BUILDING GROUP (G3)

Enhancement of Seismic Resistance of Buildings

15-16 March 2010

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OBJECTIVES

Enhancement of seismic resistance of buildings is the high priority in Peru to reduce the human losses due to earthquakes. To achieve this objective, we set the following research subjects:

1. Development of seismic performance model of buildings in Peru
2. Development of seismic evaluation and rehabilitation technologies for buildings in Peru
3. Enhancement plan of seismic resistance of buildings in Peru
4. Dissemination of knowledge to Latin countries

RESEARCH SUBJECT 1

Development of seismic performance model of buildings in Peru

- Identification of building types
- Study of building damage (in Peru, Chile)

- Creating database of test results and models
- Conducting structural tests
- Development of performance model

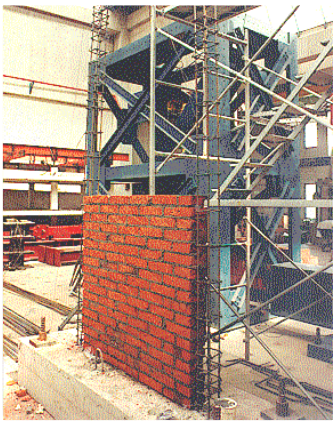
stone

adobe

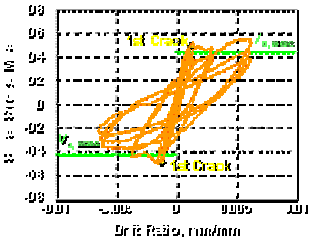
masonry

RC

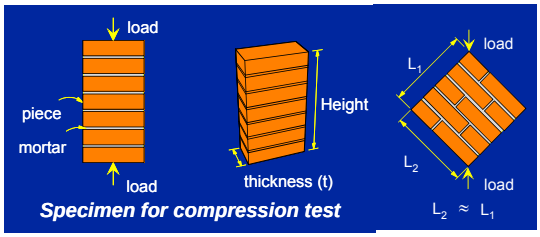
Creating database of test results and models



Quite a few researches have been done conducting structural tests of masonry structures around the world to evaluate the seismic resistance capacity. However, the test results and obtained knowledge are not shared among countries.



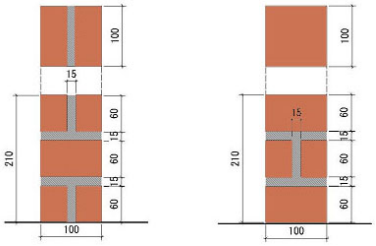
- **Material properties**
- **Failure patterns**
- **Mathematical models**
- **Design equations**
- **etc.**



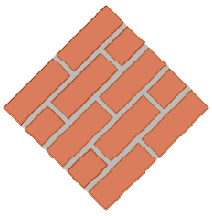
Database for seismic performance of masonry structures are quite useful to share the knowledge and develop effective technology to enhance seismic resistance of buildings.

Conducting structural tests

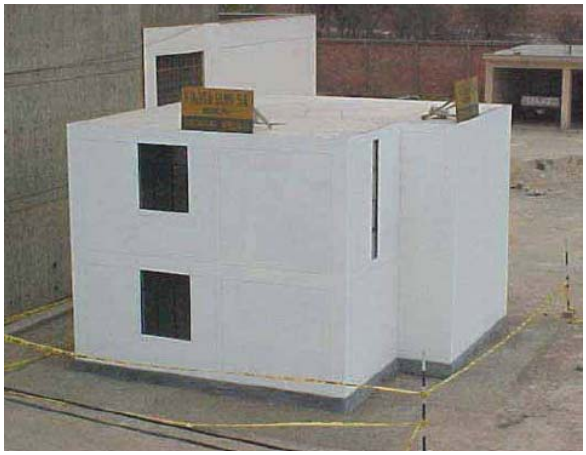
Compression test on masonry prism



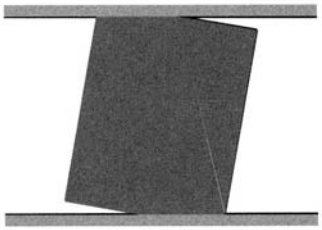
Diagonal compression test on masonry prism



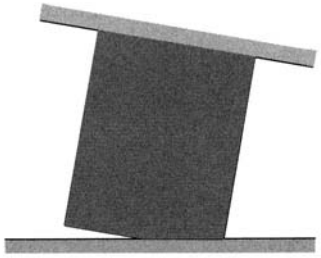
Full scale test of confined masonry house



