2nd Chiba Workshop on Enhancement of Earthquake and Tsunami Disaster Mitigation Technology

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STRUCTURAL VULNERABILITY IN ECUADOR

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Ecuadorian code R/C Buildings Chapter Coordinator

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Buildings

Code

Research


E
UNA VIA


Rodrigo Salas


10
9
8
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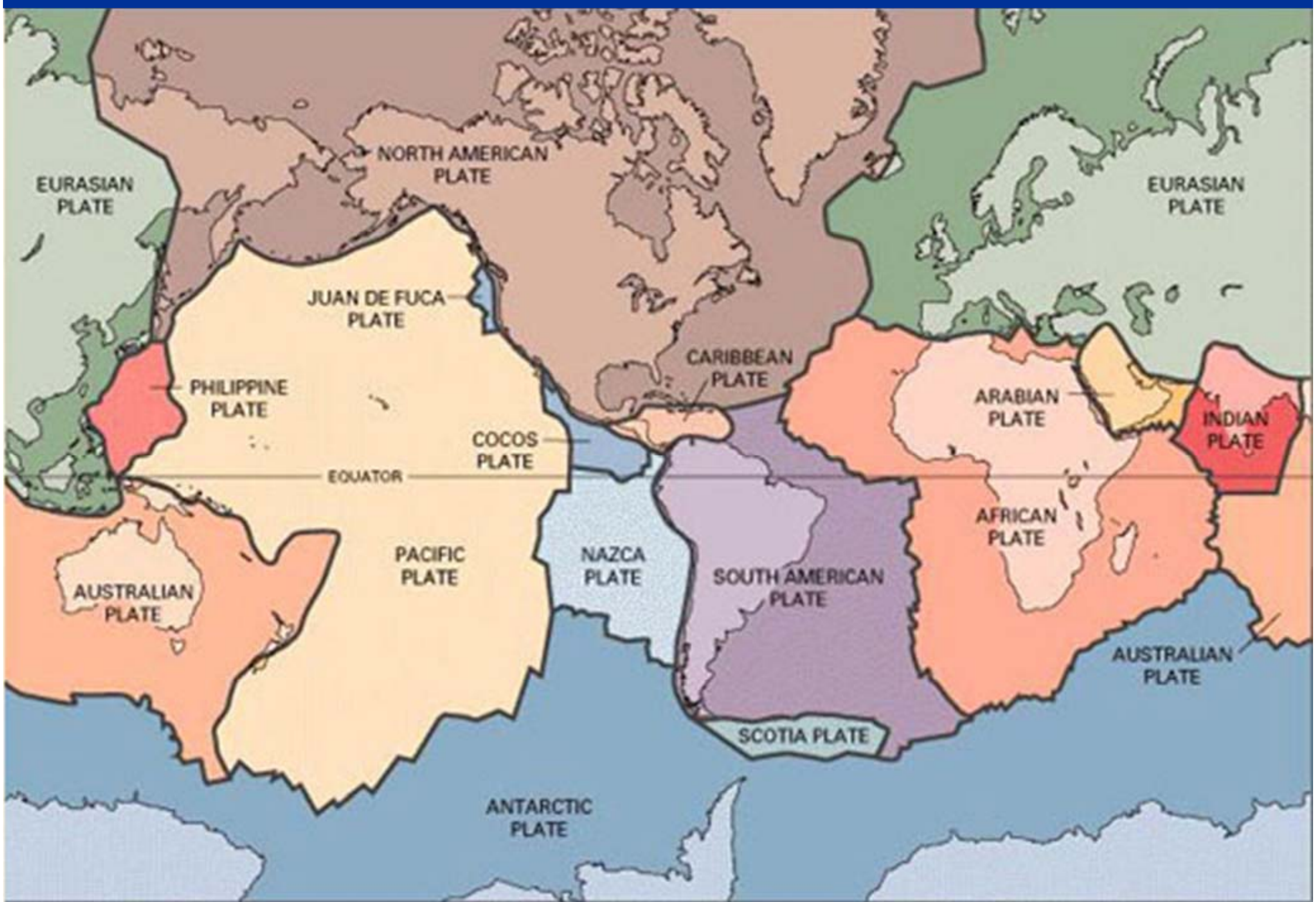
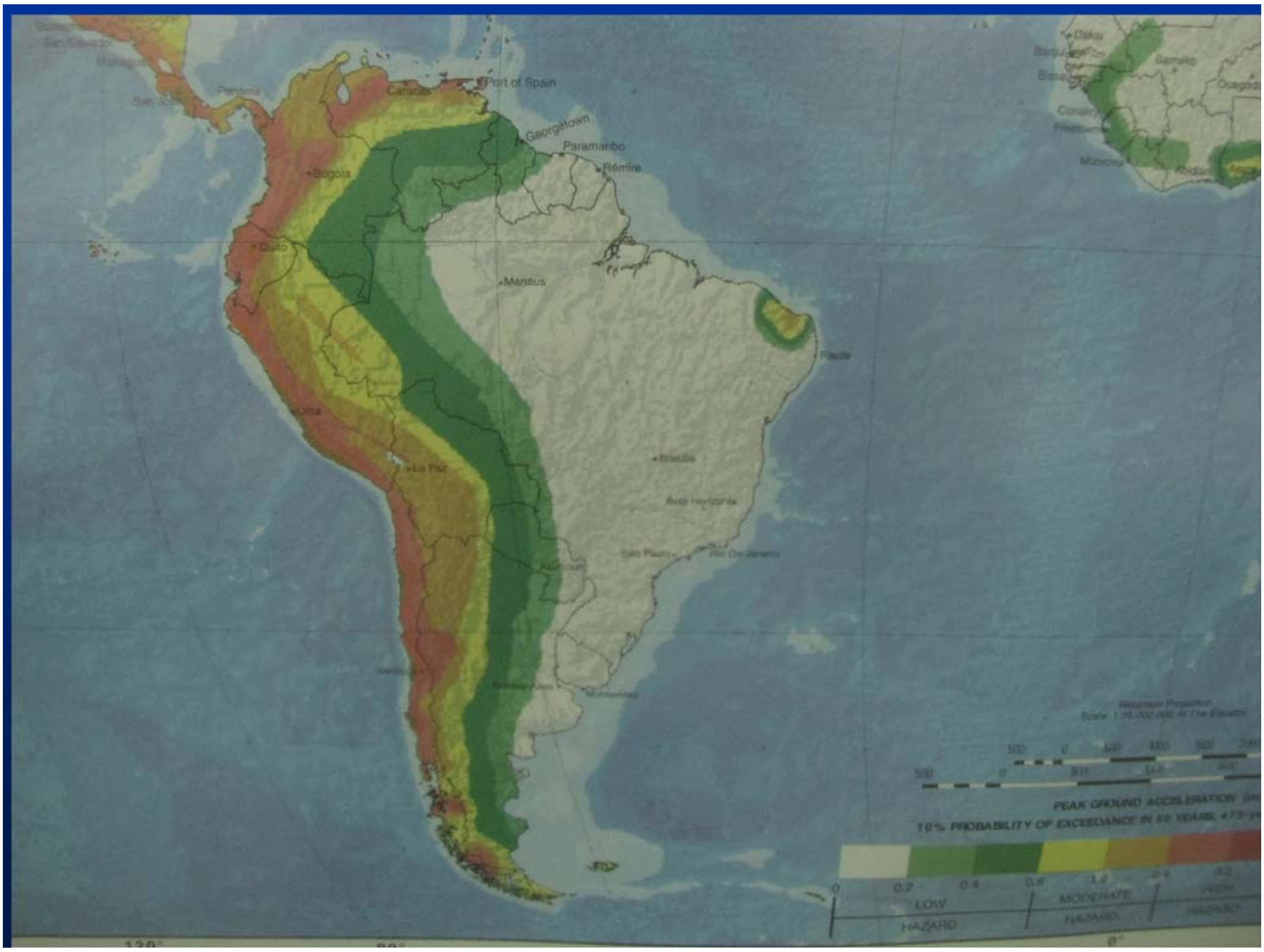
Mario Rubio
PLASTIGAMA

