

Masonry Investigation

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Presentation Outline

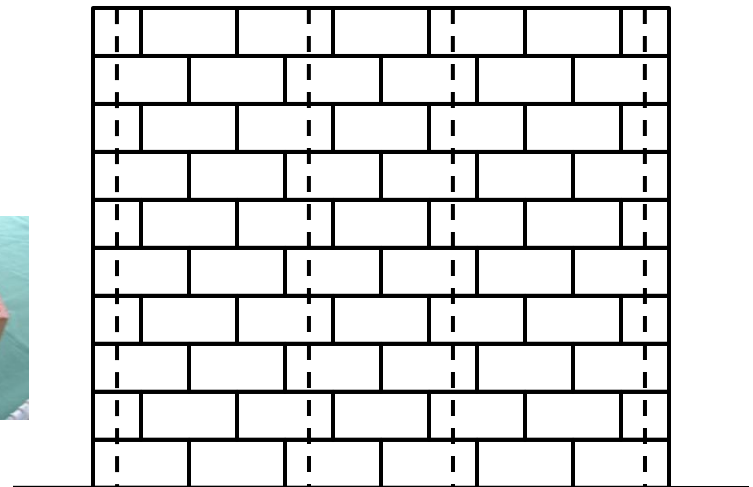
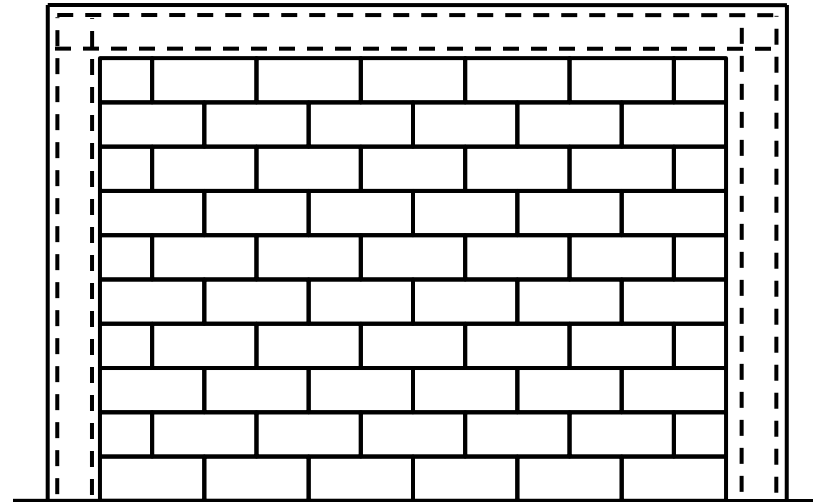
- General masonry definitions
- Performance of reinforced masonry
- Performance of confined masonry
- Construction issues
- Performance of unreinforced masonry

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



Chile



Construction with Reinforced Masonry



Reinforced Masonry (Brick)



Reinforced Concrete Masonry



- This building could be mistaken for reinforced concrete due to “repello” or cementitious 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

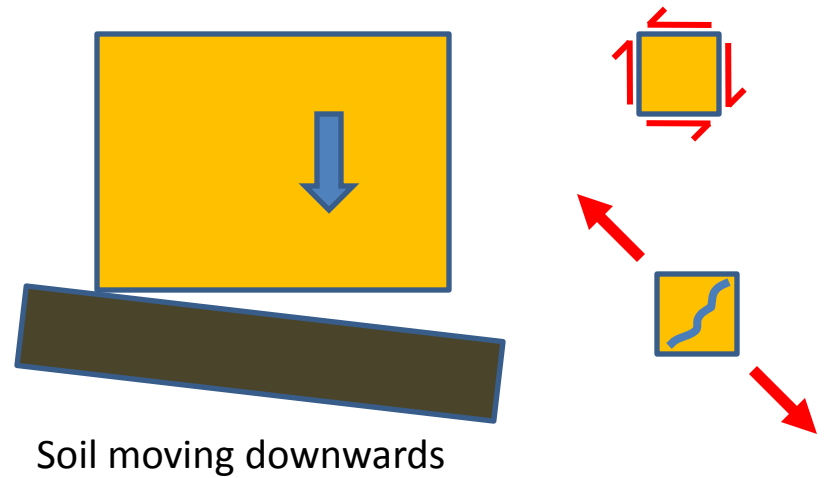
- Soil moving downhill





Mesa Seco

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



Constitución Apartments – O'Higgins 859



Poor construction - O'Higgins 859

- Aggregate size too large
- Lack of confinement
- Different bar sizes



O'Higgins 859



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

Chillán



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



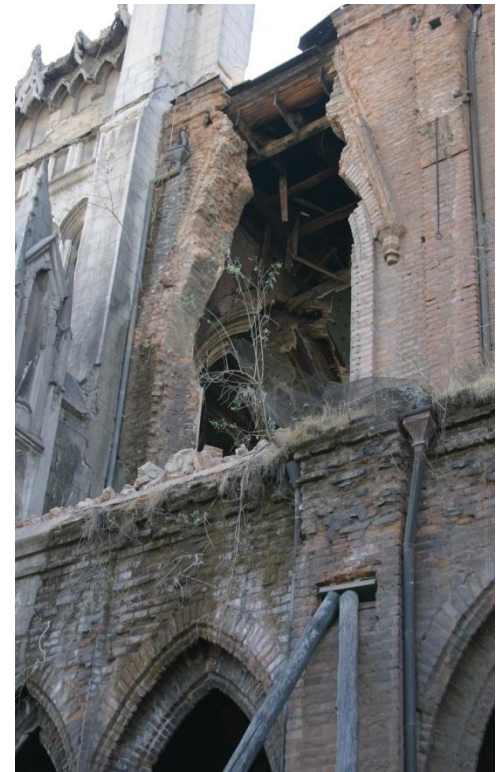
Dante Theater (2)

- 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





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