Flexural and Rocking Failures

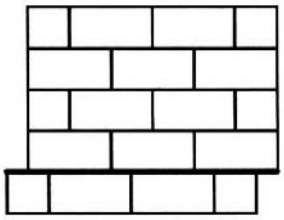


Flexural Failure

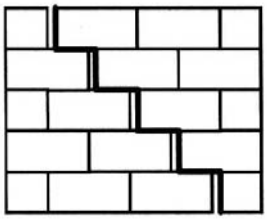


Rocking Failure

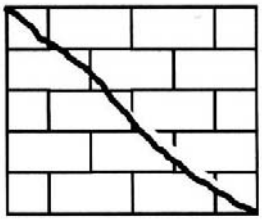
Shear Failures



Sliding Failure



Joint Failure



Diagonal Failure

Out of Plane Failures

Out-of-plane failure tests are very limited since it requires dynamic loading facility

Tilting table test of Adobe house in El Salvador, JICA-TAISHIN Project

Shaking table test, Sidney

RESEARCH SUBJECT 2

Development of seismic evaluation and rehabilitation technologies for buildings in Peru

- Development of seismic screening method of buildings
- Computer simulation for seismic evaluation

- Development of rehabilitation technologies
- Conducting structural tests to verify the technologies

Seismic Evaluation Standard in Japan

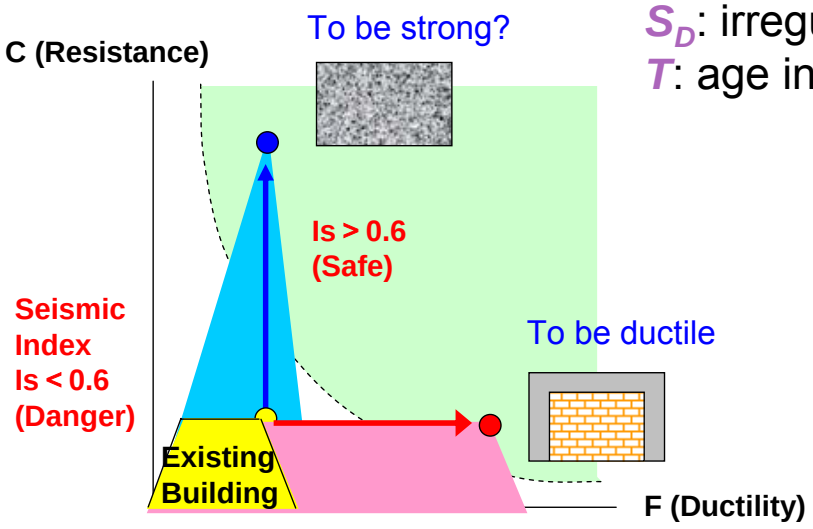
Seismic Structural Index I_s

$$I_S = \phi \times (C \times F) \times S_D \times T$$

φ: story index

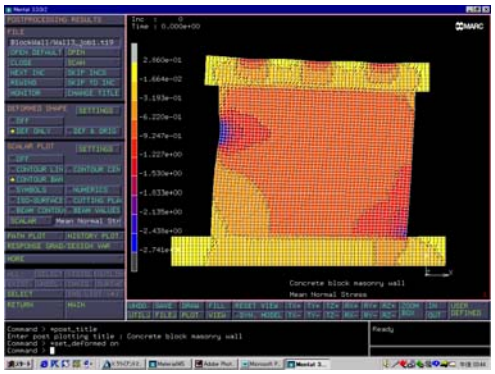
S_D: irregularity index

T: age index

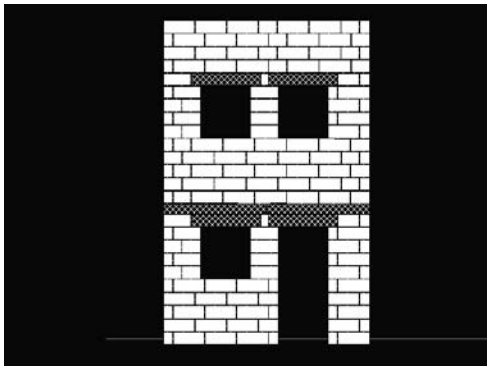


Computer simulation for seismic evaluation

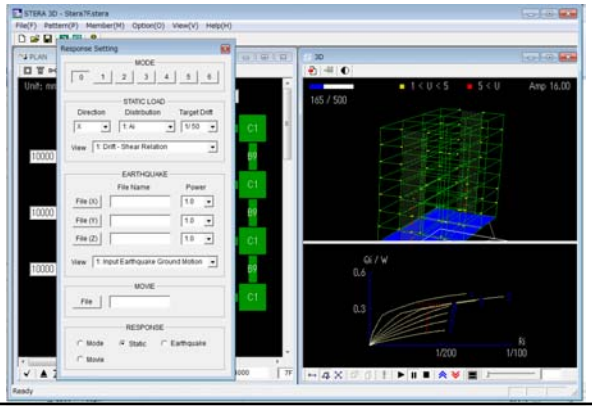
FEM analysis

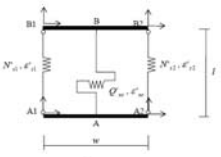


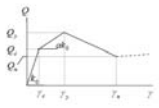
DEM analysis

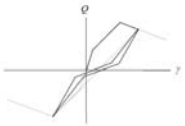


Frame analysis (STERA 3D Software)