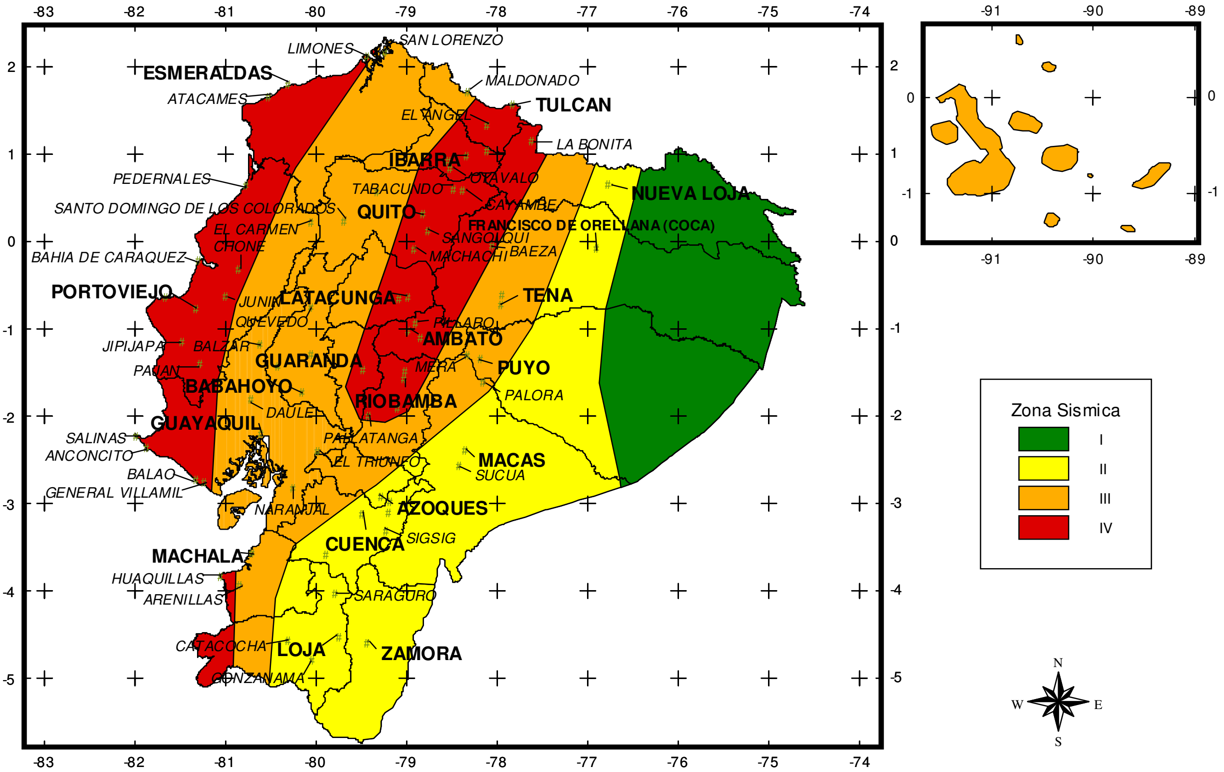


EURASIAN PLATE
NORTH AMERICAN PLATE
EURASIAN PLATE
JUAN DE FUCA PLATE
CARIBBEAN PLATE
PHILIPPINE PLATE
ARABIAN PLATE
COCOS PLATE
INDIAN PLATE
EQUATOR
AFRICAN PLATE
PACIFIC PLATE
NAZCA PLATE
SOUTH AMERICAN PLATE
AUSTRALIAN PLATE
AUSTRALIAN PLATE
SCOTIA PLATE
ANTARCTIC PLATE


Caracas
Georgetown
Paramaribo
Cayenne
Bogotá
Quito
Lima
La Paz
Brasilia
Asunción
Santiago
Montevideo
Buenos Aires
CERESIS - 1996
MAPA PROBABILÍSTICO DE
PELIGRO SÍSMICO DE SUDAMÉRICA
Curvas de aceleraciones máximas con el 10% de probabilidad de excedencia en 50 años
Compilado y procesado por
Ing Juan C.Castano Ing Marcelo H.Millón


Caracas
Port of Spain
Georgetown
Paramaribo
Bogota
Quito
Manaus
Lima
La Paz
Brasilia
PEAK GROUND ACCELERATION
10% PROBABILITY OF EXCEEDANCE IN 50 YEARS
LOW HAZARD
MODERATE HAZARD

Zonificación Sísmica



TO REDUCE SEISMIC RISK

WE MUST REDUCE

STRUCTURAL VULNERABILITY

KEY ASPECTS TOWARDS SEISMIC SAFETY

1. Adequate Architectural seismic configuration
2. Proper structural analysis and design
3. Revision and approval of structural design.
4. Proper construction of structure - seismic detailing
5. Revision of construction – mainly seismic detailing

ECUADORIAN CODE

CODIGO ECUATORIANO DE LA CONSTRUCCION CEC - 2000

EFFECTIVE SINCE MAY 2002

CURRENTLY REWRITEN

CURRENT SITUATION

1. We are updating the code.

There are several committees that deal with different structural systems or materials.

1. R/C Buildings Committee.

The committee for R/C buildings, recommended the adoption of ACI 318-08 S plus an additional section with local recommendations in order to get safer shear design of 5 important elements of frame buildings:

