Science and Technology Research Partnership for Sustainable Development (**SATREPS**)

Progress of G3 Activity

JAPANESE SIDE

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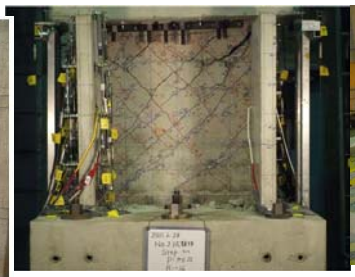
Masaomi Teshigawara (Nagoya University)
Koichi Kusunoki (University of Tokyo)
Carlos Cuadra (Akita Prefectural University)
Shunsuke Sugano, Tomohisa Mukai, Masanori Tani (BRI)
Akio Abe (Tokyo Soil Research Co.Ltd.)
Toshikazu Kabeyasawa, Haruhiko Suwada (NILIM)
Zhang Wei (Tsukuba University)

PERUVIAN SIDE

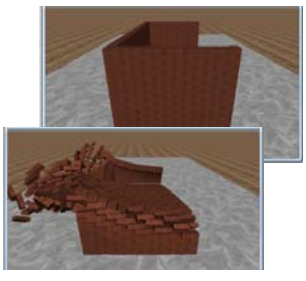
Carlos Zavala, Javier Pique, Jorge Gallardo, Patricia Gibu, Miguel Diaz
Ricardo Proaño, Luis Lavado, Jenny Taira, Lourdes Cardenas, Lucio Estacio (CISMID-FIC-UNI)
Gabriela Silva (Ministry of Culture)
Maria del Carmen Corrales (Metropolitan Municipality of Lima)
Carlos Montes de Oca, Carmen Kuroiwa, Gabriela Esparza (SENCICO)

Asociación de Investigación en Ciencia y Tecnología para el Desarrollo Sostenible (**SATREPS**)
Science and Technology Research Partnership for Sustainable Development (**SATREPS**)

Progress of G3 Activity






Presented by:
Dr. Carlos Zavala PI - SATREPS Peruvian side, Professor CISMID-FIC-UNI
Dr. Taiki Saito Professor, Toyohashi University of Technology

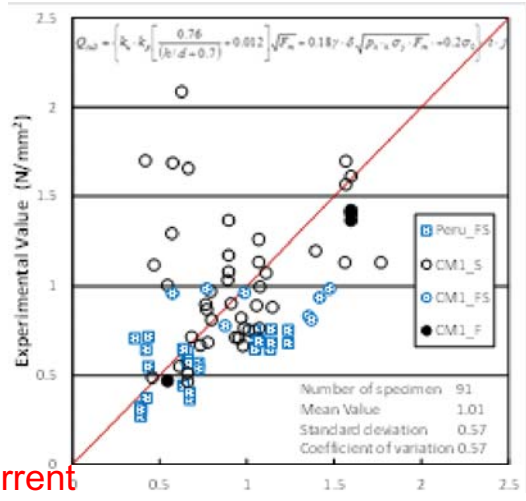
6-1
Developing a database of structural test results and material test results for buildings

Journal of Disaster Research, Vol. 9, No. 6, 2014

Strength and Deformation of Confined Brick Masonry Walls Subjected to Lateral Forces - Review of Existing Test Data in Japan and Peru -

Test results of confined brick masonry walls in the Japanese database (55 walls) and Peruvian database (34 walls) were reviewed.

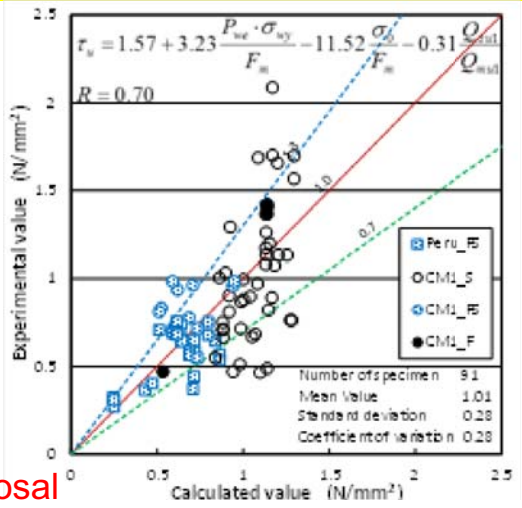
Empirical equations for strength and deformation of walls are developed base on the multiple regression analysis.



