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PROCEEDINGS
of
INTERNATIONAL VIDEO WORKSHOP 2009
on
SAFER HOUSING FOCUSING ON CONFINED MASONRY STRUCTURES

枠組み組積造の耐震性向上に関する国際ビデオワークショップ報告書
＜振動台実験結果、壁体繰り返し加力実験結果、現地建設状況調査報告を中心に＞

March 23, 2009
Tokyo, Tsukuba, Jakarta, Bandung, Yogyakarta, Kathmandu, Islamabad, Peshawar, Istanbul and Ankara

Building Research Institute (BRI)

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1. OUTLINE OF WORKSHOP

ワークショップ概要

International Video Workshop 2009 on Safer Housing Focusing on Confined Masonry Structures

1. Date (Japan Time)

March 23(Monday), 2009 16:00 - 21:00

2. Venues

JAPAN

- Tokyo – (Main Venue) World Bank Tokyo Development Learning Center (TDLC)
- Tsukuba – Building Research Institute (BRI)

INDONESIA

- Jakarta – JICA Indonesia Office
- Bandung – Bandung Institute of Technology
- Yogjakarta – Gadjah Mada University
  – Universitas Islam Indonesia

NEPAL

- Kathmandu – JICA Nepal Office

PAKISTAN

- Islamabad – JICA Pakistan Office
- Peshawar – NWFP University of Engineering and Technology Peshawar (UETP)

TURKEY

- Istanbul – Bilgi University
- Ankara – JICA Turkey Office

4. The number of the participants

Venue	Countries	turnout
Tokyo（Main Venue）	Japan	30
Tsukuba	Japan	11
Jakarta	Indonesia	2
Bandung	Indonesia	3
Yogyakarta	Indonesia	16
Kathmandu	Nepal	18
Islamabad	Pakistan	8
Peshawar	Pakistan	23
Istanbul	Turkey	8
Web Streaming services		9
TOTAL		128

5. Language English/Japanese (simultaneous translation)

枠組み組積造の耐震性向上に関する国際ビデオワークショップの開催概要
＜振動台実験結果、壁体繰り返し加力実験結果、現地建設状況調査報告を中心に＞

1．日時

	2009 年 3 月 23 日（月）
日本	16:00 － 21:00
インドネシア	14:00 － 19:00
ネパール	12:45 － 17:45
パキスタン	12:00 － 17:00
トルコ	09:00 － 14:00

2．開催地

下記の5ヵ国を世界銀行グローバル・ディスタンス・ラーニング・ネットワークのビデオ会議システムで繋いで実施。

・ 主会場：世界銀行東京開発ラーニングセンター（内幸町富国生命ビル）
・ 国内サブ会場：建築研究所（つくば市）
・ 海外サブ会場：インドネシア（ジャカルタ、バンドン、ジョグジャカルタ）
ネパール（カトマンズ）
パキスタン（イスラマバード、ペシャワール）
トルコ（イスタンブール、アンカラ）

3．参加者

場所（国）		参加者数
東京（主会場）	日本	30
つくば	日本	11
ジャカルタ	インドネシア	2
バンドン	インドネシア	3
ジョグジャカルタ	インドネシア	16
カトマンズ	ネパール	18
イスラマバード	パキスタン	8
ペシャワール	パキスタン	23
イスタンブール	トルコ	8
ウェブ・ストリーミング・サービス		9
合計		128

4．言語

日本語及び英語（日英の同時通訳を行います）

Summary of discussions/comments during Q & A times

- **Affect of the first earthquake occurred before the second (big) earthquake**
  - **Dr. Toshikazu Hanazato, Mie University:** Actually there was some impact from the first earthquake.
  - **Dr. Tatsuo Narafu, BRI:** Accumulation of the defect is a very important point and we have to take in account the already made cracks in order to analyze this result.

- **Difference of strength in brick bond between Pakistan brick and Japanese brick**
  - **Dr. Toshikazu Hanazato, Mie University:** Bonding strength between brick and mortar was less in Pakistan brick than Japanese brick. Same mortar was used for both types of brick. Tensile strength between brick and mortar was 0.525 Newton for Pakistan brick and 0.7 Newton for Japanese brick in average.

- **Influence of the soaking**
  - **Dr. Tatsuo Narafu, BRI:** If we construct walls without soaking, the brick will absorb water and it will influence mortar strength. That influence has to be identified but we think it will not affect largely because strength of mortar completely depend on water ratio. Strength of brick is not so much influential as we do not see bricks that had been broken. Most failure occurs on cement mortar.

- **Different conditions of brick surface**
  - **Dr. Tatsuo Narafu, BRI:** The fact that the wall made by Japanese brick did not collapse while the Pakistan brick did, tells us that brick surface is very influential. Surface condition affects a lot on bonding strength.

- **Comparative studies**
  - **Dr. Tatsuo Narafu, BRI:** We have just conducted a comparative study of different conditions of cement. We followed the usual testing method of compression for cement. But the point is not compression strength but bonding strength. We need further research.

- **Cement / water ratio for different weather conditions**
  - **Dr. Tatsuo Narafu, BRI:** In places like Indonesia where rainy season exists, strength of mortar may not be controlled well because weather condition differs by season (moisture / dry). Further investigation on this point. (Report on the condition of Indonesia will be contained in Mr. Shirakawa's presentation later.)

- **Difference between the LED image processing and other conventional measurements**
  - **Dr. Yasushi Niitsu, Tokyo Denki University:** For this experiment we did not compare it with other measurements but for other experiments in Japan, we regularly compare them with shaking table experiment and the resolution accuracy is better than 1 mm for 10 m large space.

- **Better way to make confined masonry a safer structure**
  - **Dr. Toshikazu Hanazato, Mie University:** Any defect will affect seismic capacity more than strength of materials. You need to look at how the perfection is being done.
  - **Dr. Chikahiro Minowa, NIED:** Lintel reinforcement as well as wire mesh has significant effect in reinforcement. It can be said that structure collapse have some kind of defect in the building.

- **Toughness of brick**

  Mr. Teddy Boen, Indonesia: Indonesian masonry brick is very very weak. Indian, Pakistan, and Nepal brick is very strong.

- **Basic difference between "Himis" and the other timber reinforcement "Badadi"**

  Dr. Ahmet Turer (or Dr. Altug Erberik), Middle East Technical University: Badadi has a completely wooden front panel which is covered with thin layer, and it is filled with clay mud. Himis has its surface exposed and it is not covered with any plaster on surface. Badadi, whose whole surface is covered with wooden confinement, can be explained as a confined masonry but not being reinforced by cement.

- **For confined masonry with timber, which comes ahead, frame or infill?**

  Dr. Ahmet Turer (or Dr. Altug Erberik), Middle East Technical University: If there is too much wood, it can be called a structure with masonry infill, but with less wood, it can be called masonry with wooden strength.

- **Laboratory tests on to find out minimum diameter of timber.**

  Dr. Ahmet Turer (or Dr. Altug Erberik), Middle East Technical University: Some tests had been implemented but I do not have the data.

- **Type of connection of confined masonry with timber**

  Dr. Ahmet Turer (or Dr. Altug Erberik), Middle East Technical University: Connection is made of nails and what is discovered so far is that the strength depends on nails. Number of nails causes difference and wood does not fail but separates. There is not much study in Turkey on wooden confined masonry and we are now working on it.

  Dr. Toshikazu Hanazato, Mie University: We will start a research on seismic safety of timber composite brick masonry from coming April with shaking table experiment. We will present it next year.

- **Construction workers in Indonesia**

  Ms. Shizuko Matsuzaki, EVAA: Many construction workers regularly work for other occupation (mainly farmer) and they build houses only for family members. Professional workers are called from time to time when needed. Worker skill problem still exists.

  Ms. Dyah Kusumasututi, ITB: Drawings vary from place to place and some just show big elements (column, etc.) and do not provide specification on other factors such as join, etc. Their problem is not only technical but their idea of how the construction should be.

- **Comment on quick report of cyclic loading experiments on confined masonry in Bundung**

  Mr. Wira, ITB: Best specimen is Model F because it realizes high resistance and long activity before collapse. Also its structure is simple than lintel model beam.

  Ms. Dyah Kusumasututi, ITB: When designing the structure, not only strength capacity but also ductility should be considered. Model G reaches the maximum force but degrades rather quickly. In this point Model F has comparative advantage. Model F seems to be the best but further research is needed.

- **Specimen used in experiment by Gadjah Mada University**

  Mr. Iman Satyarno, UGM: Reinforcement by plaster using "1 cement: 2 sand". Its compression strength was around 23 MPA, which is quite high compared to common masonry brick wall (2~5 MPA). We put wire mesh on the wall and plastered it for about 2 cm. Improvement was only made by the plaster and reinforcing bars and diameter of column and ring beam were the same.

- **RC frame used in experiment by Gadjah Mada University**

  Mr. Iman Satyarno, UGM: We took off all the brick and replaced them with RC. We didn't plaster the wall. Concrete quality was 19.52 MPA, which was slightly less than compressive strength of plaster (23.33 MPA). Our suggestion is, in order to confine brick masonry wall you should put plaster to improve safety.

- **Placement of plaster and prevention of cracks**

  Mr. Iman Satyarno, UGM: Plasters were on both sides. The wall had no crack at all. However strengthening of house didn't comply with earthquake resistant requirements. You just have to put plaster on the wall. It is proved in the lab that plaster can improve strength of the walls and also change the failure of the wall due to rocking.

- **Cost of plaster used in experiment by Gadjah Mada University**

  Mr. Iman Satyarno, UGM: "1 Cement :2 sand" plaster will be quite expensive for common or new houses with confinement elements (column, reinforcement bars, ring beam) so I would suggest "1 Cement :4 sand". For a house with no column or ring beam (like ones we found in Yogyakarta) retrofitting by "1 Cement :2 sand" won't be expensive.