1. Slab – column joints
2. Beam - column joints,
3. shear walls ,
4. Beams
5. columns.

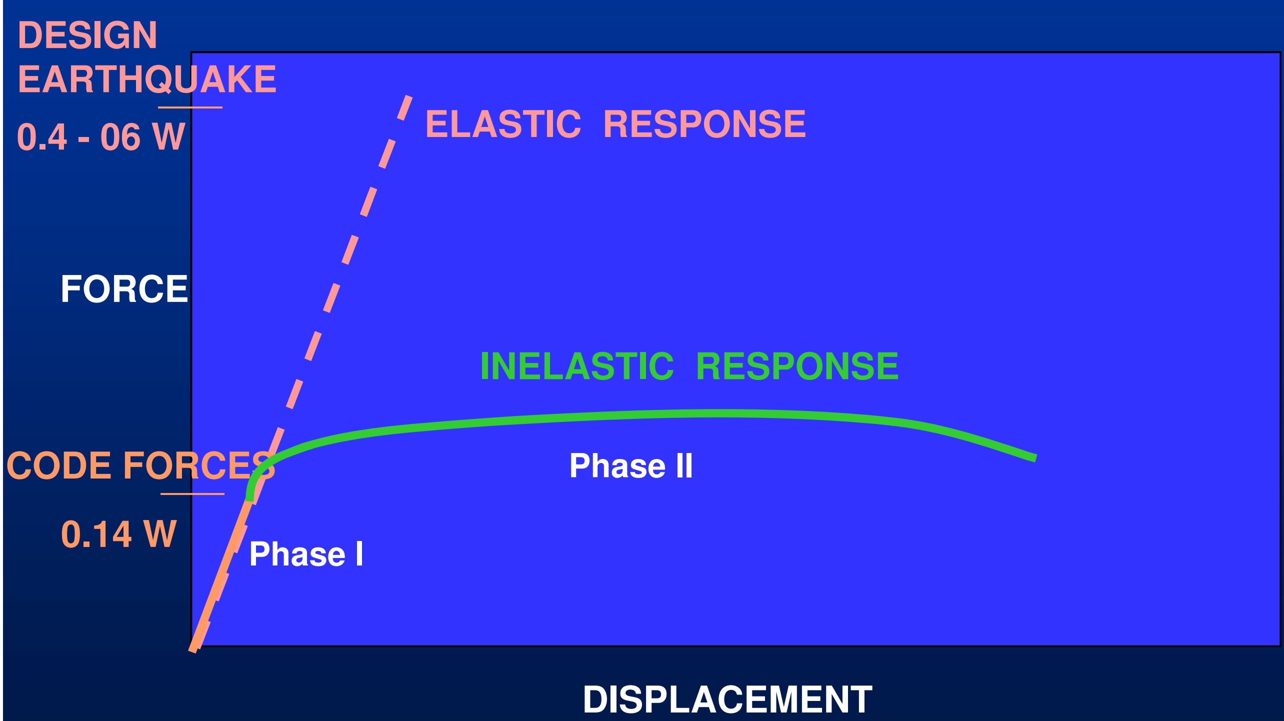
- Chapter 21 is clarified:

- It includes Flat plate systems, in addition to
  - Frame buildings
  - Frame with Shear Wall buildings
  - Frame with diagonal bracing buildings

- It states, for each building system, which elements should yield under a severe earthquake, and how to design for

- General seismic design objective is set in the following graph:

SEISMIC DESIGN - SIMPLIFIED GRAPH



FLAT PLATE BUILDINGS

(without shear walls)

•ACI 318-08 does not give provisions for seismic design of this type of buildings in zone 3 or 4

•Most codes restrict its use to zone 2 at most

•Very poor behavior in past earthquakes

•Despite these facts, more than 50 % of buildings use this system

BUILDING CHARACTERISTICS

- 4 to 12 stories
- Columns + Waffle slabs
- Rather small columns
- Integral beams between columns
- No shear walls
- Partitions made of non industrial concrete blocks, and located arbitrarily

ANALYSIS

- •Use higher forces
  - •CEC 2000: R= 8
  - •(R = 10 Special Moment Frame)
- •Use effective width of 1/3 L
- •Limit Inter story drift to 0.002

TRANSVERSE REINFORCEMENT

- Stirrups shall be designed for the most critical case of 1D or 2D shear.
- In 1D shear, the acting shear Vu shall be computed using the beam probable Flexure capacity Mn pr
- In 2D shear, the resultant punching stress shall be computed using the probable flexural capacity when finding M unbalanced.

INELASTIC RESPONSE

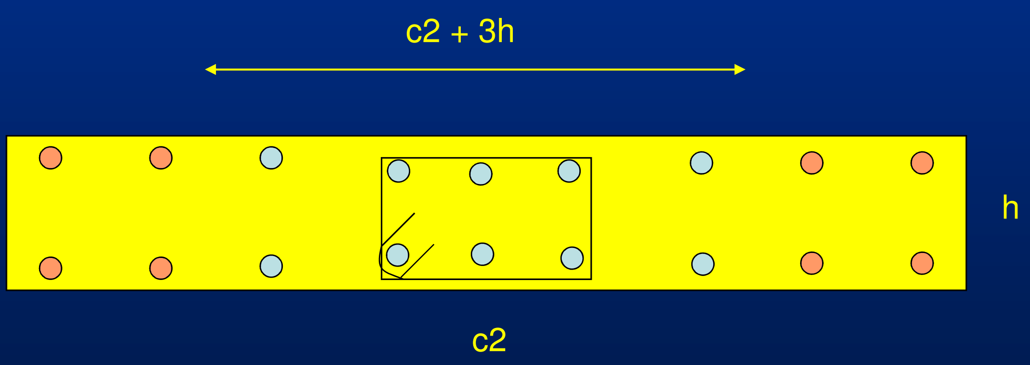
- **Objective :**
- Yielding of slab bars within the effective width

- **Strategy :**

1. Strong Column - Weak Beam
2. Strong slab for punching -
   Weak slab in flexion

1. Strong Column - Weak Beam

Sum M cols > 1.4 Sum M "Beams"



- As for M "Beams"

2. Strong slab for punching - Weak slab in flexion

ACI 318 - 08 + CAPACITY CRITERIA

$$v_{u\ punch} < \phi\ v_{n\ punch}$$

$$v_{u\ punch} = V_u / A_c + \gamma_v\ M_{uub}\ c / J$$

M_{uub} from flexural capacity

$$v_n = v_c + v_s < 1.59 \sqrt{f'_c}$$

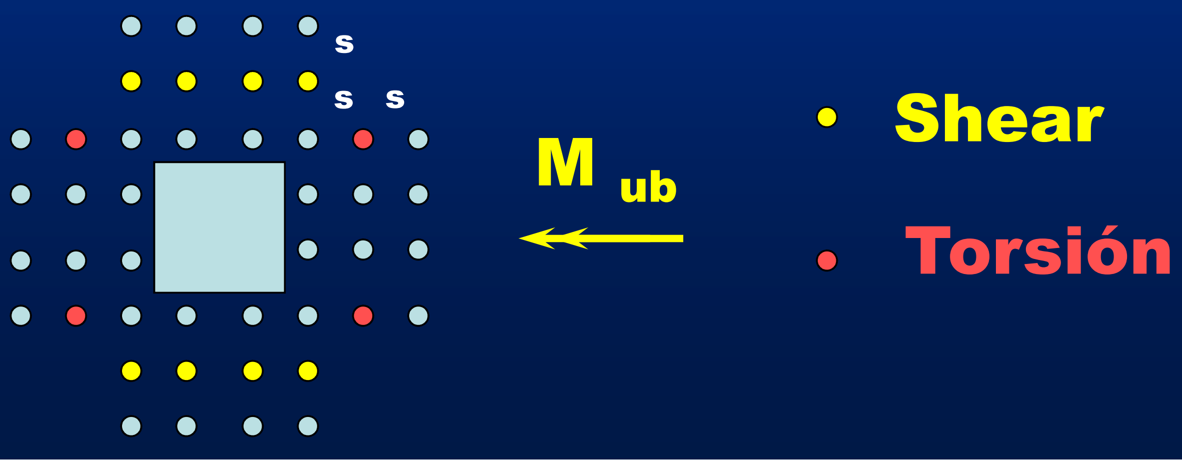
Kg/cm2

If $v_{u\ punch}$ [$\phi\ 1.59\ \sqrt{f'_c}$ Design the stirrups

If not, redesign the structure

STIRRUPS DESIGN FOR PUNCHING

- Av / # legs of stirrups
- Legs in tension from shear = n
- Legs in tension from torsion = 2