Current

Maximum shear strength using AIJ equation (stand. dev = 0.57)

Significant improvement

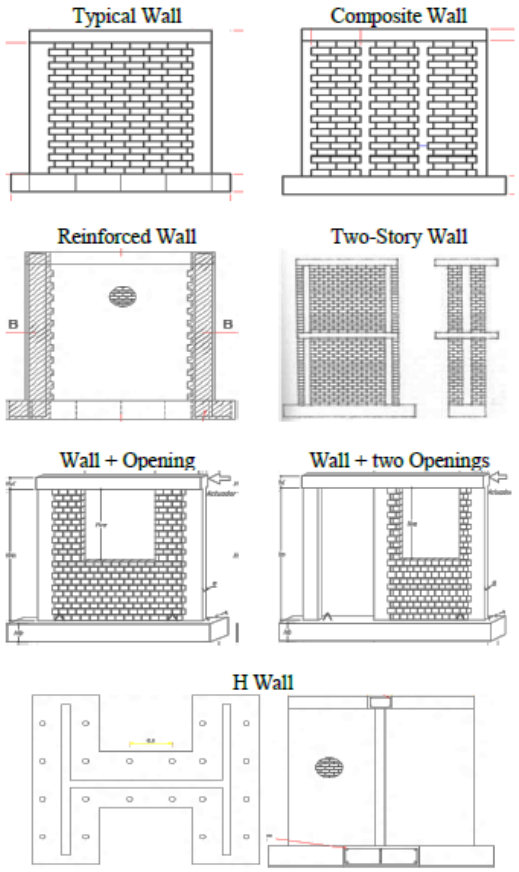


Proposal

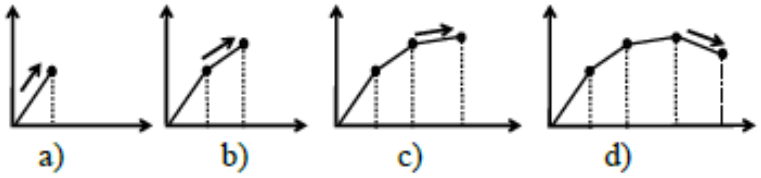
Maximum shear strength using proposed equation (stand. dev = 0.28)

Journal of Disaster Research, Vol. 9, No. 6, 2014

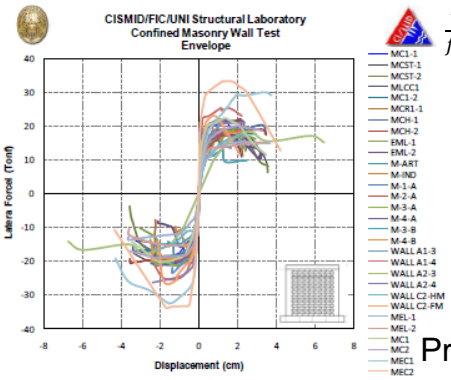
Implementation of Database of Masonry Wall Tests - Review of Existing Test Data in Peru



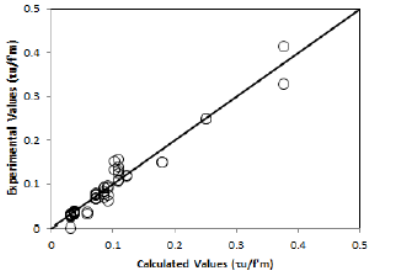
Collection of test results in CISMID:
30 typical walls, 2 composite Walls, 2 Reinforced Walls, 8 Two-Story Walls, 2 Walls + Opening, 2 Walls + two Openings and 3 H Walls, in total 49 walls.



Process of limit states of confined masonry wall



$$\frac{\tau_u}{f'_m} = 0.023 - 0.022\frac{h}{L} + 0.015\frac{P_t\sigma_y}{f'_m} + 0.037\frac{\sigma_0}{f'_m}$$