東京会場風景

各会場風景

東京会場発表風景

海外からの発表風景１

東京会場発表風景（海外からの招聘者）

会場風景（質疑応答、コメント）

2. PRESENTATION MATERIALS OF WORKSHOP

ワークショップ発表資料

2.1. Confirmation of connection of the venues, inauguration, comments on experiments (Dr. Tatsuo NARAFU) / 接続状況確認、開会（趣旨、次第確認、振動台実験のコメント）

（独立行政法人建築研究所　楢府龍雄）

Comments on the Results of Shaking Table Experiments focusing on Mortar

International Video Workshop 2009 on Safer housing Focusing on Confined Masonry Structures

March 23, 2009

The World Bank Tokyo Development Learning Center (TDLC), Tokyo, Japan

Dr. Tatsuo Narafu

General Coordinator of R&D Project

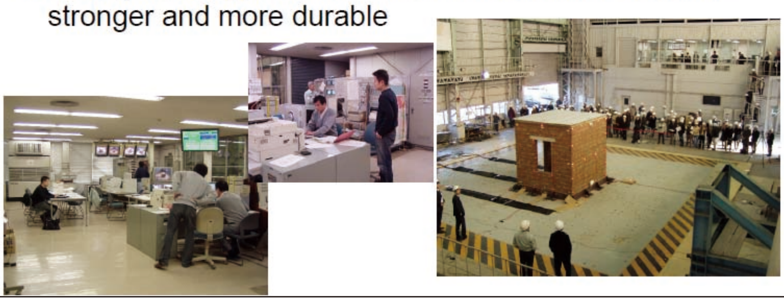
Senior Coordinator for International Cooperation, Building Research Institute Japan (BRI)

Background of Study

Shaking table experiment on non-reinforced brick masonry specimen in July 2008

Major findings of the experiment

- The specimen was Very strong against lateral forces
- Strong bonding of cement mortar makes the structure stronger and more durable



Strength test on mortar

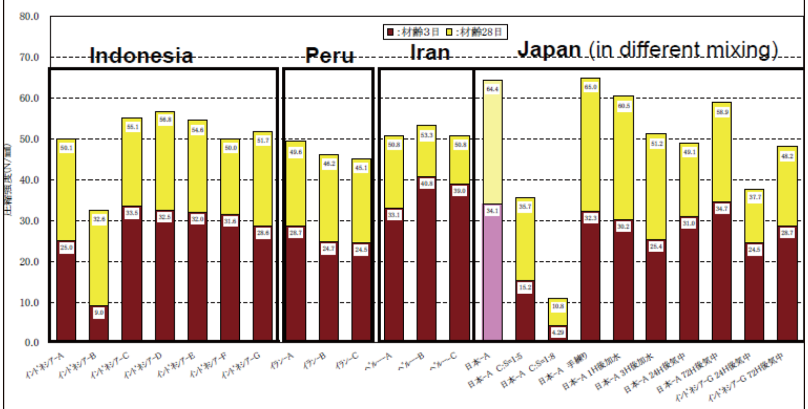
- BRI is to conduct strength test of mortar of
  - different cement (Indonesia: 7 samples, Iran: 3 samples, Peru: 3 samples, Japan 1 sample)
  - different conditions (mixture ratio, cement/water ratio, effect of additional water and curing condition)
- Fabrication of specimens: July 2008
- Strength test: July – August, 2008

List of sample cement

sample	manufacturer	Shop/donor	remarks
Indonesia A	Holcim	Construction site, Jogja	Donation by a resident
Indonesia B	Gresic	Laboratory of Univ., Jogja	Donation by Univ.
Indonesia C	Gresic	Shop, Jogja	Buy by KG
Indonesia D	Gresic	Shop, Jogja	Buy by KG
Indonesia E	Gresic	Shop, Jogja	Buy by KG
Indonesia F	Indocement	Shop, Jogja	Buy by KG
Indonesia G	Indocement	Shop, Jakarta	Buy by bag
Peru A	SOL	Home Center, Lima	Buy by KG
Peru B	SOL	Shop, Lima	Buy by KG
Peru C	SOL	Shop, Lima	Buy by KG
Iran A	NA	Cement Plant, Kerman	Buy by KG
Iran B	NA	Construction site, Bam	Donation by workers
Iran C	NA	Construction site, Bam	Donation by workers
Japan	Taiheiyo Cement	Wholesaler	Buy by bulk

Compression strength of cement mortar by sample cement

age: 28 days
age: 3 days



Findings 1

- Difference in samples in compression strength of standard mixture ratio
  - All the specimen in age 28 days show 45 - 64 N/mm^2 except one from Lab. of Univ.
  - Difference between countries or manufactures is not significant
  - Difference of circulation does not influence much (shop or home center, packed or measured and packed)

Findings 2

- Difference in cement/sand ration is significant
  - Different Cement/sand ratio and almost same flow value
  - Compression strength shows a wide range of 64.4 to 10.8 N/mm^2

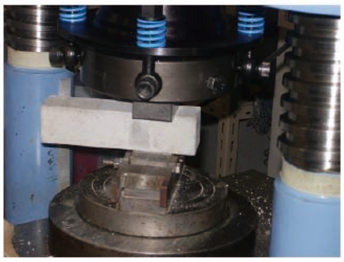
Measurement of flow value

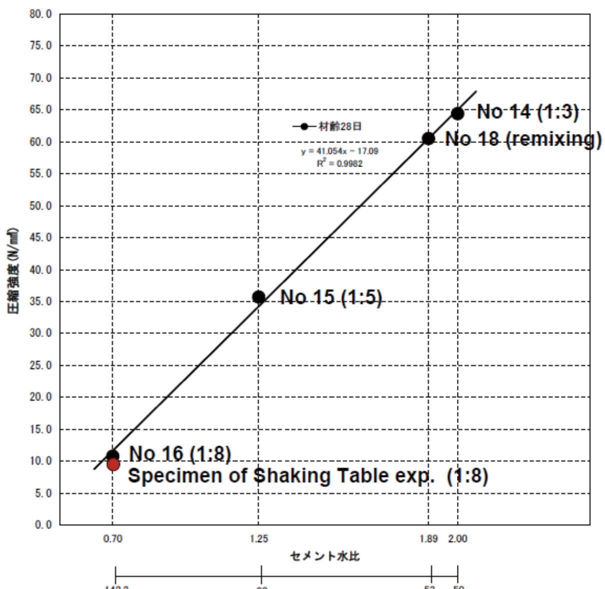
No	Cement/sand C:S	Water/cement W/C	Cement/water C/W	Compression strength N/mm^2	Strength ratio
14	1:3	50	2.0	64.4	100
15	1:5	80	1.25	35.7	
16	1:8	142.2	0.7	10.8	

Findings 2

- Dominant index of strength: Cement/water ratio
- In case volume of sand becomes large, mortar needs more water to have similar flow value
- Larger water ratio makes mortar strength smaller

Compression strength test





Findings 3

- Influence by remixing
- Two specimens by remixing
  - remixing one hour after mixing
  - remixing three hours after mixing
- Mortar needs additional water to have similar flow value

No	remixing	Water/cement W/C	Cement/water C/W	Compression strength N/mm^2	Strength ratio
14	-	50	2.0	64.4	100
18	One hour later	80	1.25	60.5	94
19	Three hours later	142.2	0.7	51.2	81

Findings 4

- Influence by curing
- Two specimens of different curing
  - in water, 1day in water, 3 days in water

No	curing	Compression strength N/mm^2	Strength ratio
14	In water	64.4	100
20	I day in water	49.1	76
21	3 days in water	58.9	91
7	In water	51.7	100
22	I day in water	37.7	73
23	3 days in water	48.2	93

Conclusion

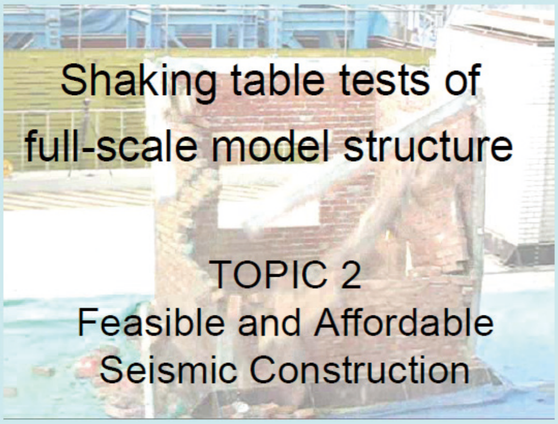
- Mortar of C/S ratio 1/8 is strong enough judging from the shaking table experiment (strength of construction sites seems to be far weaker)
- Cement/sand ratio makes a significant difference in compression strength
- Remixing with additional water makes the strength smaller
- In both cases, cement/water ratio is the dominant index for the strength
- Difference of mortar strength of different manufacturers is not so big
- Curing has also certain influence to the strength
- Further investigation to identify dominant factors for the lateral strength of brick wall is necessary such as filling work, soaking

2.2. Summary of shaking table experiments on confined masonry in July 2008 in Tsukuba

(Dr. Toshikazu HANAZATO)

2008 年 7 月振動台実験結果の概要 （三重大学 教授　花里利一 ）

International Collaborative Research for Disaster Mitigation in Earthquake-Prone Countries in Asia



Mie University, NIED, BRI

Activities in 2008

- Conduct shaking table tests of confined masonry model structures (Popular in South-East Asia)
- Provide technical report based on the present project of the shaking table tests for proposing the guideline on feasible and affordable seismic construction

Scope of Shaking Table Tests Using Full Scale Model in 2008

- To understand actual seismic behaviors of masonry house of confined masonry at safety limit

  ➡ at NIED in July 2008
- To study effectiveness of strengthening methods on improvement of seismic performance of confined masonry structure

  ➡ at PUCP (Peru) in December 2008

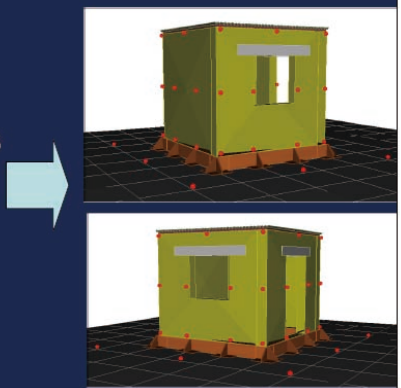
Outline of Test – Model structure Shaking table test at NIED in July,2008

Designing confined masonry structure being popular in South East Asia – Indonesian type

Fabrication of thin brick wall using joint mortar made in consideration of actual construction condition

Outline of Shaking Table test Measurements

- Video recorder
- Accelerometers
- Optical instruments for 3-dimentional displacement records
- Strain gauge for dynamic strain