FRAME BUILDINGS

H beam > 3 h slab

- **Beams:**
  - **When computing Design shear force:**

Mpr= 1.2 (Mpr 318)

1.2 due to slab reinforcement

Columns:

- **Design shear force for the 1st floor:**

$M_{c\ top}$ and $M_{c\ bot}$ are $M_{c\ max} = M_{c\ balanced}$

INELASTIC RESPONSE

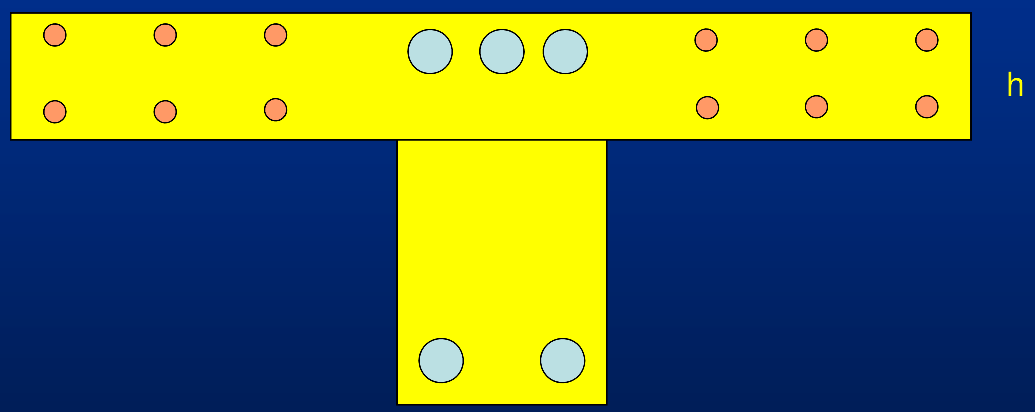
- **Objective :**
- **Yielding of beam bars at column faces**

- **Strategy :**

1. **Strong Column - Weak Beam**
2. **Strong Joint - Weak Beam**

1. Strong Column - Weak Beam

Sum M cols > 1.4 Sum M beams

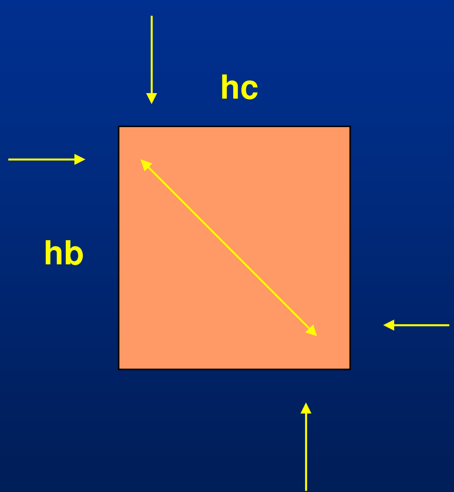


A steel for M Beams

2. Strong joint - Weak Beam

SHEAR

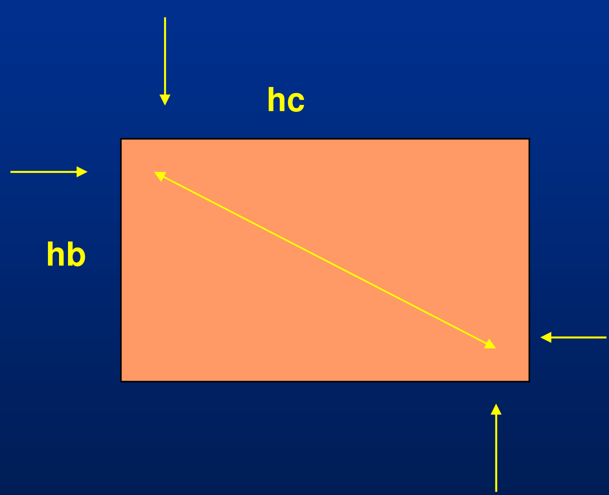
hb / hc = 1



Vn = Vc

Vs = 0

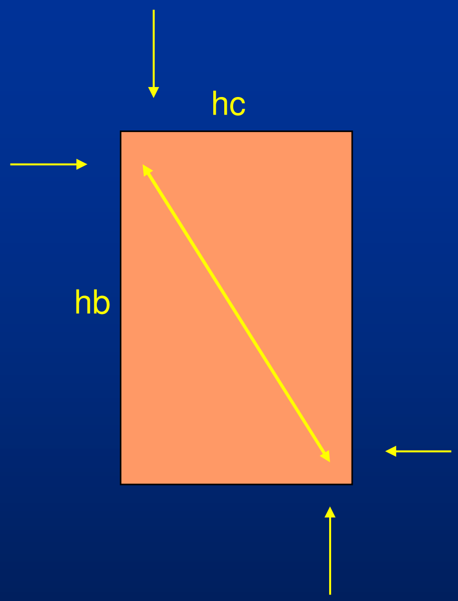
hb / hc = 0.5



Vn = Vc

Vs = 0

$1 < hb / hc < 1.5$

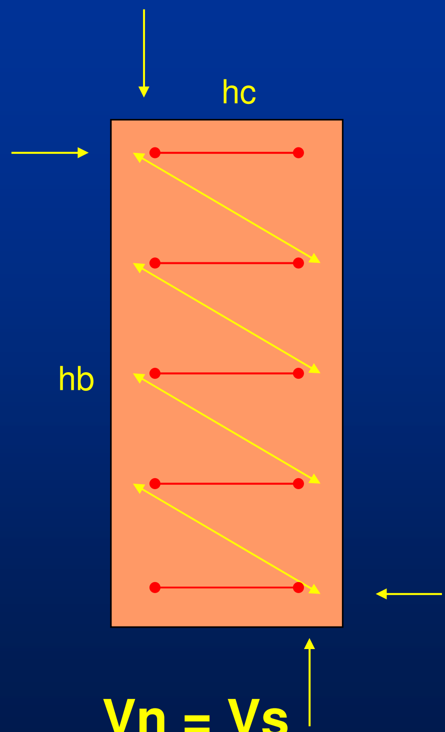


Vn = Vc + Vs

hb/hc= 1 **Vc = Vc** 318

hb/hc= 1.5 **Vc = 0**

$hb / hc > 1.5$



Vn = Vs

Vc = 0

2. Strong joint - Weak Beam

Bar passing through the joint

Hcol > 20 d beam

H beam > 20 d col

SHEAR WALL BUILDINGS
(+ Frames)

- Individual
- Coupled

SHEAR WALL BUILDINGS
(+ Frames)

INELASTIC RESPONSE

- Objective :
- Yielding of vertical wall bars at base of wall

- Strategy :

1. Strong wall in shear -
   Weak wall in flexion

Design shear force at base Vu

$$Vu = Vu_{analysis} \, (Mn / Mu)$$

$$Mn / Mu \;\; / \; 1.43$$

Where Mn = Wall flexural capacity from a P-M interaction diagram

Mu = Factored design moment

STRUCTURAL SYSTEMS RECOMMENDED

- Concrete structural walls
- Frame + shear walls
- Frames
- Avoid flat plate systems w/o shear walls