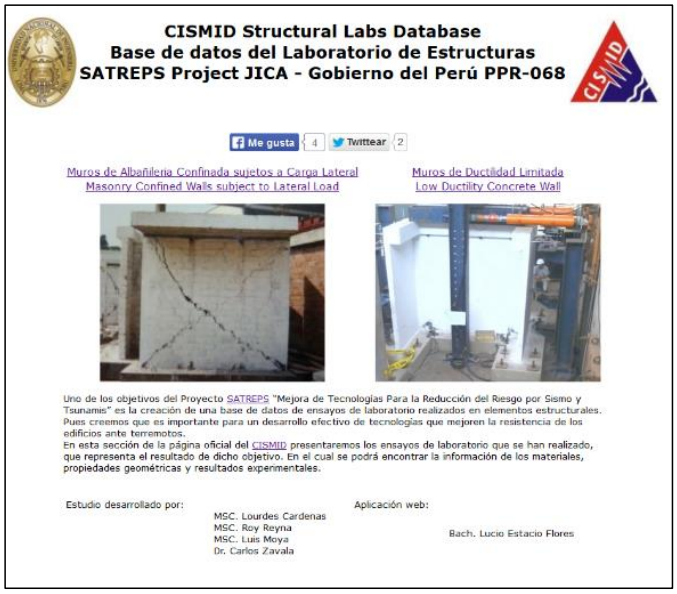


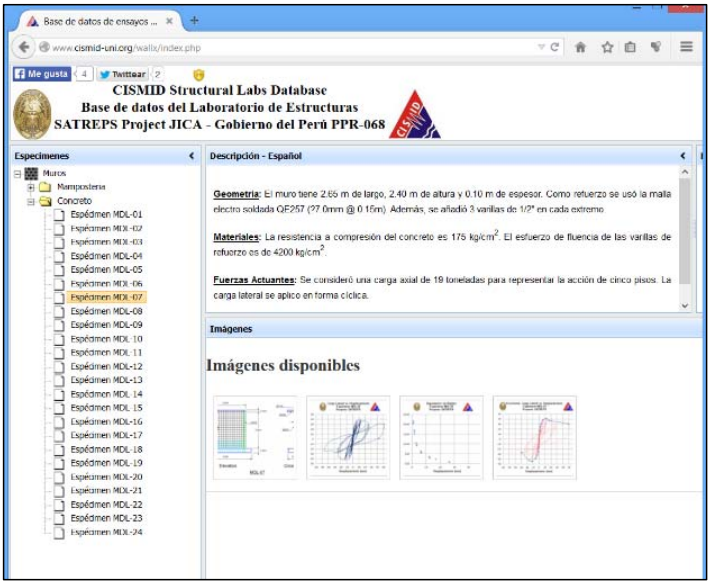
Proposal of evaluation formula

Journal of Disaster Research, Vol. 9, No. 6, 2014

Implementation of Database of Masonry Wall Tests - Review of Existing Test Data in Peru

EXPERIMENTAL DATABASE OF CONCRETE & MASONRY WALLS TEST WEB SITE





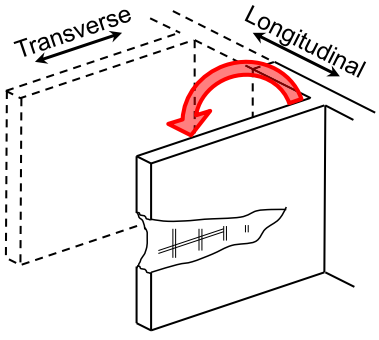
Database is open on the web site: http://www.cismid-uni.org/wallx/

6-2
Developing technology of seismic – diagnosis and retrofit for different types of buildings prevalent in Peru

Journal of Disaster Research, Vol. 8, No. 2, 2013

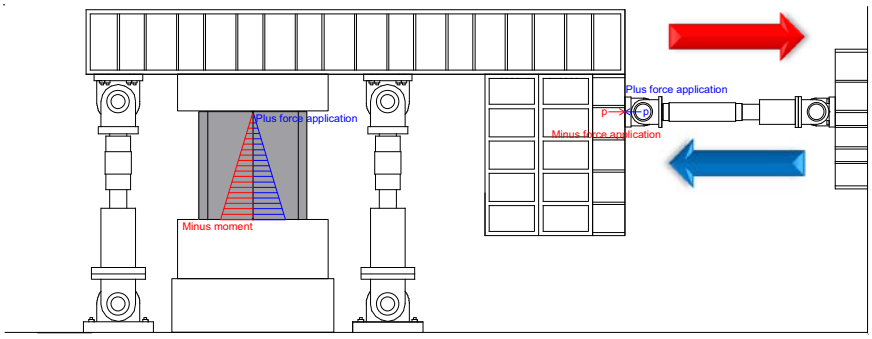
Experimental Study on Flexural Behavior of Reinforced Concrete Walls