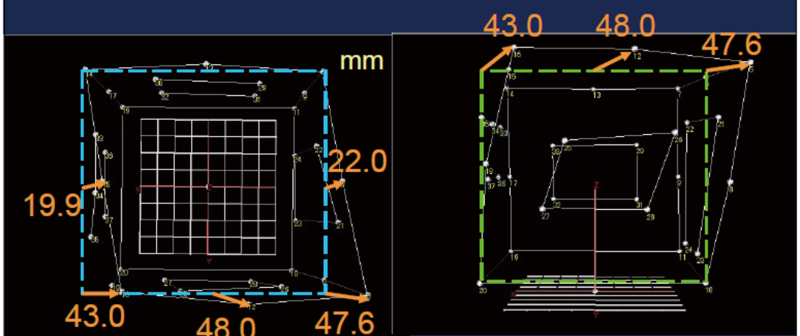
Behaviors of Model Structure

Input motion	Peak Acc. (G)	Peak Disp. (mm)	Damage
Step	0.29	1	No damage
Pisco Earthquake of August 15,2007 at ICA, Time scale = 0.1	0.79	10	No damage
Pisco Earthquake of August 15,2007 at ICA, Time scale = 0.1	1.22	15	No damage
Pisco Earthquake of August 15,2007 at ICA, Time scale = 0.1	2.27	30	Crack in brick wall , damage in tie-column and separation between column and wall
Pisco Earthquake of August 15,2007 at ICA, Time scale = 0.58	0.60	140	Damage extended but survived
JMA Kobe NS	1.07	200	Collapse

Pisco Earthquake of August 15,2007
Record at Ica, Time Scale =0.1, Amax =2.27G

JMA Kobe NS January 17,1995
Amax =1.07G , Time Scale=1.0

Deformability of confined brick wall



Input motion : Pisco Earthquake of August 15, 2007
Earthquake Record at Ica Amax=060G, Time Scale=0.58

Damage to Model structure : damage extended but survived

Findings

- Typical failure behaviors of confined masonry house were reproduced and successfully recorded by the shaking table tests.
- Most of cracks occurred between brick surface and mortar, indicating the bonding has essential effect on the seismic resistance of wall. (the wall fabricated by imported bricks collapsed, while the wall by Japanese bricks survived.)
- Joint between brick wall and tie-column also has significant effect.
- Deformability of brick wall of both in-plane and out-of-plane was recorded in dynamic phase.

2.3. Summary of shaking table experiments on confined masonry in December 2008 in Lima, Peru (Dr. Chikahiro Minowa) / 2009 年 12 月震動台実験（ペルー　カトリカ大学振動台）結果の概要

（防災科学技術研究所　箕輪親宏）

Shaking Table Test of Confined Brick Masonry at PUCP

Nov. – Dec. 2008

C.Minowa

Ponteficia Universidad Catolica Per
Shaking Table Photos

Flexure Plate Bearing

Pre-stressed RC Platform

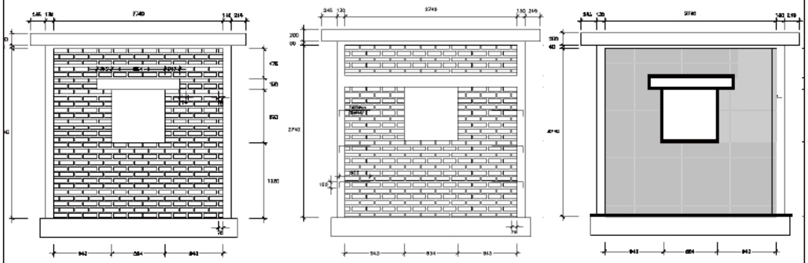
Actuator

Model A

Model B

Model C

Test Models



Model A	Model B	Model C
Confined Brick Masonry	Confined Brick Masonry With Lintel Beam and Wall Boundary Reinforcement	Confined Brick Masonry With Wire Mesh and Mortal Finishing (east wall of both faces)

No bolt connection with table,
and
Bolt connection with table

Lintel and Frame Works

Mortal Work

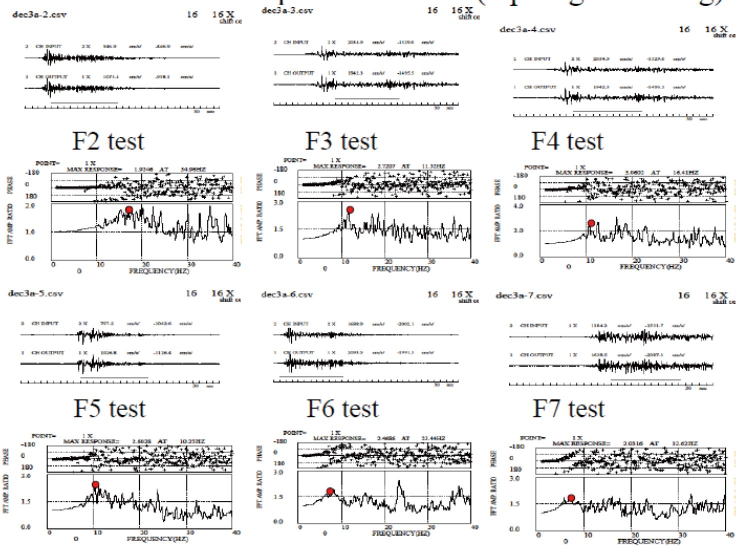
Wire Mesh Work

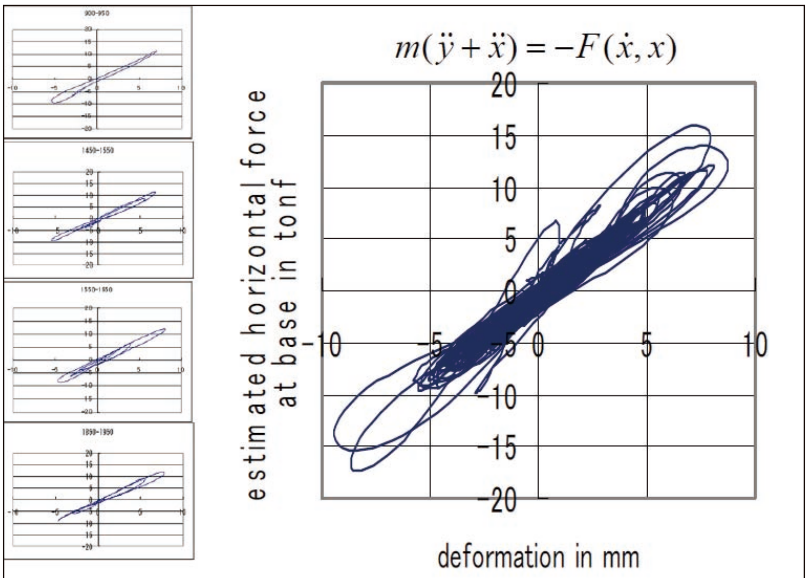
Model A

Confined Masonry

			table	table	building		
F1.	ICA	TS=1/10	5mm				
F2.	ICA	TS=1/10	16mm	0.95G	1.03G	17Hz	
F3.	ICA	TS=1/5	40mm			11Hz	
F4.	ICA	TS=1/5	70mm	2.03G	1.91G	11Hz	Cracks Occurred
F5.	JMA KOBE NS	TS=2/3	75mm	0.75G	1.02G	10Hz	
F6.	ICA	TS=1/10	30mm	1.68G	2.09G	8 Hz	Crack increased
F7.	May 70	TS=1/1	135mm	1.18G	1.64G	7 Hz	Bricks Broke down Column-wall line separated

Model A Spectrum Ratios (top ring /base ring)



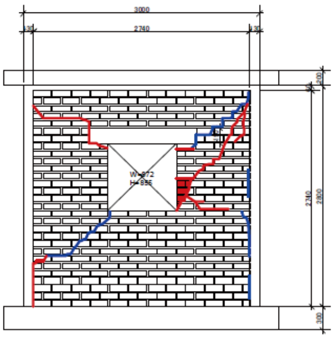


Model B

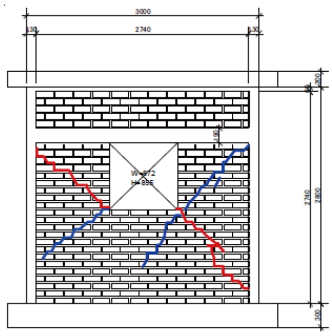
Confined Masonry with Lintel Beams

			Table	Table	Building		
L1.	ICA	TS=1/5	40mm	1.03G	1.10G	17Hz	
L2.	ICA	TS=1/5	70mm	2.57G	2.09G	12Hz	Crack Occurred
L3.	May	70	135mm	1.91G	2.10G	10Hz	Crack increased
L4.	ICA	TS=1/10	30mm	1.71G	2.45G	7Hz	Crack increased

Crack Sketch



Model A



Model B

Model C

Confined Masonry with Wire Mesh

Test Weight 15t

			Table	Table	Building		
M2.	ICA	TS=1/10	30mm	2.07G	2.50G	13Hz	small crack Occured
M3.	ICA	TS=1/5	70mm	2.17G	1.67G	11.5Hz	
M4.	May	70	120mm	1.67G	1.55G	12Hz	

It takes much time to find cracks.

Findings

- Lintel Beam Reinforcements

  No separations found around wall boundary.
  Lintel Beam prevented crack developments.

- Wire Mesh and Mortal Finishing.

  Mortal Finishing increased rigidity and make structures strong.

- Inertia Shear Force-Deformation Curve

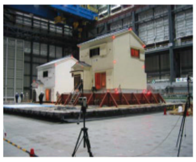
  A shaking table test provides the shear force – deformation curve by the use of actuator driving force.