HOUSING RESEARCH CENTER

ESCUELA POLITECNICA NACIONAL - QUITO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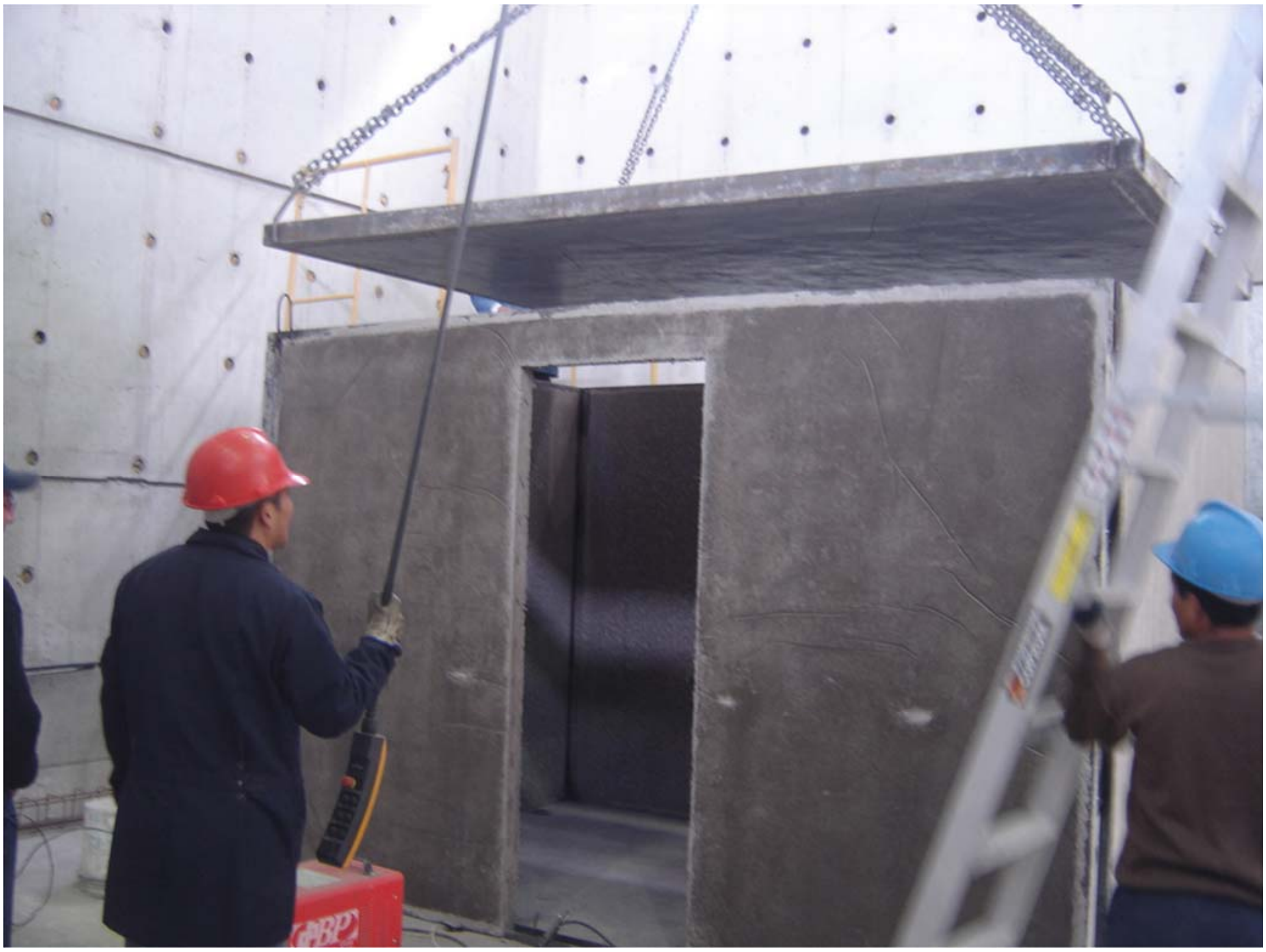