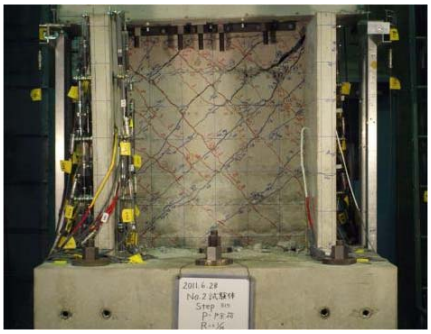
Japan-Peru-Chile joint investigation team



Lessons of 2010 Chile Earthquake
Extensive damage to wall structures by flexural failure

Structural Test in National Yokohama University (2010-2011)



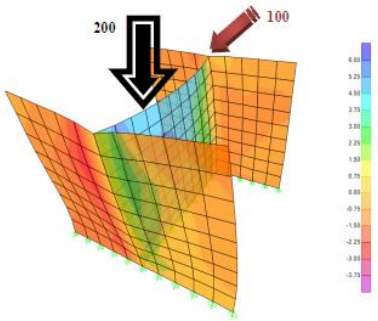


Journal of Disaster Research, Vol. 8, No. 2, 2013

Cyclic Behavior of Low Ductility Walls Considering Perpendicular Action

Low ductility wall buildings have become popular in Peru.

It is necessary to evaluate their performance by structural test, especially for H-shaped wall.



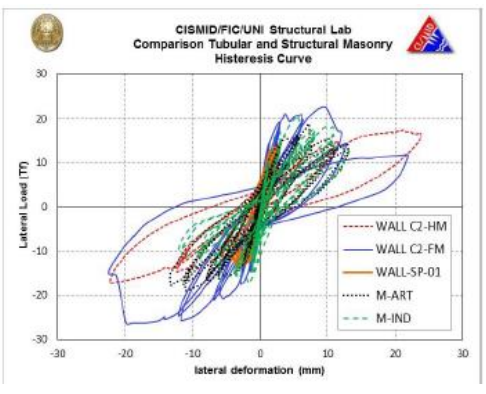
Journal of Disaster Research, Vol. 9, No. 6, 2014

Non-Engineering Masonry Tubular Block Behavior against Solid Engineering Wall

Around 60% of the population lived on non-engineering houses that use masonry tubular blocks on walls.

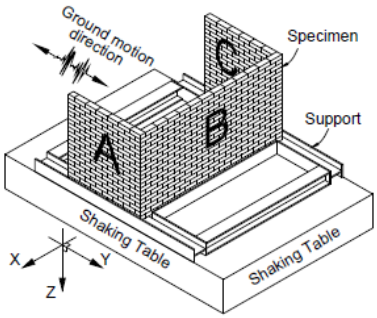
Behavior of a tubular brick wall was investigated by structural test in CISMID Lab.

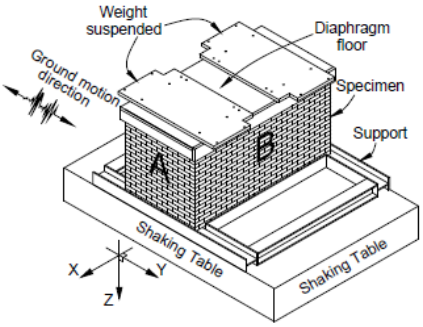
Tubular brick walls show more than 30% lower capacity than solid walls.



Journal of Disaster Research, Vol. 8, No. 2, 2013

Experimental Study on Dynamic Behavior of Unreinforced Masonry Walls





(b) Specimen of the shaking table

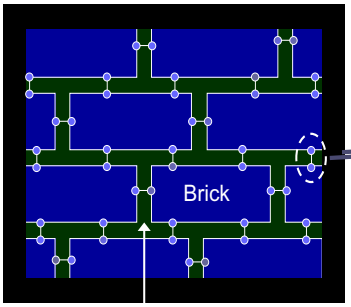
(b) Specimen of the shaking table

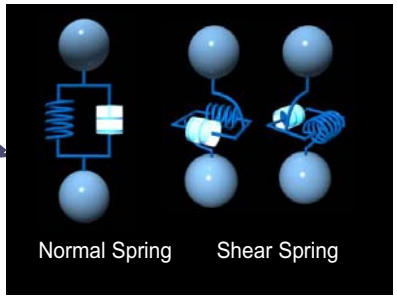
The main reason of earthquake damage in developing countries is the collapse of unreinforced masonry houses.

