected Performance of Memphis/Shelby Country URM’s

Prior studies
• Hwang & Lin – Univ of Memphis 1997 (also fire and police stations)
• Inventory of Essential Facilities Memphis, St Louis, and Charleston – MAEC 2001
• MAE Center – Memphis Test Bed as part of MAEViz development (inventory) 2006
• MAE Center – Impact of New Madrid Seismic Zone on the Central USA 2009
• South Main Demonstration Project (in progress 2012)

Expected Performance

Key issues
Level of hazard considered
Inventory
Occupancy
Type URM (construction, height, size, vintage)
Location
Value/contents
Vulnerability
Fragility
Results
Typical damage
Memphis/Shelby County
Suggested priorities and conditions
Expected Performance

Level of hazard considered

- M7.5-M7.9 NMSZ
  MAEC studies
- M7.0 Southern segment NMSZ (Hwang)
- M6.2+ Southern segment NMSZ
  Lower threshold for damaging ground motions

Inventory

Occupancy
Type URM (construction, height, size, vintage)
Location
Value/contents

Principal reliance on 2006 MAEC Memphis Test Bed inventory (Steve French/GA Tech et al)
Based on Shelby County Tax Assessor office data
Performance results from MAE Center – Impact of New Madrid Seismic Zone on the Central USA 2009
Inventory

Occupancy

Commercial/institutional/multi-family residential
(single family excluded)
• 292,438 buildings in Memphis/Shelby County incl. single family residences
• 266,618 single family residences [approx. 25,000 S1 URML]
• Population approx. 930,000 (approx. 3.5 persons/dwelling unit)

Inventory

Occupancy

Commercial/institutional/multi-family residential
(single family excluded)
• 25,820 buildings other than single family residences
• 6,302 URM’s
• 24% of building stock (vs. 23% W1 Light wood - 26% S3 Light steel - 10% RM Reinforced masonry)
• But URM comprise only 14% of gross bldg area
Inventory
Type URM (construction, height, size, vintage)

Construction
• Typically unreinforced clay brick masonry (some stone/ashlar masonry)
• Conventional CMU excluded

Height
• 85% URM’s – 1 story
• 9% URM’s – 2 story
• 5% URM’s – 3-5 story
• 23 6-10 stories

Size
• 40% less than 2500 sf
• 23% 2500-5000 sf
• 17% 5000-10,000 sf
• 17% 10,000-50,000 sf
• 4% greater than 50,000 sf

Vintage
• 33% URM’s pre-1939
• 38% 1940-1960
• 28% 1960-1980
Inventory

Location
- URM’s concentrated in older areas of Memphis (Downtown & Midtown)

Inventory

Location
- URM’s typically not impacted by liquefaction hazard
Inventory

Value/contents

- Appraised value
- 72% URM's less than $100,000 in value
- 27% URM's less than $1,000,000 in value
- 8 worth more than $5,000,000

- URM's value relative to building stock
- $1.23B vs. total building stock $40.07B (not including single family residential)
- URM’s 3% of value of total building stock

Contents value (Shelby Co Appraisal Office)

- 73% URM's less than $100,000 in contents
- 25% URM's $100,000 - $1,000,000 in contents
- 5 with more than $5,000,000 in contents
URM Vulnerability

• Fragility curves
• Strengthened?

Fragility curves conventional method of assessing damage to groups or classes of buildings on a regional basis
Typically NOT appropriate for facility-specific loss evaluation without careful use

Essentially no seismic retrofit/strengthening in Memphis-Shelby County. Maintenance of masonry questionable, including and especially historic properties.