2.4. Introduction of LED image measurement and summary of its application to the shaking table experiments (Dr. Yasushi Niitsu)

振動台実験の画像計測手法の概要と計測結果の概要（東京電機大学　教授　新津　靖）

3D-Measurement by Image Processing (at Catolica Univ. in PERU)

Yasushi NIITSU, Ph.D
Professor of
Tokyo Denki University


PAST TECHNOLOGY AND DEVELOPMENT TARGET

Past technology for measurement of displacement or strain
Displacement transducer (1 point, 1 direction)
Strain gauge (1 dot, 1 direction)

Necessity of measurement method for multi points without contact (Non-contact)

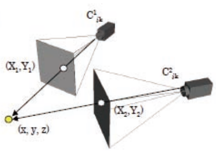
Past image processing system
Measurement resolution: about 1/1000

Target performance specification
Measurement resolution: Over 1/10000
Measurement speed: 1/100 – 1/200
Measurement points: 40~256

Principle of 3D-Position Measurement

Determinate Camera Parameters C^1_{jk} C^2_{jk}

Obtain Marker Position (X_1, Y_1), (X_2, Y_2)



$$\begin{cases} C^1_{11}x + C^1_{12}y + C^1_{13}z + C^1_{14} - C^1_{31}xX_1 - C^1_{32}yX_1 - C^1_{33}zX_1 = X_1 \\ C^1_{21}x + C^1_{22}y + C^1_{23}z + C^1_{24} - C^1_{31}xY_1 - C^1_{32}yY_1 - C^1_{33}zY_1 = Y_1 \end{cases}$$

$$\begin{cases} C^2_{11}x + C^2_{12}y + C^2_{13}z + C^2_{14} - C^2_{31}xX_2 - C^2_{32}yX_2 - C^2_{33}zX_2 = X_2 \\ C^2_{21}x + C^2_{22}y + C^2_{23}z + C^2_{24} - C^2_{31}xY_2 - C^2_{32}yY_2 - C^2_{33}zY_2 = Y_2 \end{cases}$$

→ 3D Position (x, y, z)

Least Squares Method

Key Points:
(1) Precise Determination of C_{ij}^k
(2) Precise Detection of (X_k, Y_k)
(3) Prevention of Vibration of Cameras

HIGH SPEED DIGITAL CAMERA

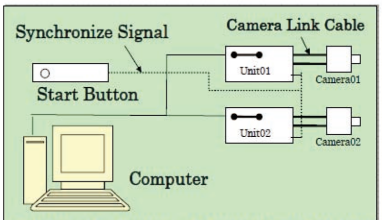
Resolution and Memory

- 1024 x 992 x 8bits (100-500fps)
- Memory capacity: 8456 MB

MARKER

4 LED type

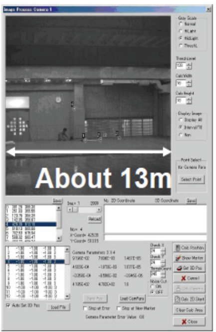
MEASURING SYSTEM

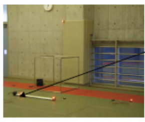


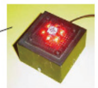
Schematic figure of Computer System

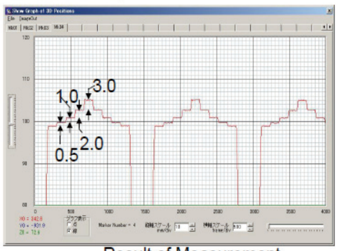
EXAMPLE OF PRECISE DISPLACEMENT MEASUREMENT

Movement of Actuator was
0mm → 100 → 100.5 → 101.5 → 103.5 → 106.5mm
→103.5 → 101.5 → 100.5 → 100 → 0mm → Iteration





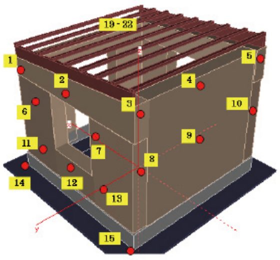


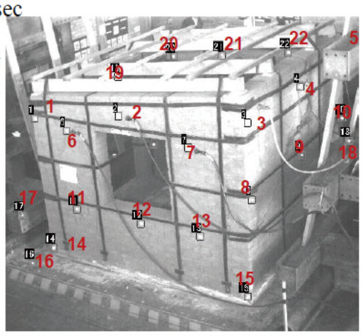


Result of Measurement

Results of Measurement of ADOBE House Model

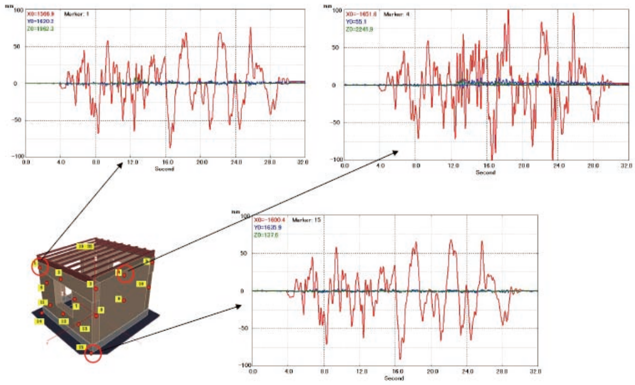
Experiment Date: 2008/12/12
Sampling Speed: 100 frame/sec
Marker Numbers: 22
Marker Type: 4 LED / 6V



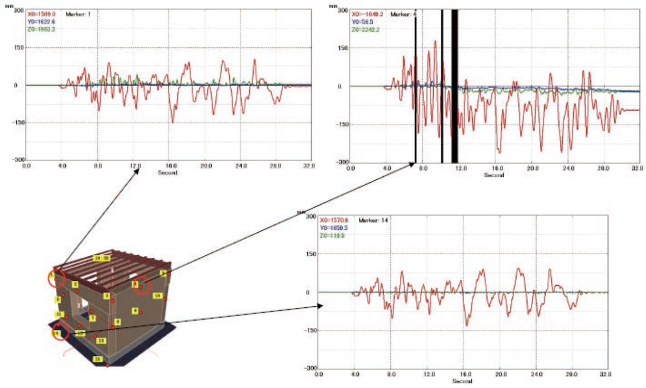


Marker Numbering and Positions

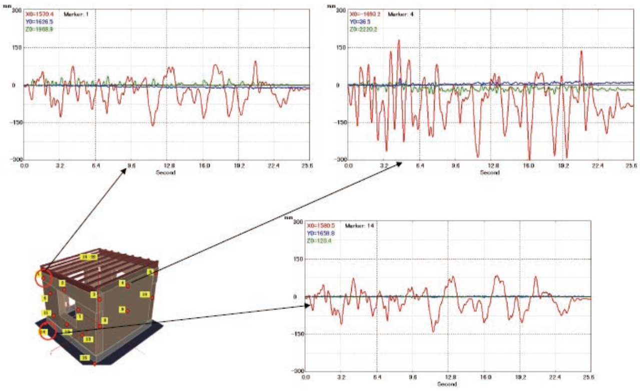
Results (15:05 Start)
Marker 01, 04 and 15



Results (15:25 Start)
Marker 01, 04 and 14

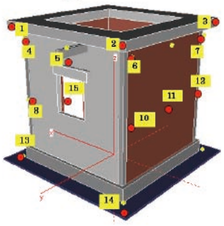


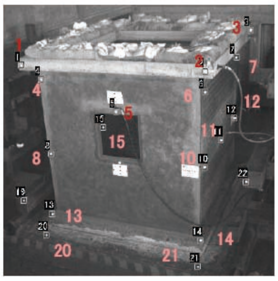
Results (15:40 Start)
Marker 01, 04 and 14



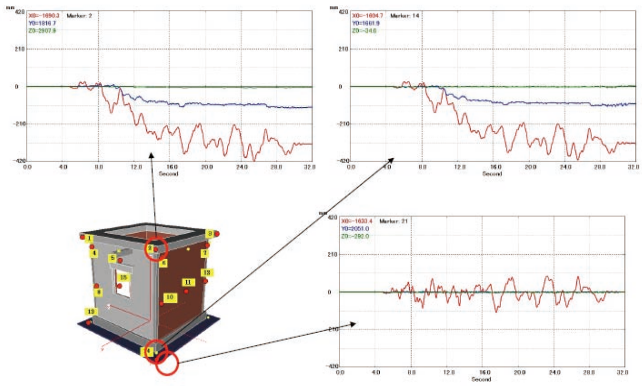
Results of Measurement of Masonry House Model

Experiment Date: 2008/12/19
Sampling Speed: 100 frame/sec
Marker Numbers: 22
Marker Type: 4 LED / 6V

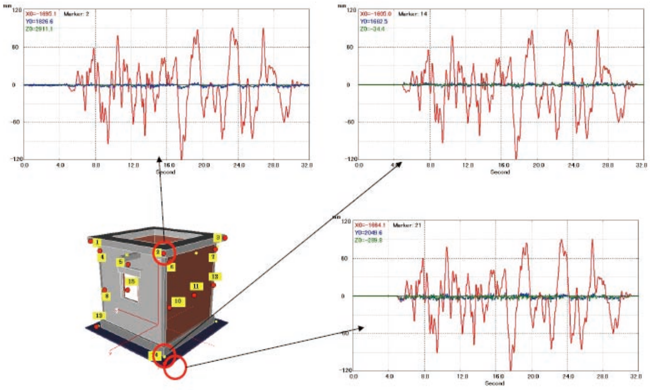




Results (12/19 11:33 Start)
Marker 02, 14 and 21



Results (12/19 16:14 Start)
Marker 02, 14 and 21



2.5. Report on confined masonry structures in Nepal (Dr. Jishnu Subedi)
ネパールにおける枠組み組積造について（ネパール工科大学　ジシュヌ・スベディ）

REPORT ON CONFINED MASONRY STRUCTURES in NEPAL

Jishnu Subedi
Suman Narsingh Rajbhandari, nec

CONSTRUCTION PRACTICE PREVAILING IN VALLEY

- BRICK IN MUD
- BRICK IN CEMENT MORTAR
- TIMBER-BRICK COMPOSITE
- CONFINED MASONRY
  - Most common
  - Different modality of construction exist