Dynamic behavior of an unreinforced masonry walls were investigated through a shaking table test.

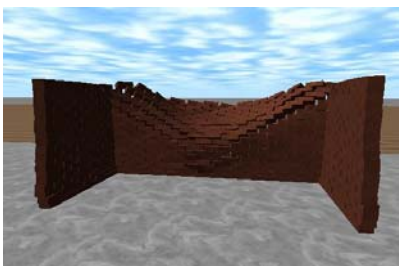
The first specimen showed the out-of-plane flexural failure mechanism, the other specimen exhibited in-plane shear failure mechanism.

Simulation of collapse behavior of masonry structure





A software was developed using Discrete Element Method (DEM) for simulating collapse behavior of masonry structure.



Network of ITK sensors for earthquake response of buildings

CIVIL ENGINEERING FACULTY BUILDING (FIC-UNI)

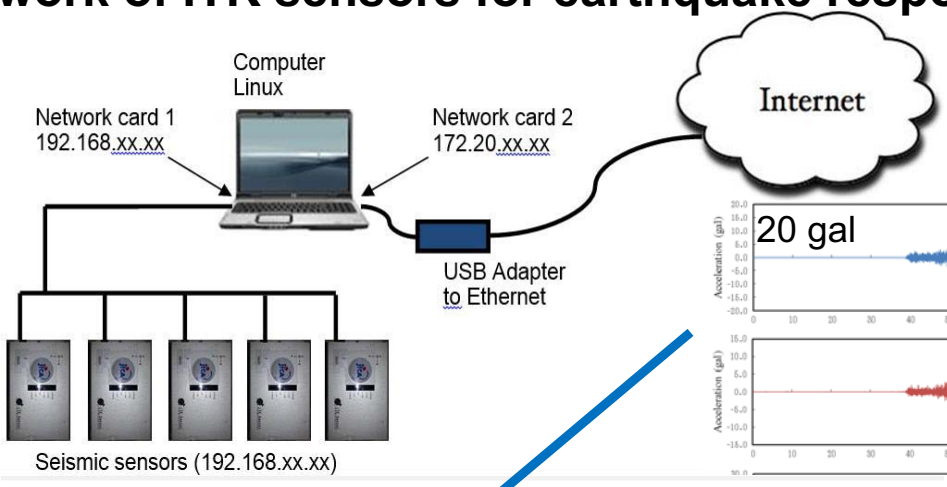
UNI CENTRAL BUILDING (PC-UNI)