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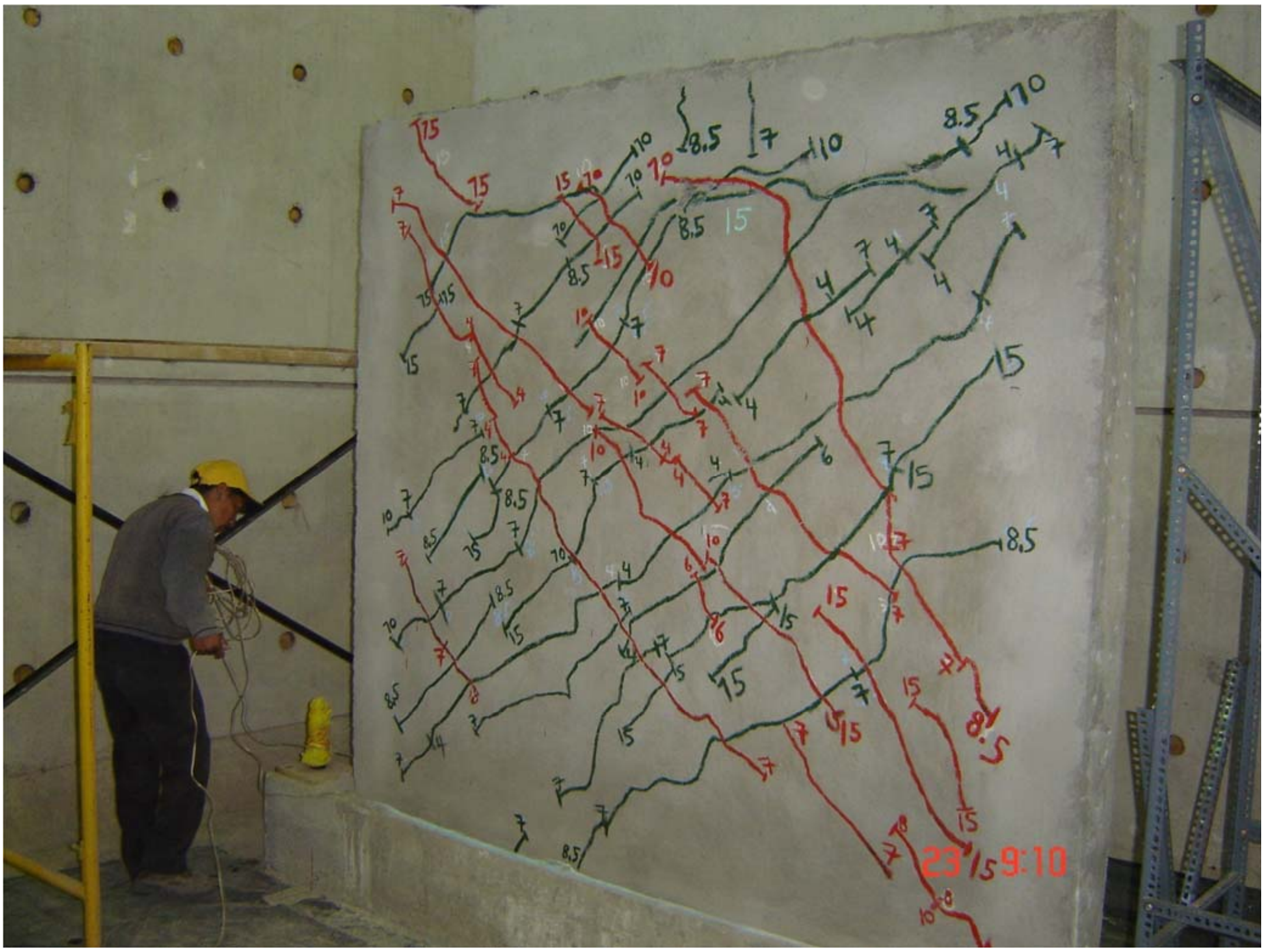
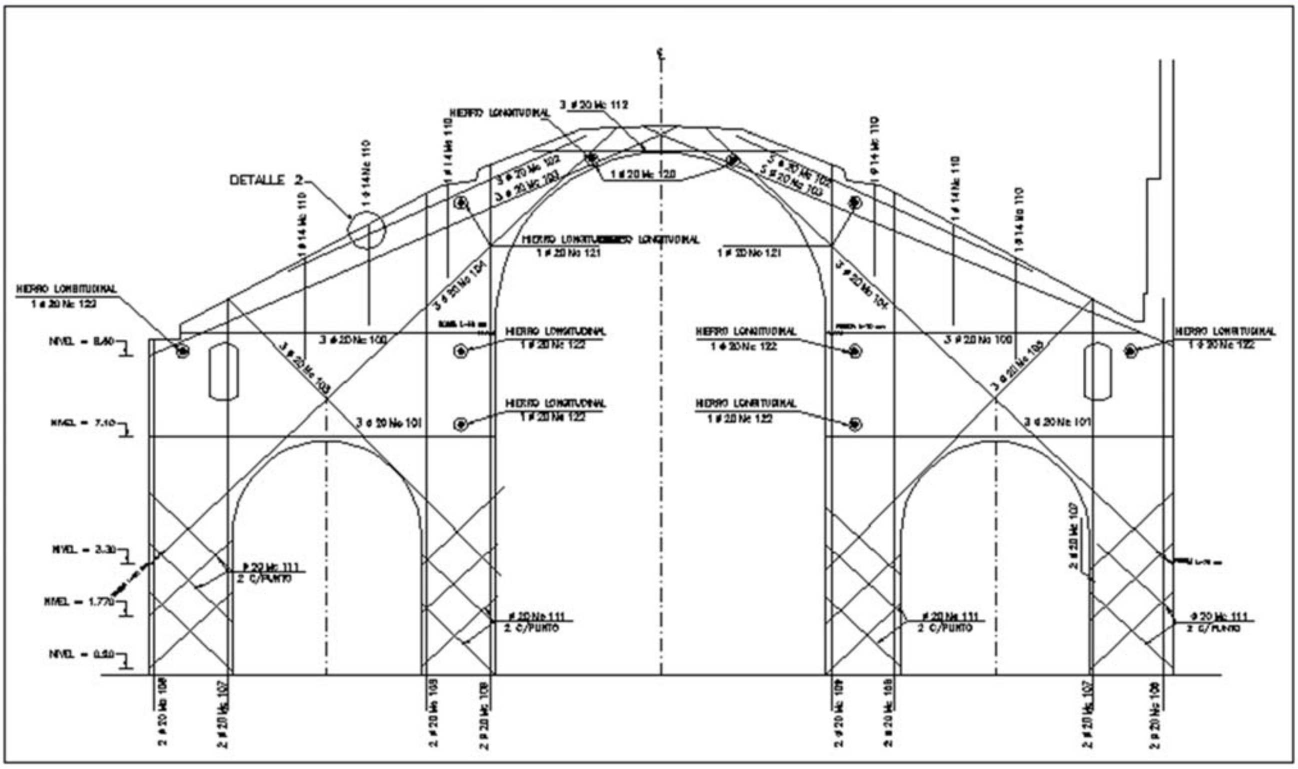
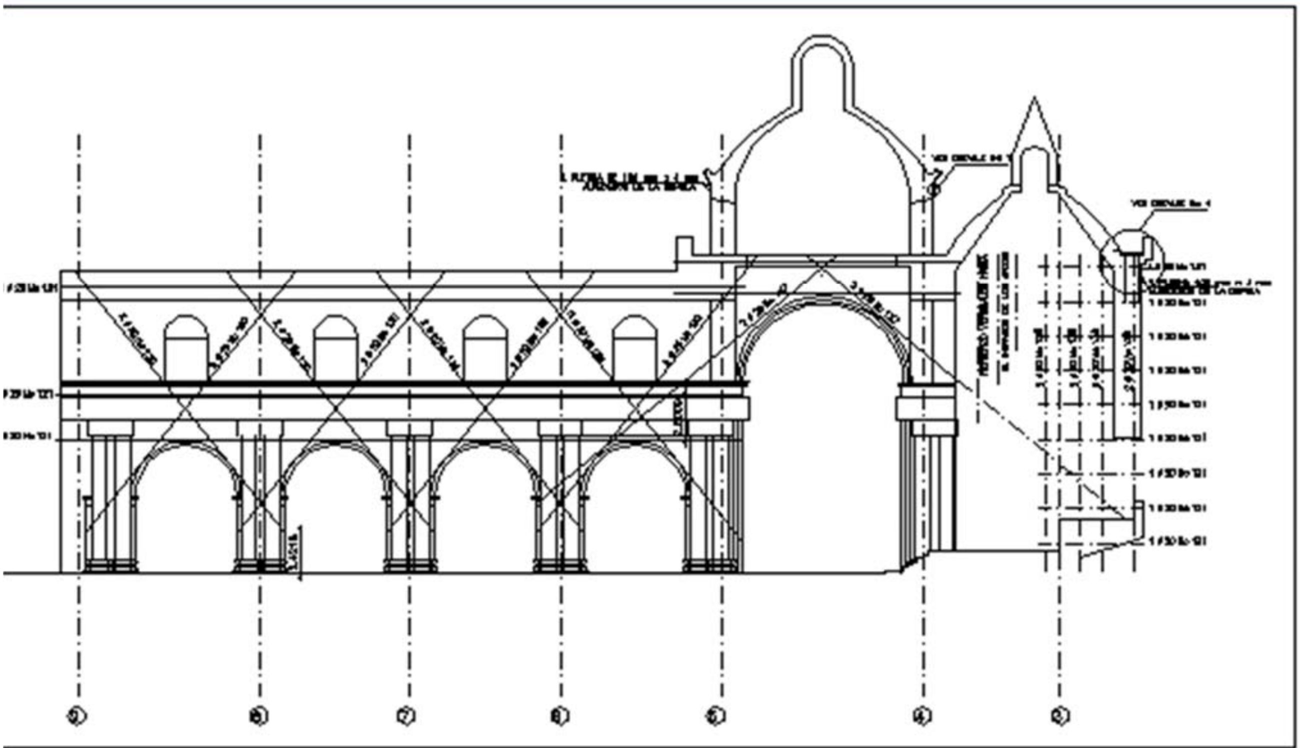