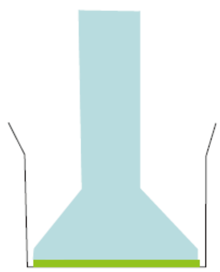
Confined Masonry

Issues in Confined Masonry

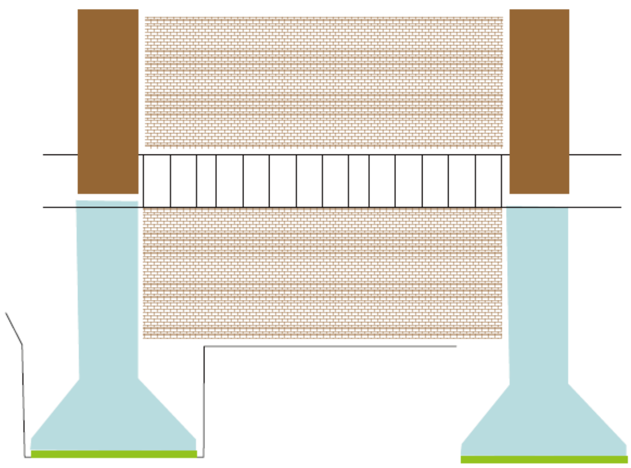
- Bridging gap between Non-Engineering and Engineering
- Bridging gap between Engineering and Construction
- Bridging gap between Construction and Quality

Construction sequence

- Independent footing
- Wall up-to plinth level
- Beam casting at plinth level
- Column
- Wall casting
- Beam slab



Construction Sequence

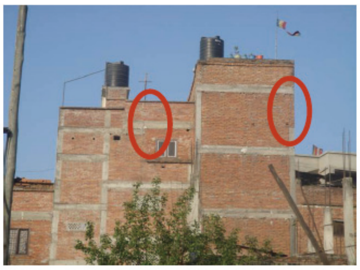


Alternative construction sequence

Design and construction

Mixed Framed system and Load bearing system

Engineering and construction




Construction and quality


Recommendation

- Increasing scope of Mandatory Rules of Thumb (MRT)
- Incorporate present construction
- Quality assurance
  - Material
  - Workmanship
  - Design
- Field inspectors

2.6. Report on confined masonry structures in Pakistan

(Dr.Qaisar Ali, Professor, NWFP University of Engineering and Technology Peshawar)

パキスタンにおける枠組み組積造について（ペシャワール工科大学　教授　カイザル・アリ）

Report on confined masonry structures in Pakistan

Qaisar Ali, Phd
Director Earthquake Engineering Center
Department of Civil Engineering
NWFP University of Engineering and Technology, Peshawar Pakistan
drqaisarali@nwfpuet.edu.pk

1

Confine Masonry Before Kashmir Earthquake

- Mostly un-reinforced masonry
- Inventory survey of existing 425 buildings in Muzaffarabad in 2006
- CM buildings were not following code
- CM buildings were mostly single story

RCC Frame	URM	CM	RM
41.5 %	31%	27.5%	0 %

Research Work on Confined Masonry in EEC N-W.F.P UET, Peshawar

- Shake table test of Single and Double storey typical reduced scale confined masonry building model (Amjad Naseer 2009)
- Scale factor of 4 was used.
- Models confined according to EC-8 provisions
- Complete model similarity laws followed
- That is strength is reduced with geometric scale factor
- and strain and density are same as of prototype materials

Research Work on Confined Masonry in EEC N-W.F.P UET, Peshawar

Target Values for confined Masonry Model

Description	Prototype	Model (Target Value)	Prot/Model
Compressive Strength of Masonry unit, (psi)	2338	585	4
Density of Masonry unit (lb/cft)	101	101	1
Compressive Strength of Masonry Mortar, (psi)	997.3	249	4
Compressive Strength of Masonry, *f*k, (psi)	839.6	210	4
Tensile Strength (shear) of Masonry, *f*tk, (psi)	51.27	13	4
Modulus of Elasticity of Masonry, E, (psi)	288,000	72,000	4
Shear Modulus of Masonry, G, (psi)	42,000!	10500	4
Compressive Strength of Concrete, (psi)	1500-2000	375-500	4
Yield Stress of Reinforcing Steel, (psi)	45,000-50000	11,250-12,500	4

Research Work on Confined Masonry in EEC N-W.F.P UET, Peshawar

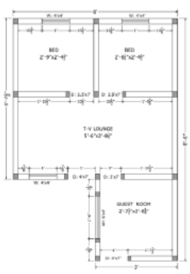
- Simulation of Masonry Materials and Masonry Assemblage:
- Almost 40 batches of cement-lime-sand, cement-lime-khaka (stone dust), cement-lime-surkhi (crushed brick) and lime-surkhi were prepared.
- 15-20 batches with different proportion of cement, sand and lime were used.
- Cement-lime-surkhi in different proportion was used to simulate compressive strength and density.
- Compressive strength, tensile strength, Modulus of elasticity and rigidity and energy dissipation was simulated by testing reduced scale wallets

Research Work on Confined Masonry in EEC N-W.F.P UET, Peshawar

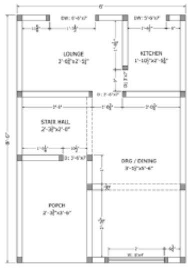
- Compressive Strength of model masonry mortar (1:1:5) = 238 psi
- Compressive strength of model masonry unit = 634 ps,
- Density of model masonry unit = 98 pcf
- Compressive strength of micro-concrete = 365 psi
- Aluminum wire (3mm dia) of tensile strength = 19000 psi

Research Work on Confined Masonry in EEC N-W.F.P UET, Peshawar

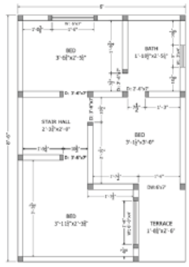
- Almost 65 building drawings collected from Peshawar,
- A typical single and double story building was selected on the basis of wall density ratio



Single Story Model



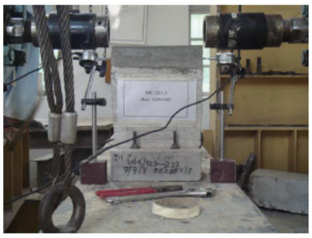
Double Story: Ground floor



Double Story: First floor

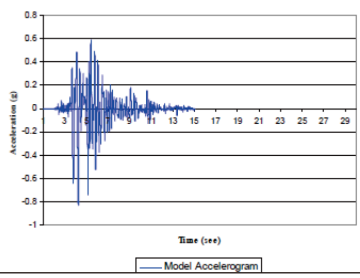
Research Work on Confined Masonry in EEC N-W.F.P UET, Peshawar

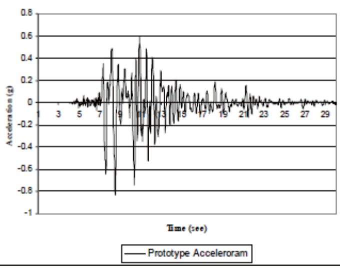
- Results of wallet tests
- Compressive Strength = 278 psi,
- Modulus of elasticity, E = 46 ksi,
- Tensile strength = 32 psi,
- Modulus of Rigidity = 17 ksi



Research Work on Confined Masonry in EEC N-W.F.P UET, Peshawar

- Kobe 1995 earthquake Accelerogram used
- Accelerogram scaled in time (with square root of scale factor)
- No scaling of the amplitude
- Addition weight attached to simulate live and flooring weight
- Models instrumented with accelerometers and sting pots transducer





Research Work on Confined Masonry in EEC N-W.F.P UET, Peshawar

Research Work on Confined Masonry in EEC N-W.F.P UET, Peshawar

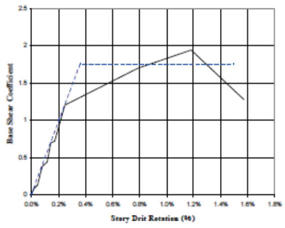
Characteristic Parameters of Shake Table Motion for Single Story Model

Test Run	Input Model Accelerogram		Shake Table Motion	
	Max. Acceleration (g)	Displacement (mm)	Max. Acceleration (g)	Displacement (mm)
5	0.0417	2.34	0.0603	5.485
10	0.0833	4.679	0.1073	5.409
20	0.1666	9.359	0.1955	7.161
40	0.3332	18.718	0.4853	18.181
60	0.4998	28.078	0.5761	25.849
80	0.6664	37.437	0.9659	28.922
100	0.833	55.276	0.8825	44.64
125	1.0413	58.495	1.0433	60.637
150	1.2495	70.194	1.3192	64.471
175	1.4578	81.893	2.01	70.565
60R	0.4998	28.078	0.4	25.849
100R	0.833	55.276	0.82	46.595
150R	1.2495	70.194	1.49	-

Research Work on Confined Masonry in EEC N-W.F.P UET, Peshawar

Single Story Model

Description of limit state	Base shear Coefficient	Story Rotation angle (%)
Elastic limit (125)	1.205	0.25
Maximum Resistance (175)	1.843	1.18
Ultimate state (200)	0.443	2.1



2.7. Report on confined masonry structures in Turkey (Dr. Ahmet Turer, Associate Professor, and Middle East Technical University (METU))
トルコにおける枠組み組積造について（中東工科大学　アフメッド・トゥレー）

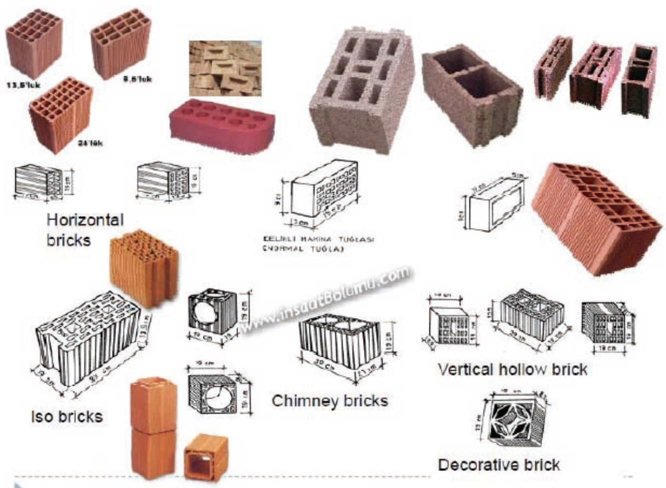
International Video Workshop 2009 on Safer Housing focusing on Confined Masonry Structures
March 23, 2009.