Sensor at ceiling

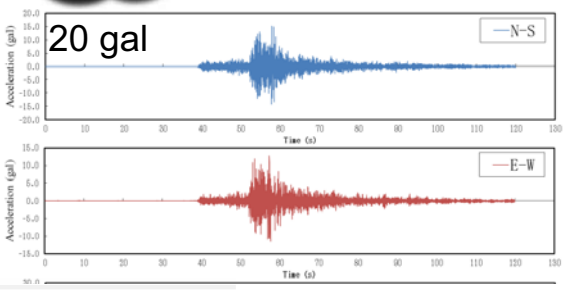
Sensor at ground

E. REBAGLIATI MARTINS HOSPITAL (HERM)

Network of ITK sensors for earthquake response of buildings

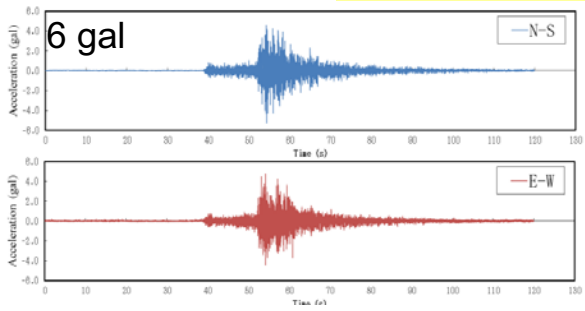


Roof level



CIVIL ENGINEERING FACULTY BUILDING

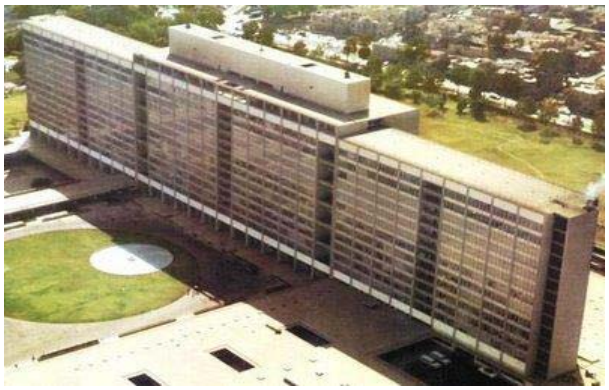
Basement level

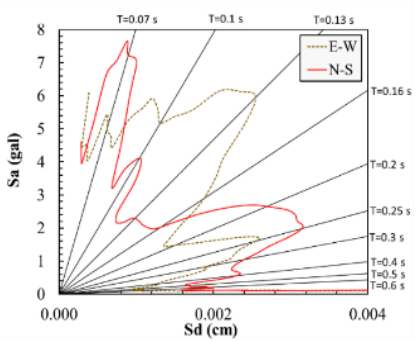


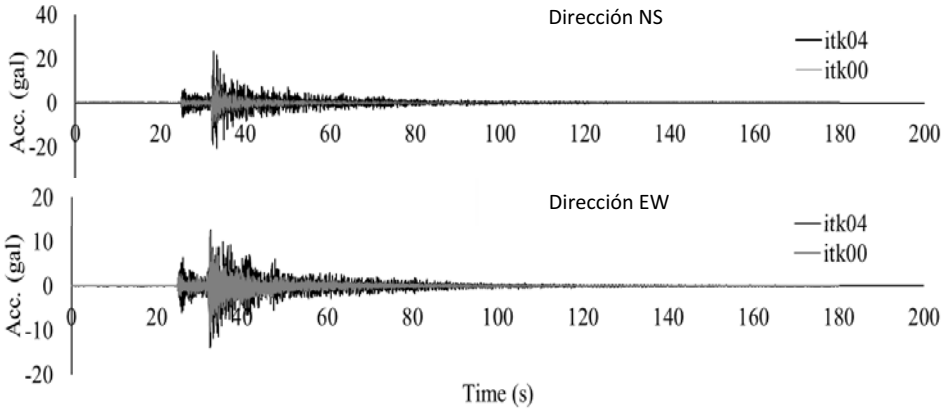
Network of ITK sensors for earthquake response of buildings

Date	Depth (Km)	Magnitude (ML)	Distance (Km)		
			HERM	PC-UNI	FIC-UNI
2012/11/03	110.0	4.7	111	112	112
2012/12/28	96.0	4.3	81	76	75
2013/10/18	11.0	4.2	58	64	64
2013/11/25	59.0	5.8	98	103	104
2014/02/20	38.0	4.1	83	89	90
2014/02/22	40.0	4.0	27	22	22
2014/04/26	35.0	4.0	84	87	88
2014/06/03	38.0	5.4	67	72	72

E. REBAGLIATI MARTINS HOSPITAL



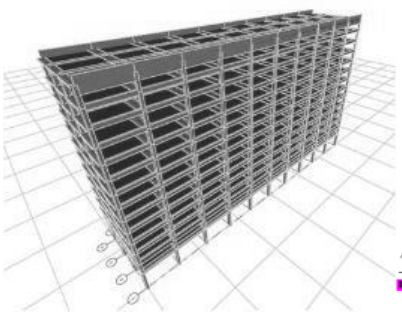


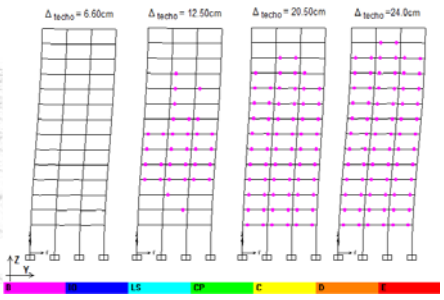


Journal of Disaster Research, Vol. 9, No. 6, 2014

Implementation of Building Monitoring Network in Peru under SATREPS Project

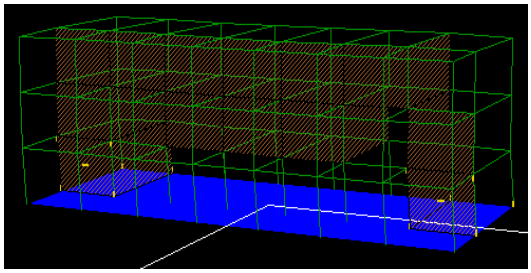
Diagnosis of Edgardo Rebagliatti Hospital – Block A



