Masonry Investigation

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Presentation Outline

• General masonry definitions
• Performance of reinforced masonry
• Performance of confined masonry
• Construction issues
• Performance of unreinforced masonry
Objectives

• Observed masonry construction practices in Chile
• Observe and document damage to masonry structures in Chile
• Work together with local resources to expand data
• Disseminate information to engineering community
General Masonry Terms

• Confined masonry
  – Very common in Chile
  – Masonry portion of wall constructed first
  – Confining elements (beams and columns) built around the masonry

• Reinforced masonry
  – Reinforcement is grouted in cells and carries the tensile stresses generated in the structure
  – Unit with cells from Ceramica Santiago
General Masonry Terms (2)

• Unreinforced masonry
  – Masonry carries tensile stresses in structure
  – Generally cracks early when subject to large lateral loads

• Adobe
  – Generally unreinforced
  – Bricks made by hand
Places Visited

1. Santiago
2. Constitución
3. Concepción
4. Talcahuano
5. Chillán
Construction with Reinforced Masonry
Reinforced Masonry (Brick)
• This building could be mistaken for reinforced concrete due to “repello” or cementitous stucco on the structure. We know it is masonry due to the stair step shear crack between piers.
• Over 20 apartment complexes had no visible damage
• Performed very well
Reinforced Concrete Masonry (2)
Confined Masonry

- Typically used in apartment complexes
- Regular structures with standard openings
- Buildings observed had 3-5 stories
- All cities visited had confined masonry present
Santiago
Constitución Apartments – Rengifo 705

- In-plane shear failure of masonry visible in several buildings
- Damage concentrated in lower levels where shear is highest
Local Soil Issues – Rengifo 705

• Evidence of lateral spreading
• Soil cracking
• Soil movement towards steep slope approximately 20 ft from home.
• Highest level of damage in buildings located near the slope.
Constitución Apartments – Mesa Seco

- Soil moving downhill
Mesa Seco

- Shear cracks in one direction
- Earthquake would cause shear cracks in two directions
- Free-body diagram explains everything

Soil moving downwards
Constitución Apartments – O’Higgins 859
Poor construction - O’Higgins 859

- Aggregate size too large
- Lack of confinement
- Different bar sizes
Diagonal cracks in fourth floor on inside and outside of structure
Chillán

Confining elements around window openings
Confined Masonry Residences

2 story homes
Masonry on first floor
Nearly no cracking
Concepción

School building that is out of service due to shear cracks
Concepción School – No Damage
Steel confinement
Confined Masonry Fence
Confined Masonry Fence (2)

- Enlarging section at base
- Attempt to tie back top of column
Confined Masonry Fence

• Different than fence in previous two slides. This one had out-of-plane failure and the concrete column is the only section that remained.
Out-of-plane failure
Floor diaphragm sag
Under Construction
Poor Construction
Poor Construction
Unreinforced Masonry

• Typical structures
  – Churches
  – Older structures
  – Walls in homes

• Examples in this presentation
  – Chillán
  – Talcahuana (Municipality Building and Theater)
  – Santiago (Basilica de El Salvador)
Adobe

Often is lower quality.

Can see straw in some units.
Column in masonry wall has no vertical steel
Typical Scene in Coastal Cities

Unreinforced masonry failures were very common
Talcahuana Municipality Building
250 Sargento Aldea
250 Sargento Aldea

- Diagonal cracking in piers
- Diagonal cracking in shear wall between window openings
Dante Theater

- Cracked windows
- Loss of cementitious coating
- Problems at connection
- Out of plane failure in side wall
Dante Theater (2)

- Out of plane failure in side wall
Basilica de El Salvador

• Exterior arch was lost
• Out-of-plane failure of gothic arch section
Chillán

- Diagonal crack
- Window effect?
Technical Summary

• Unreinforced masonry should not be used as the primary lateral force resisting system due to poor performance
• Few examples of reinforced masonry
• Confined masonry performed quite well
  – Many residential buildings are still functional
  – Other buildings that suffered damage still met the design goal of life-safety
Bridge to Hotel
Nonstructural Damage at Hotel
Notable signs

• We are all fine. You can find us at 1827 Charcarilla Street 14 (Names of two families)

• We need water, light, and cleanliness (Location)

• We need a solution now
Notable signs (2)

Someone: Take responsibility for your criminal actions

8 deaths
Our Clients
Flags everywhere
Acknowledgements

- Earthquake Engineering Research Institute (EERI)
- The Masonry Society (TMS)
- National Concrete Masonry Association (NCMA)
- University of Chile (Ofelia Moroni, Maximiliano Astroza)
- Pontifical Universidad Católica de Chile (DICTUC, Raúl Alvarez Medel, Hernán Santa María)
- Municipality of Santiago (Guillermo Santana)
- Municipality of Concepción (Karen Ruediger)
- Municipality of Constitución (Doris Illames)