Confined Masonry Structures in Turkey

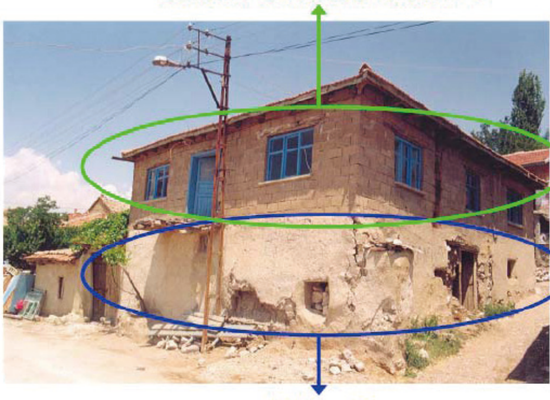
Altug Erberik & Ahmet Turer
METU-CE Dept., Turkey.

Facts about Masonry Construction in Turkey

- Most of the masonry buildings are of the type unreinforced masonry (URM).
- URM buildings constitute major part of the building stock in urban and rural regions of Anatolia.
- They are generally used for residential purposes and number of stories is generally between one and three.
- Load bearing wall material is solid local brick, hollow factory brick, hollow concrete block, stone or adobe.



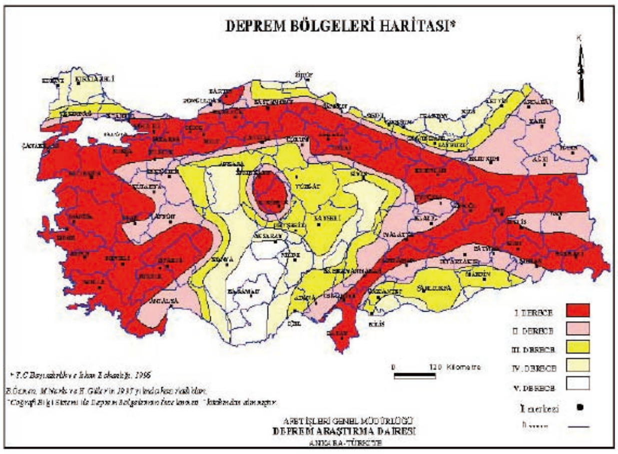
Examples: Hybrid Masonry Buildings



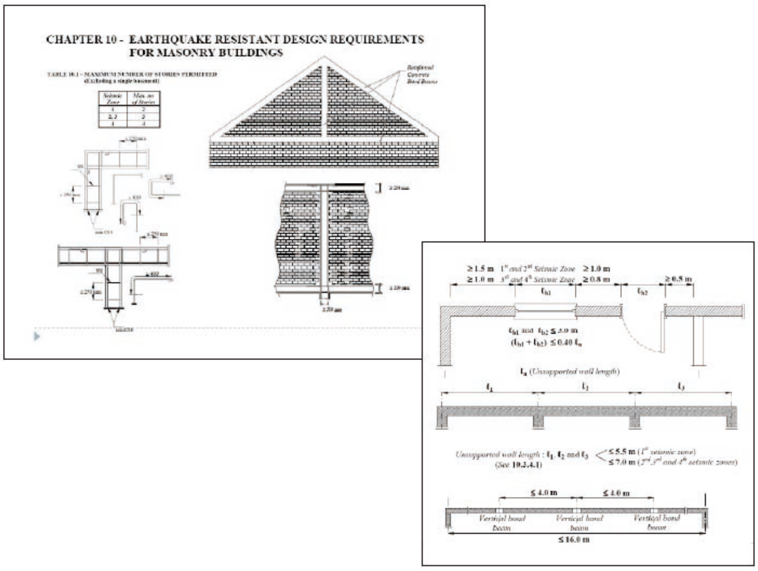
Facts about Masonry Construction in Turkey

- Reinforced masonry (RM) construction is very rare except newly constructed villas with specially manufactured Autoclaved Aerated Concrete (AAC) or concrete blocks.

- Confined masonry (CM) construction exists although it is not very common.
- The main reason for the unpopularity of the CM construction is that it is not encouraged by the technical provisions and authorities in Turkey.
- There exists a small section in the latest version of the Turkish Earthquake Code (2007) related with the design of CM buildings.



Turkey seismic zone map has 5 regions; 1 being the worst region.



Confined Masonry Construction in Turkey

- One of the common examples of CM construction in Turkey is masonry buildings with load bearing walls made from local solid brick or hollow factory brick confined by non-load bearing RC horizontal bond beams and vertical tie columns.

- This type of construction is sometimes refered as "hybrid" in Turkey since it contains both horizontal and vertical RC components together with masonry load-bearing components.

Examples of CM Construction in Turkey

Examples of CM Construction in Turkey

Confined Masonry Construction in Turkey: Himis

- There exists a special type of traditional CM construction which is called as "himis".
- This is timber-laced masonry construction dating from the Ottoman Period.
- Generally, horizontal, vertical and diagonal timber members are embedded into bearing wall masonry.

Gülkan & Langenbach (2004)

Confined Masonry Construction in Turkey: Himis

- Masonry is generally one layer in thickness, therefore the walls are light enough to be supported on the timbers.
- The masonry material is either brick, adobe, or rubble stone.
- Since timber members divide the wall, the loss of portions of masonry panels does not lead to progressive collapse of the wall.

Confined Masonry Construction in Turkey: Himis

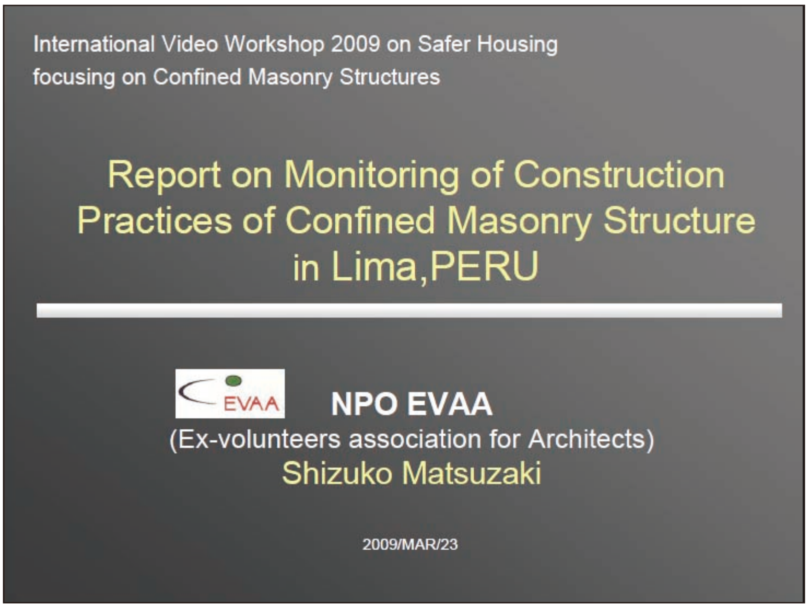
Early 20th century dwelling in Bayirköy (Bilecik, Turkey) with horizontal timber members (hatils) in the masonry bearing ground floor walls, and "himis" construction above.

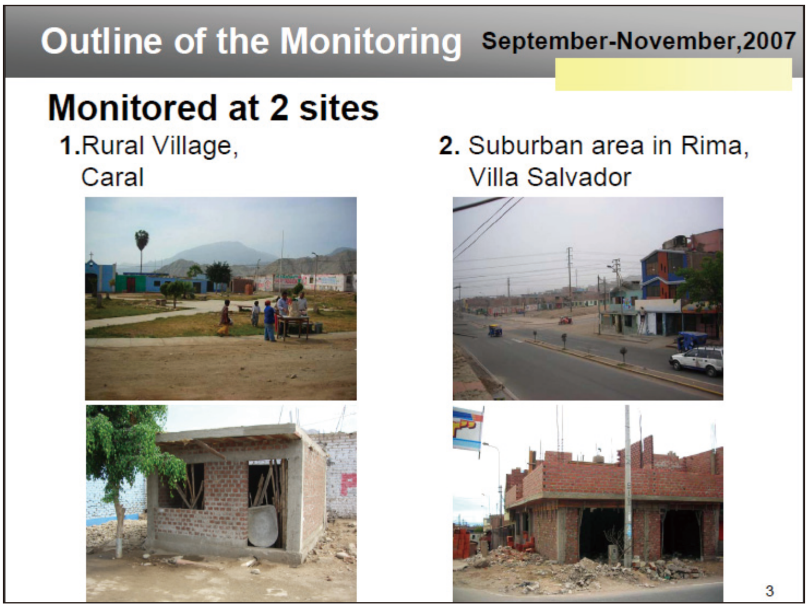
Gülkan & Langenbach (2004)

Confined Masonry Construction in Turkey: Himis

Old style CM masonry house, where wood reinforcement divides the masonry wall into small pockets which dissipate energy without leading to complete collapse after İzmit Earthquake (1999), M = 7.4.

2.8. Construction practice of confined masonry structures in Peru<Report of monitoring survey of construction sites> (Ms. Shizuko Matsuzaki) / ペルーにおける枠組み組積造の建設の実態（現地モニタリング報告）（NPO 法人都市計画・建築関連 OV の会（EVAA） 松崎志津子）





The Characteristics of Peru's Construction work

from the monitoring and interview with the workers

- Confined Masonry houses are constructed by **professional** masons and craftsmen
- Not much different between rural area and urban area regarding construction method

4

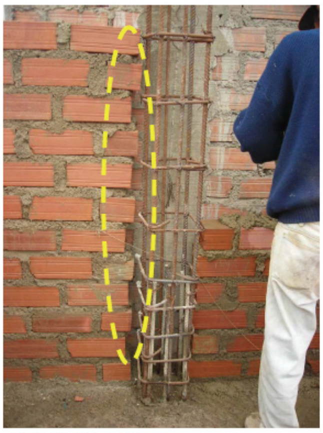
The Characteristics of Peru's Construction work

- Masonry work first, and next reinforced frame
- Column's section is bigger than the wall
- There are no building drawings in some construction sites

5

The Characteristics of Peru's Construction work

- Construction quality depends on **experience of master** (maestro)



(toothed wall edge)

6

Problems

1) **Quality of Concrete**

mixture concrete on the ground

stuffing up the crack of frameworks with paper of cement

7

Problems

2) Lack of **COVERING** for steel reinforcement, Lack of beam's steel **ANCHORAGE** (FIRM CONNECTION) to columns

Supplement concrete subsequently

8

Conclusion

Causes of the problems:

Less proper supervision
for not only foreman
but also architect

- No official certification
- Less opportunity to learn new method

Proposed Suggestion:

Institutional Management

- Official supervision
- Official certification
- More training

9

Report on Monitoring of Construction Practices of Confined Masonry Structure in Lima, PERU

NPO EVAA (Ex-volunteers association for Architects)
Shizuko MATSUZAKI

ABSTRACT

This paper presents the result of monitoring of construction practices of confined masonry houses in Peru. Building Research Institution of Japan (BRI) implemented the monitoring for about two months in 2007 and made a research on how to construct the houses in the field of developing countries. The author was assigned to the monitoring survey on the site in Peru.