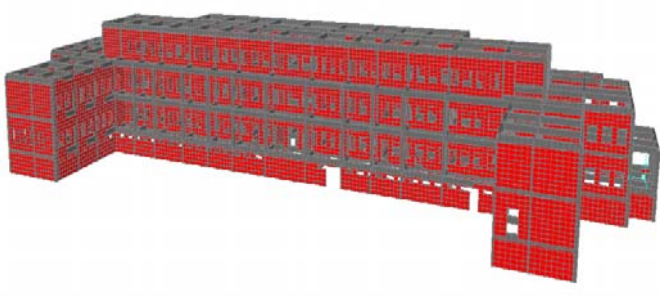


Together with monitoring with ITK sensors, seismic diagnoses of buildings were conducted using computer software.

Diagnosis of FIC-UNI Building – Block G



Diagnosis of PC-UNI Building



6-3
Identifying historical buildings in the study areas that face significant earthquake disaster risks

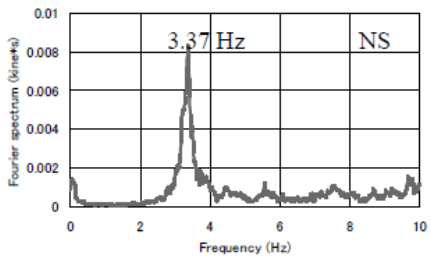
Journal of Disaster Research, Vol. 8, No. 2, 2013

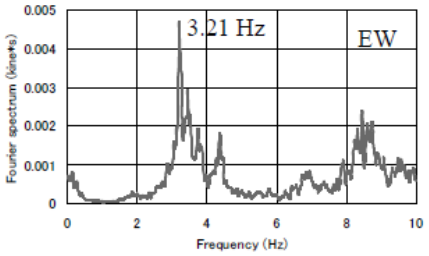
Diagnosis for Seismic Vulnerability Evaluation of Historical Buildings in Lima, Peru

Vibration Characteristics of Traditional Adobe-Quincha Buildings
(Akita Prefectural University, BRI and CISMID)

Comercio Hotel

Micro-tremor measurement

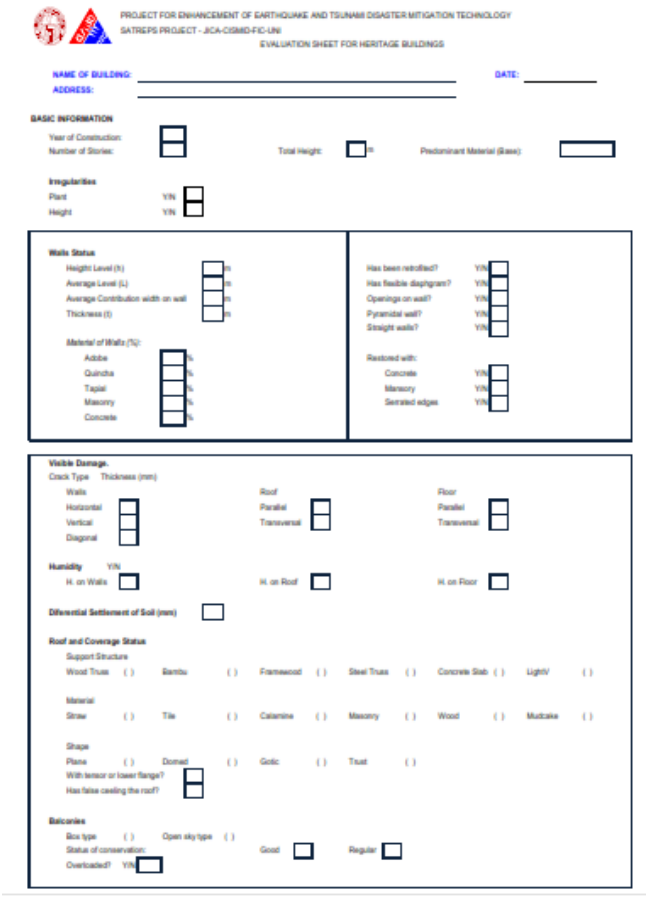




Dominant frequency

Evaluation of Historical Buildings in Lima, Peru

FORMAT FOR EVALUATION OF HERITAGE BUILDINGS



PROJECT FOR ENHANCEMENT OF EARTHQUAKE AND TSUNAMI DISASTER MITIGATION TECHNOLOGY
SATREPS PROJECT - JICA-CISMID-FIC-UNI
EVALUATION SHEET FOR HERITAGE BUILDINGS