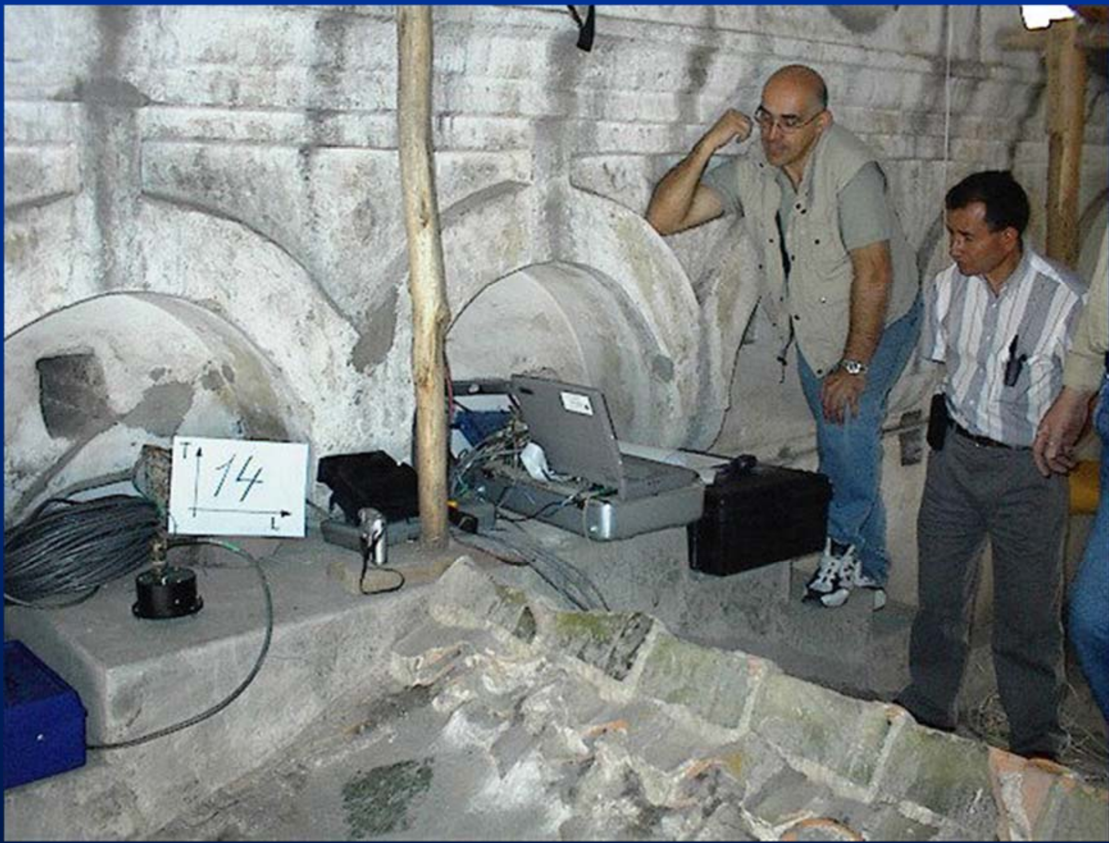
REFORZAMIENTO DE PORTICOS TRANSVERSALES 5,6,7,8,9

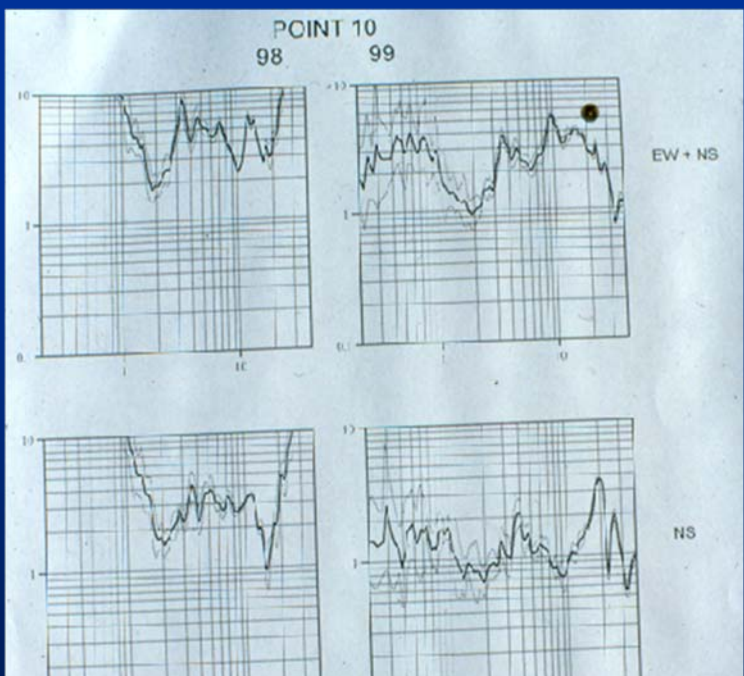
ESCALA 1:100



REFUERZOS DE PORTICOS LONGITUDINAL

ESCALA 1:250





RESULTADOS MEDICION DE PERIODOS - PUNTO 10

Dynamic Characteristics of a 17th Century Church in Quito, Ecuador

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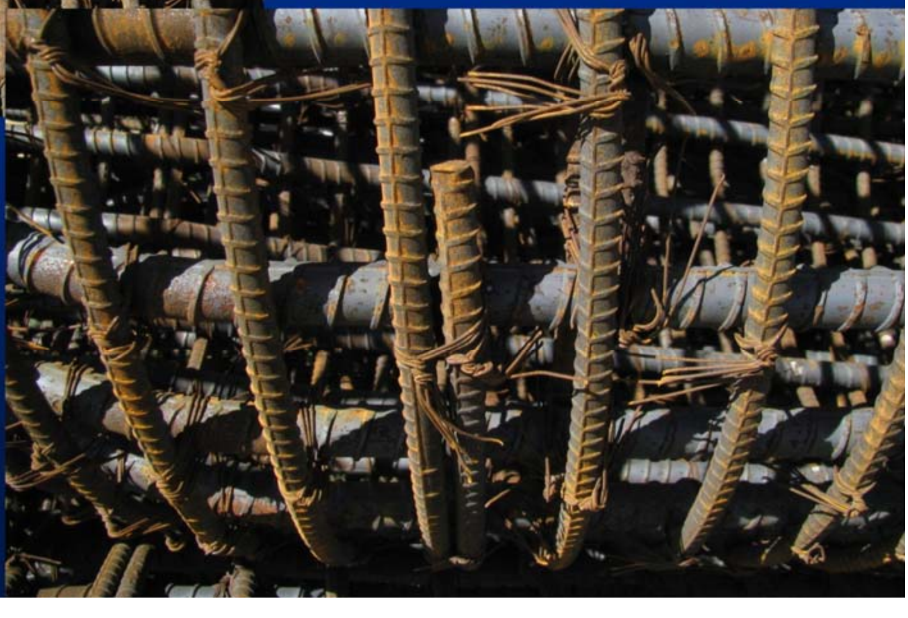
ABSTRACT