According to the monitoring, the construction quality was generally not so low, but some problems could be seen. Several institutional management ideas are suggested for improvement of the works; official supervision of construction, official certification and further training for craftsmen.

INTRODUCTION

Peru is also prone to earthquakes as Japan. In 2007 "Near Coast of Central Peru Earthquake" caused extensive damage to the Pisco city, where about five hundreds lives were taken for the collapse of the houses. In developing countries, the houses are constructed with little technical intervention (called non-engineered house). To improve seismic safety of the houses, comprehensive construction process is needed. The monitoring activity was carried out in order to grasp the actual condition of the construction works in Peru.

Photo.1 Damage of Near Coast of Central Peru Earthquake of August, 2007

OUTLINE OF THE MONITORING

The monitoring survey started on October 9 and ended on November 28 in 2007. The term was about 2 months. Four construction sites in the region of Lima were monitored, and one in rural area and three in urban area. The site in rural village is in Caral and suburban site is in Villa Salvador.

The monitoring was conducted alternately between four sites, because of frequent interruption of the construction which was caused by lack of materials. Generally house owners have to supply materials in the construction process. But majority of owners has no funds and organized planning. Thus the construction process often breaks. The term of monitoring was about one week to two weeks. The photo 2 and 4 show the condition of each town, and the photo 3 and 5 show the monitored houses.

Photo.2.   Sight of Caral Village

Photo.3.   Monitored House in Caral Village

Photo.4.   Sight of Villa Salvador District

Photo.5.   Monitored House in Villa Salvador

THE CHARACTERISTICS Of PERU'S CONSTRUCTION WORK

Brick house confined with concrete beam and column is popular in Peru. From the monitoring and interviews with the building workers, it was found that there are several characteristics of Peru’s confined masonry work.

Photo.7.   Picture of Neat Laying Work in Villa Salvador

Photo.8.   Ditto

The founded characteristics are as follows:

1. Confined Masonry houses are constructed by professional masons and craftsmen;

2. Not much difference between rural area and urban area regarding the construction method;

3. In the construction process, the masonry work is first and the reinforced frame is second (Photo.9, 11);

4. The width of the side of Column is longer than the thickness of the wall (Photo 9, 11);

5. There is no building drawing in some construction sites. In Caral, there aren't.; and

6. The construction quality depends on the experience of the master (maestro).

Photo.9. Reinforced Frame in Caral

For example, in one construction site, steel bars were used as spacers to support the bars (Photo.10). It was the master's idea to control the quality.

The quality of the toothed wall edge also depends on masters' experience (Photo 11).

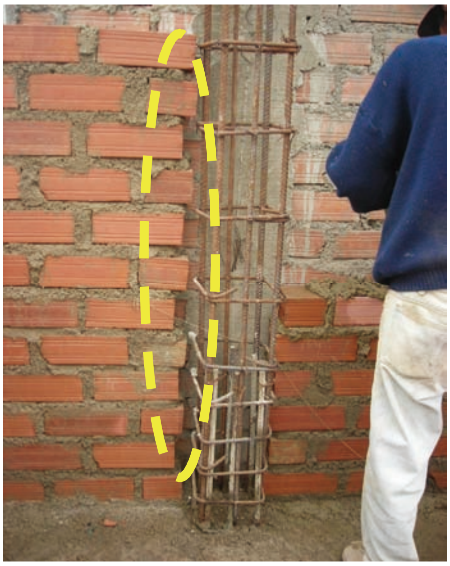


Photo.11. Toothed wall edge in Villa Salvador

Photo.10. Using steel bar support in Villa Salvador

Deformed steel bar with rib was used everywhere on the sites. However bricks were laid accurately with leveling string plumb bob. Some works were done carefully. But other problems could be seen here and there.

The problems are as follows:

1.Quality of concrete;
(e.g. Mixing the concrete directly on the ground Photo.12, Mixing in of foreign materials Photo.14)

2.Lack of concrete covering for steel reinforcement bars (Photo.13,15), sometimes honey comb can be seen; and

3.Lack of steel anchorings in the beam (firm connection) to columns (Photo.15).

Photo.14. stuffing up the crack of frameworks with paper of cement bag in Caral

Photo.12. Pouring the concrete on the ground in Caral

Photo.15. Lack of covering for steel reinforcement and Lack of beam's steel anchorage to the columns in Caral

Photo.13. Supplement concrete subsequently in Caral

PROPOSED SUGGESTIONS

The poor quality of the construction often could be seen especially in the anchoring parts and concrete covering of the reinforcement bars. The quality of the construction can be dependent upon the quality of craftsmen; luck of proper supervision and insufficiency of important supervision for not only foreman but also architect. There is neither official certification nor opportunity to learn new construction methods.

Therefore the following points as institutional management are suggested.
1. The third party official supervisor for appropriate supervision
2. The official certification of the construction skill and more trainings for craftsmen

Each master finds the way for better quality of construction. But only word-of-mouth communication guarantees his skills. Therefore the opportunity of skill training is necessary for even skilled worker to make them proud themselves in their job and feel like trying something new.

CONCLUSION

According to this survey, the construction method of confined masonry house in Peru is not so much a problem in both rural and urban areas. However, the poor quality of the construction work can be seen, and much remains to be improved. At the same time, there are some better ways with available materials in construction site. To popularize these ways and manage the workers, we should raise government's awareness level on non-engineered houses and researchers' interests.

2.9. Confined masonry structures in Indonesia <Perspective, problems and challenges>

(Mr. Teddy Boen)

インドネシアにおける枠組み組積造について（テディ・ブン）

WSSI

Confined Masonry Construction in Indonesia

Perspective, Problems & Challenges

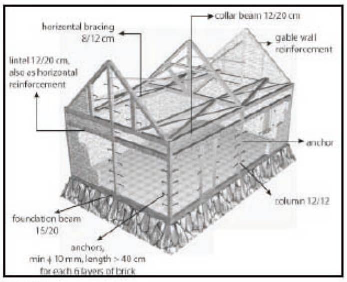
Teddy Boen
(tedboen@cbn.net.id)

Teddy Boen

WSSI

Non-Engineered Construction in Indonesia

- Confined half brick masonry bearing wall construction is the **NEW CULTURE** for the Indonesian common people's house type.
- The walls support their own weight, vertical as well as lateral loads.



- The practical columns and beams will support part of the vertical as well as lateral loads.
- Therefore, for the analysis, the walls as well as the confinement reinforced concrete beams and columns must be modeled.

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WSSI

Design Basis of Confined Masonry Construction in Indonesia

Until several years ago:

- Observed behavior of such construction during past earthquakes and trained engineering judgments

Currently:

- Laboratory experiments (very few)
- Observed behavior, laboratory experiments PLUS Analysis

Teddy Boen 3

Learning from Past Earthquake Damage of Non-Engineered Construction in Indonesia

- So far, field inspection of earthquake damaged construction is one of the most effective means for obtaining information.
- Earthquake damage is an actual SIMULATION -> actual behavior under actual loads.
- The damage or collapse of the houses are caused by out of plane loading or in plane loading of walls.
- The main cause is out of plane loading.

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Typical Damage of Confined Masonry Construction

- Walls tear apart
- Failure at corners of walls
- Failure at corners of openings
- Diagonal cracks in walls
- Walls collapse
- Failure of connections
- Total damage

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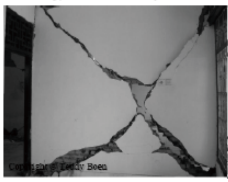
Typical Damage of Confined Masonry Construction

Walls tear apart
Yogyakarta, 27 May 2006

Failure at corners of walls
Bengkulu, 4 June 2000

Failure at corners of openings
Flores, 12 December 1992



Diagonal cracks in walls
Solok, 6 March 2007

Walls collapse
Alor, 11 November 2004

Failure of connections
Biak, 17 February 1996

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Design Basis of Confined Masonry Construction

Until several years ago:

- Observed behavior of such construction during past earthquakes and trained engineering judgments

Currently:

- Laboratory experiments (very few)
- Observed behavior, laboratory experiments PLUS Analysis

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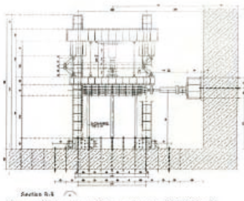
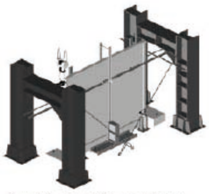
7

Laboratory Experiments



Source: "Experimental Investigation of Full-Scale Confined Masonry in Reverse Cyclic Loading", Sindur P.M., et.al

Source: Shaking Table Test, Narafu, 2007



Source: "Some Practical Aspects in the Post Yogyakarta Earthquake Reconstruction of Brick Masonry Houses", Imam Satyarno

Laboratory experiment is important, if correctly done, it is to understand the BEHAVIOR of the structure – identify load path, yield sequence, etc.

Actual earthquake damages can not be duplicated by laboratory experiments.