URM Vulnerability

Fragility curves

Bases
• Documented experience
• Expert engineering judgment
• Analytical

Limited fragility curves available for URM
• ATC-13 (expert judgment) 1985 CA
• HAZUS MH2 (expert judgment)
• Numerous recent studies (Italy, NZ, USA, etc.) including Analytical Fragility Assessment of Low-Rise URM Buildings (Park Goodno et al) 2008
URM Vulnerability

Fragility curves
Analytical Fragility Assessment of Low-Rise URM Buildings (Park Goodno et al) 2008

Results

Typical damage
Memphis/Shelby County
Moderate damage or beyond:

- Building cannot be occupied post-quake
- Building is likely beyond economical repair
- Building is likely a total loss and needs to be demolished, perhaps as part of Emergency Response and Recovery with or without Owner concurrence
URM Damage

(Photos from State-of-the-Art Report on Seismic Performance of Unreinforced Masonry Buildings (Bruneau – after Loma Prieta EQ)

FIG. 2. In-Plane Shear Failure of URM Masonry Wall (Santa Cruz, Loma Prieta Earthquake)

FIG. 4. In-Plane Shear Failure of URM Pier (Oakland, Loma Prieta Earthquake)
URM Damage

(Photos from City of San Diego Development Services website)
URM Damage

(Photos from The M6.3 Christchurch Earthquake – Performance of (URM) Buildings in CBD – Sri Sritharan/Iowa State University 2011)
URM Damage

Lessons

- URM – performed poorly but not surprising
- Retrofitted URM – prevented structural collapse but experienced damage

M&SC - URM FIRE STATIONS
(Univ of Memphis – Hwang & Lin - Seismic Performance Evaluation of Fire Stations in Shelby County, TN 1977)

Table 1. Statistics of the structural types of fire stations in the Memphis area

<table>
<thead>
<tr>
<th>Structural Type</th>
<th>Number of Fire Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ureinforced masonry (URM)</td>
<td>30</td>
</tr>
<tr>
<td>Steel frame buildings with URM infill walls (S5)</td>
<td>13</td>
</tr>
<tr>
<td>Reinforced masonry (RM)</td>
<td>2</td>
</tr>
<tr>
<td>Wood buildings (W)</td>
<td>3</td>
</tr>
<tr>
<td>Concrete frame buildings with URM infill walls (RC)</td>
<td>1</td>
</tr>
<tr>
<td>Light metal building (S3)</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5. Statistics of damage states of fire stations caused by two scenario earthquakes

<table>
<thead>
<tr>
<th>Damage State</th>
<th>M = 6.5</th>
<th>M = 7.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Damage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insignificant Damage</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Moderate Damage</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Heavy Damage</td>
<td>38</td>
<td>67</td>
</tr>
</tbody>
</table>
M&SC - URM FIRE STATIONS
(MAE Center Impact of New Madrid Seismic Zone on Central United State 2009)
**M&SC - URM FIRE STATIONS**  
(MAE Center Impact of New Madrid Seismic Zone on Central United State 2009)

**M&SC - URM SCHOOLS**  
(Yumei Wong – ASCE Workshop/EERI Annual Meeting/2012 National Earthquake Conference)

**Charleston, SC**
- **Scenario risk** 220 schools with significant damage.
- **Closed 6 schools due to seismic risk in 2011**

**Memphis**
- **286 URM schools at risk (moderate or higher)** – late awareness – current codes  
  (MAEC study 7.7 Hwang and Lin 1997)
URM Damage

Moderate damage or beyond:

- Building cannot be occupied post-quake
- Building is likely beyond economical repair
- Building is likely a total loss and needs to be demolished, perhaps as part of Emergency Response and Recovery with or without Owner concurrence

Suggested priorities and conditions

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- Funding is the key issue
- “Benefit/cost analysis” approach essential
Suggested priorities and conditions

Suggested priorities and conditions

• Low value of typical URM does not support retrofit of most URM’s (unless there are special interests and funding)

• Retrofit of schools and emergency response facilities is critical (or replace them)

• Important cultural or historic facilities must have $$ support for retrofit consistent with declared importance

EXPECTED PERFORMANCE OF URM’S IN MEMPHIS

QUESTIONS??