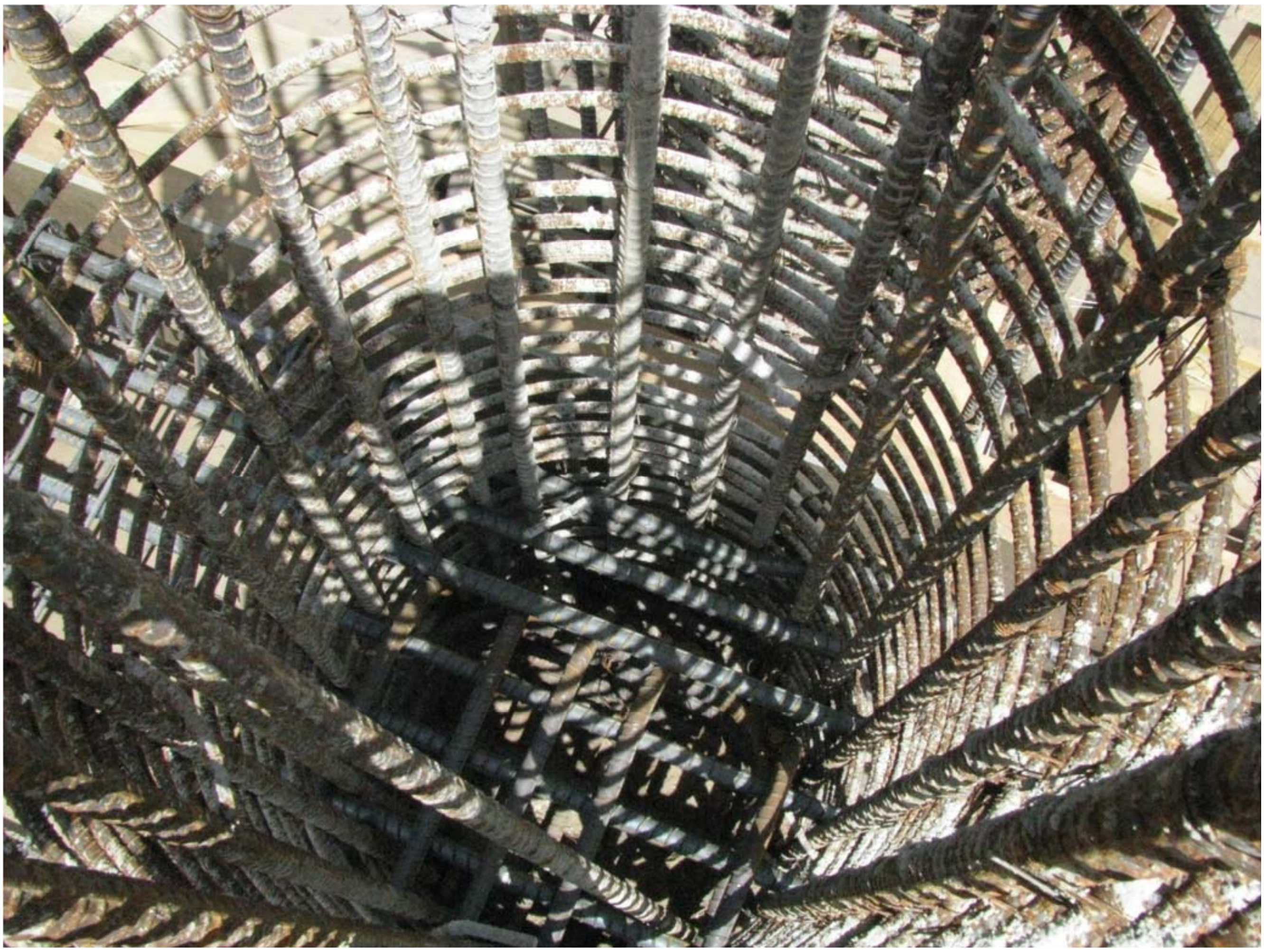
This paper presents the results of a study on the ambient vibration analysis of a historical monument in Ecuador, South America. La Iglesia de la Compañía de Jesus [the Church of the Jesuit Order] was constructed over a period of 30 years, from the mid 16th to the early 17th century and is

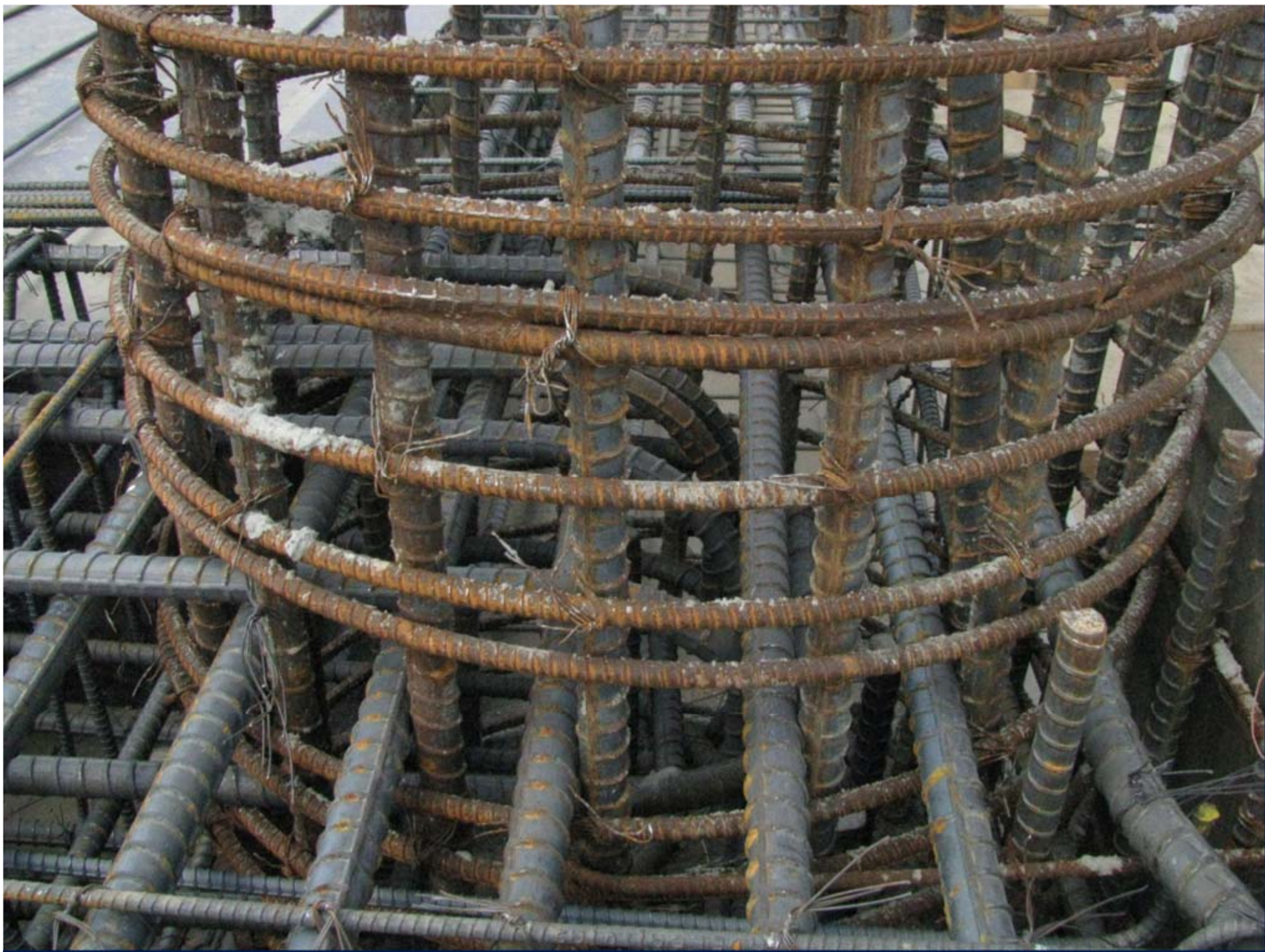
forces only. For this reason, most of the damage inflict the structure during seismic loadings occurs in region have high tensile stresses.

The church has been repaired many times througho history, and has undergone changes in terms of structu well as additions and upgrades. The behaviour c







Muchas gracias

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