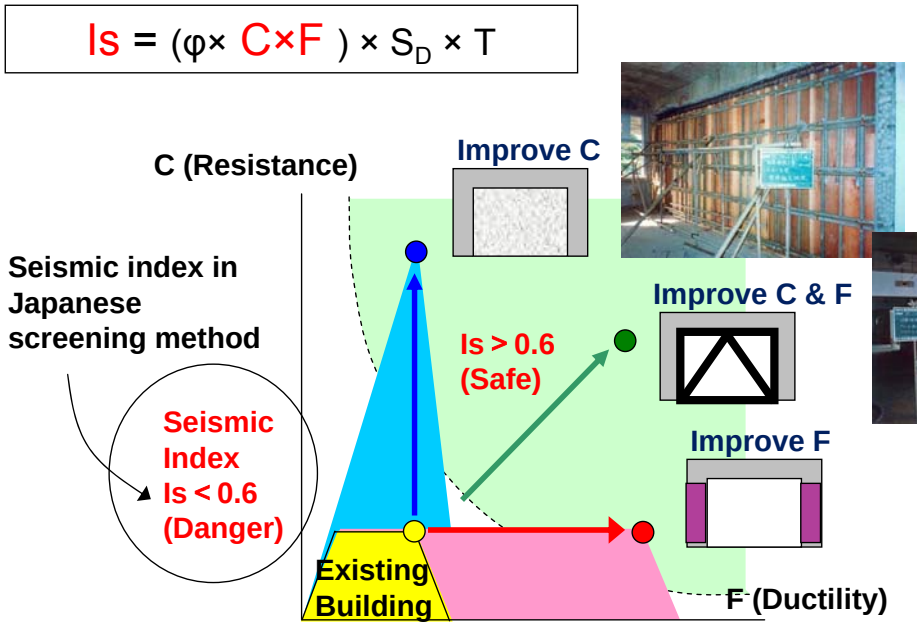






Development of rehabilitation technologies

$$Is = (\varphi \times C \times F) \times S_D \times T$$



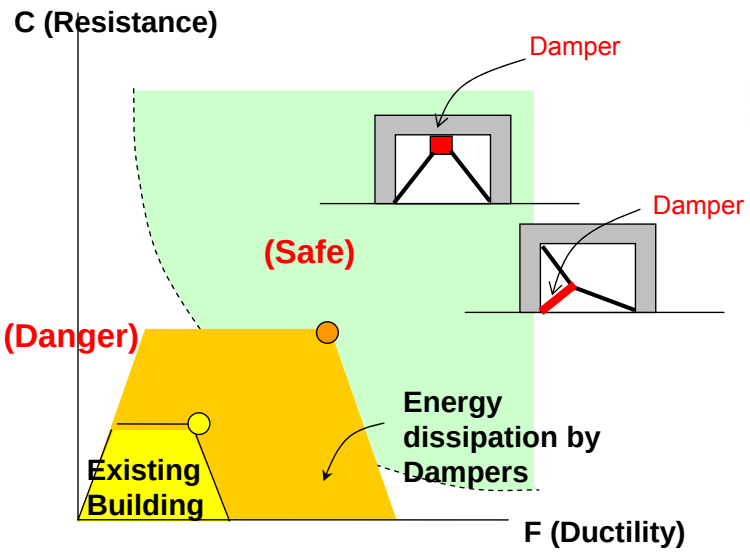
Replace brick wall to infill RC wall

Retrofitting by steel brace

Retrofitting by FRP sheet

Development of rehabilitation technologies

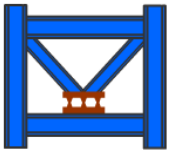
Retrofit using seismic dampers



Oil Damper

OILES Co.
http://www.oiles.co.jp

Steel Damper

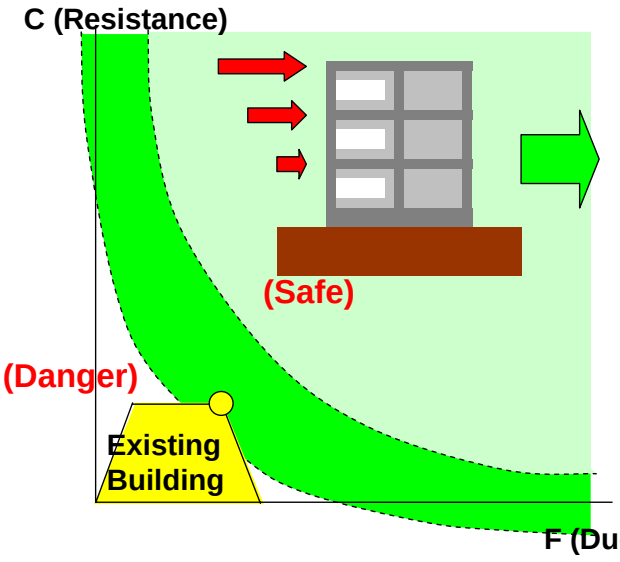


Kajima Co.
http://www.kajima.co.jp

Many other devices

Development of rehabilitation technologies

Retrofit using seismic isolation



Laminated Rubber bearing

Lead damper

Steel damper

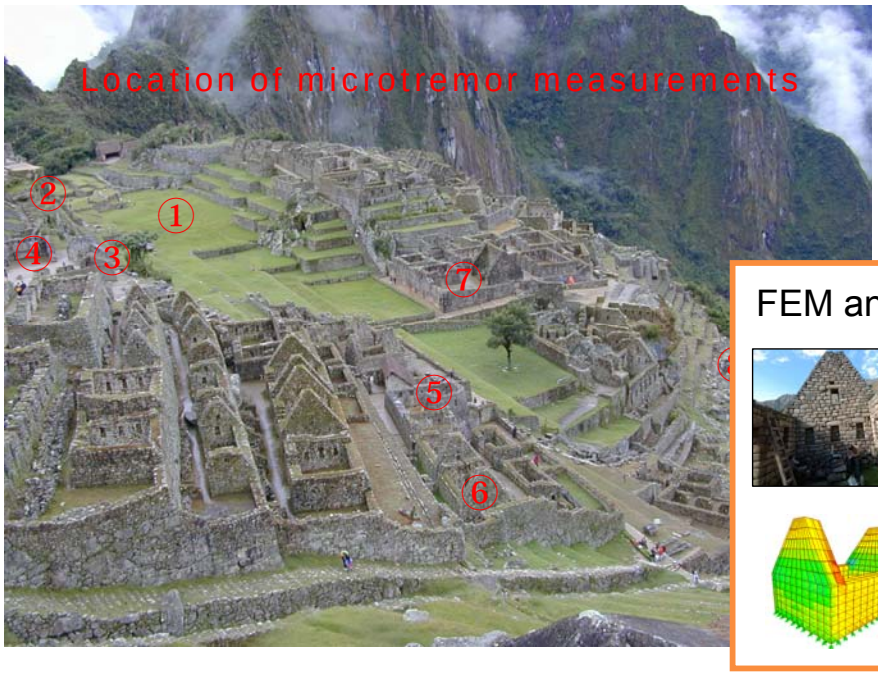
RESEARCH SUBJECT 3

Enhancement plan of seismic resistance of buildings in Peru

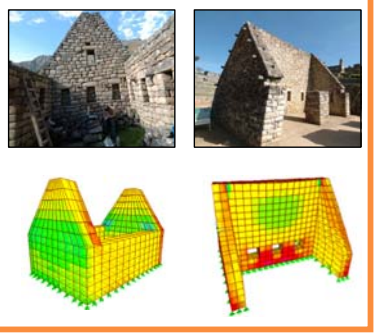
- Study on specific buildings in Peru
  - Important buildings (church, hospital, school, etc.)
  - Historical buildings (world heritage, colonial age, etc.)
  - Residential buildings (in urban area)
- Test and analysis of existing buildings
  - Non-destructive test such as micro-tremor measurement
  - Sampling test for material strength
  - Computer simulation of seismic performance
- Proposal of enhancement plan

Protection of world heritage against earthquakes

Micro tremor measurement



FEM analysis



Seismic vulnerability assessment of Lima Centro

DISCUSSION THEMES

on 16 March, 2010

- 5-year activity plan
  - Database
  - Structural test
  - Structural analysis
- List of input
  - Equipment
  - Personnel
- List of output
  - Evaluation method
  - Rehabilitation method
  - Enhancement plan