NAME OF BUILDING: _____ DATE: _____
ADDRESS: _____

BASIC INFORMATION
Year of Construction:
Number of Stories:
Total Height: m
Predominant Material (Base):

Irregularities
Plant Y/N
Height Y/N

Walls Status
Height/ Level (h)
Average Level (L)
Average Contribution width on wall
Thickness (t)
Material of Walls (%):
Adobe
Quincha
Tapial
Masonry
Concrete

Has been retrofitted? Y/N
Has flexible diaphgram? Y/N
Openings on wall? Y/N
Pyramidal wall? Y/N
Straight walls? Y/N
Restored with:
Concrete Y/N
Masonry Y/N
Serrated edges Y/N

Visible Damage.
Crack Type Thickness (mm)
Walls
Horizontal
Vertical
Diagonal
Roof
Parallel
Transversal
Floor
Parallel
Transversal

Humidity Y/N
H. on Walls
H. on Roof
H. on Floor

Differential Settlement of Soil (mm)

Roof and Coverage Status
Support Structure
Wood Truss ( ) Bamboo ( ) Framewood ( ) Steel Truss ( ) Concrete Slab ( ) Light/ ( )
Material
Straw ( ) Tile ( ) Calamine ( ) Masonry ( ) Wood ( ) Mud/aka ( )
Shape
Plane ( ) Domed ( ) Gotic ( ) Trust ( )
With tensor or lower flange?
Has false ceeling the roof?

Balconies
Box type ( ) Open sky type ( )
Status of conservation: Good Regular
Overloaded? Y/N

St. Liberata Church (Rimac)

Nuestra Señora Copacabana Church (Rimac)

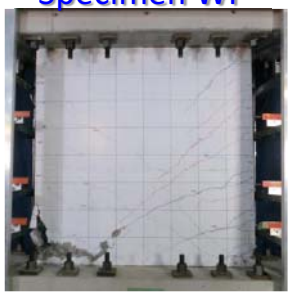
6-4
Verifying the effects of structural retrofit technologies through structural tests and numerical analyses

Journal of Disaster Research, Vol. 9, No. 6, 2014

Basic Study on Reinforced Concrete Shear Walls without Boundary Columns Retrofitted by Carbon Fiber Sheets

Development of retrofit techniques using Carbon Fiber Sheet

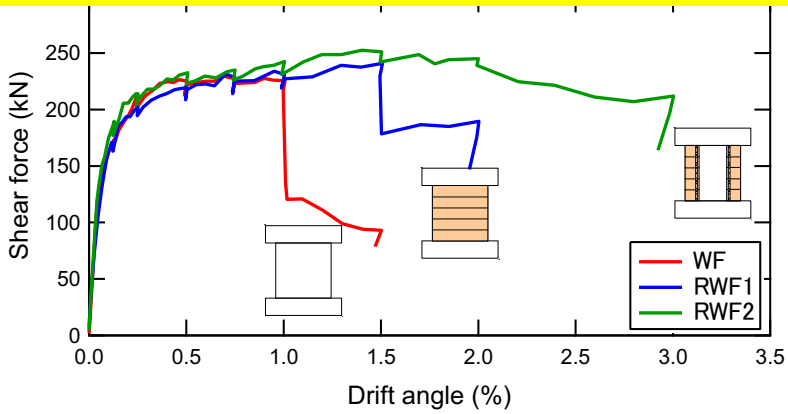
Specimen WF



Specimen RWF1

Specimen RWF2

Even partial retrofit improved ductility significantly.



Retrofit of Masonry Walls using Steel Wire Mesh




Procedure of retrofitting work:

- **To fix the wire mesh to the wall by anchoring side to side.**
- **Wire mesh is anchored to foundation by dowels.**
- **Surface is covered by mortar (1:4, cement:sand ratio).**
- **Plaster the surface till obtain uniform surface.**