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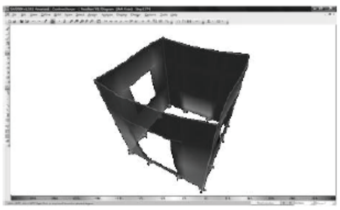
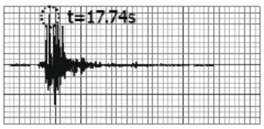
8

Confined Masonry

Shaking Table Experiment





Analysis using SAP2000

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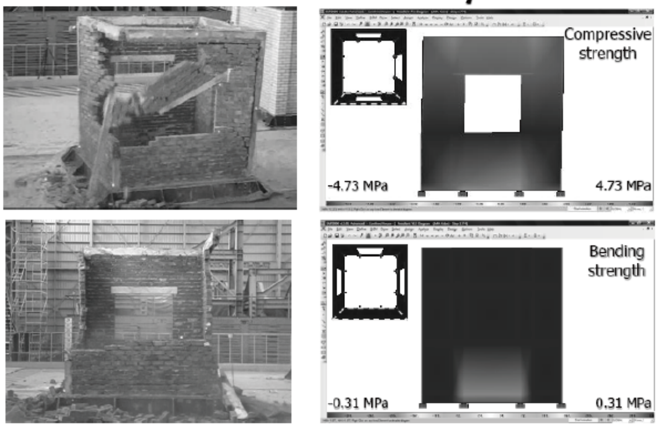
9

Confined Masonry



Shaking Table Experiment   Analysis using SAP2000

Design Basis of Confined Masonry Construction

Until several years ago:

- Observed behavior of such construction during past earthquakes and trained engineering judgments

Currently:

- Laboratory experiments (very few)
- Observed behavior, laboratory experiments PLUS Analysis

Engineering Confined Masonry Construction

- The purpose of the analysis is not to simulate the actual behavior, but to get reliable information that there is a correlation between the observed damages and the results of the analysis.
- The correlation is not perfect, but is good enough to get a good idea to build appropriate non-engineered construction that can withstand earthquakes.

The **actual** problem in Indonesia is the damage or collapse of confined masonry construction during earthquakes due to poor quality materials & poor workmanship, lack of maintenance.

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Problems of Non-Engineered construction in Indonesia

- poor materials:
  - poor quality of bricks
  - poor quality of concrete materials
- poor workmanship:
  - poor mason workmanship:
    - poor mortar mix
    - poor brick laying
  - poor concreting workmanship:
    - poor concrete mix
    - no curing
    - poor reinforcing bars detailing

NO law enforcement

Nobody follows existing standards / codes!!!

Brick, r.c. bars: size & quality not uniform

- The subjects building materials & building construction are not emphasized in the Indonesian engineering education syllabus.
- Donors (governments & NGOs) try to "teach" their own way instead of to learn from the local wisdom and trusting the local experts.

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The Challenges of Non-Engineered Construction in Indonesia

- The Government must have a political will
- Re-introduce subjects about building materials & building constructions in universities & technical high schools.
- Re-train local artisans.
- Motivate local engineers to continuously work on non engineered construction.
- Use intelligently outside resources & skills offered and resist / reject unneeded or unwanted supplies, personnel, experts & advice.

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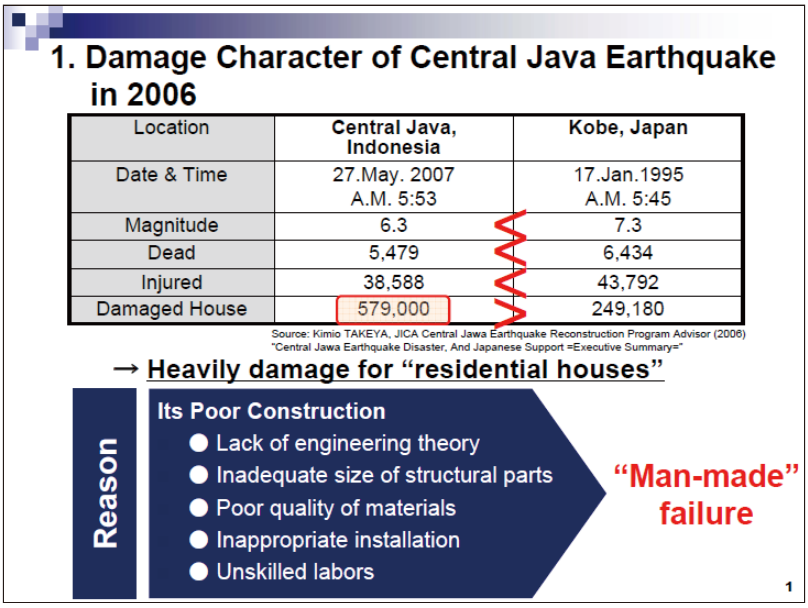
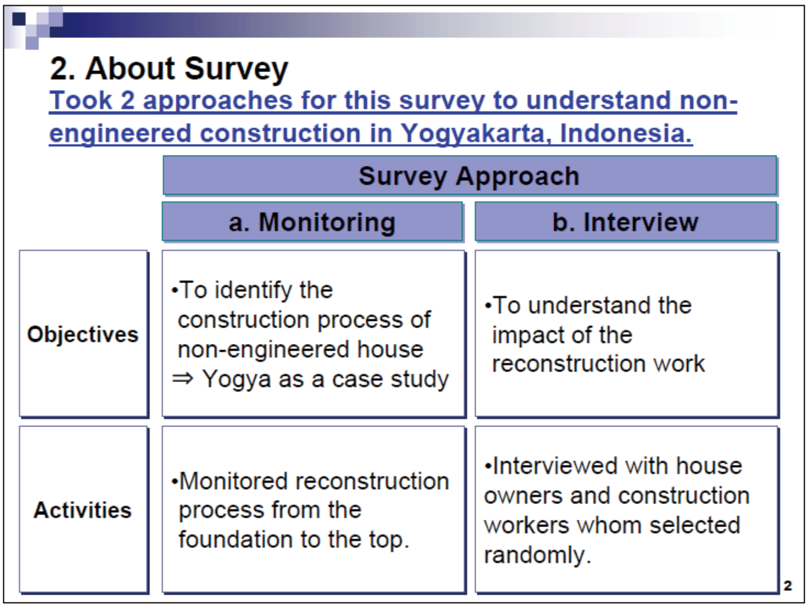
2.9. Construction practice of confined masonry structures in Indonesia <Report of monitoring survey of construction sites> (Ms. Keiko Sakoda) / インドネシアにおける枠組み組積造の建設の実態（現地モニタリング報告）(NPO 法人都市計画・建築関連 OV の会（EVAA） 迫田恵子)





3. [Monitoring] The process of the construction




3




4

4. [Monitoring] Findings from Monitoring activity

Some technical difficulties were found
but workers don't consider it as a crucial matter…



- **Assembling many iron bars** (Max 12) in small dimension
- **Bending or arranging iron bars** with bigger dimension
- **Concrete filling** in small dimension parts because of bigger dimension's iron bar

5

From field survey with 102 sampling (6 samples ×17 districts), 3 major structural problems could be found as follows.

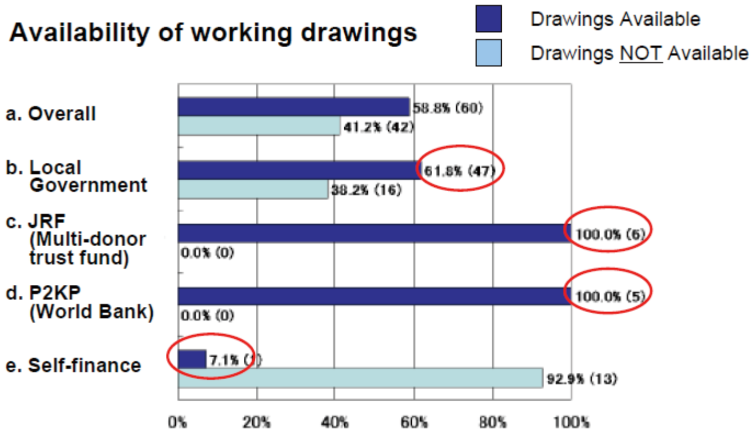
76.5% of total samples had one or more problems of those.

Exposed iron bars 30.39% (31)	Inadequate dimension of main structure parts 26.47% (27)	Not well-compacted Concrete 30.39% (31)

Source: Field survey

5. [Interview] Impact of the reconstruction work
① Introducing Working Drawings

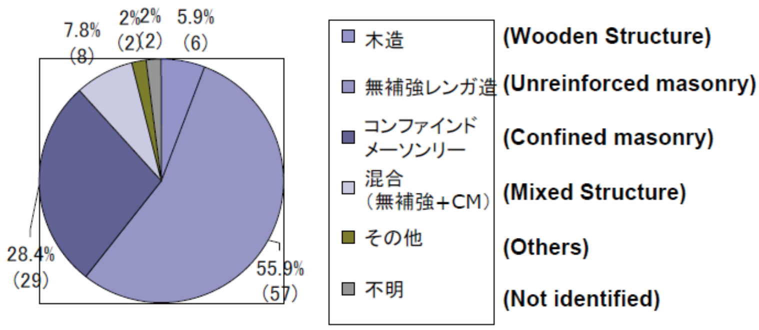
Availability of working drawings



Source: Field interview

5. [Interview] Impact of the reconstruction work
② Introducing Stronger Construction/Materials

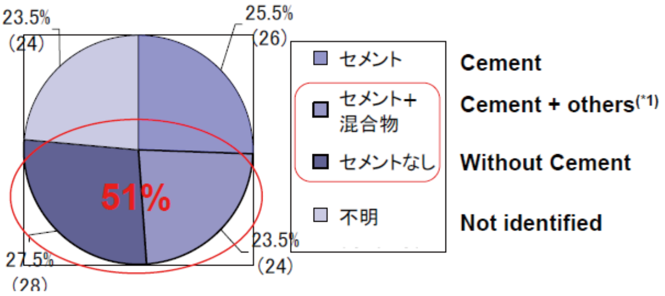
Pre-earthquake, majority of the construction style was Un-reinforced concrete.



⇒Through the reconstruction, almost all the houses became Confined masonry.

Source: Field survey

Pre-earthquake, joint materials for the bricks was varied.



⇒ Through reconstruction work, local govnt & aid agencies made big efforts to procure stronger materials.

- Local govnt set the standard quality level of structure & materials.
- Some agencies provided not money but selected materials.

Source: Field survey

(*1) Other materials are lime ash, crashed brick powder, clay, soil and etc. 9

6. Conclusion

Improvement through reconstruction work

HOUSE =

		Improvement through reconstruction work
Engineering Theory	Appearance of structure parts (column, beam...)	↗
+ Material	Standardize of material	↗
+ Construction workers' skill	Improvement of const. Workers' skill & knowledge	→

- **How to keep the impact of the reconstruction work?**
  - **Just a few houses are constructed per a year in rural area.**

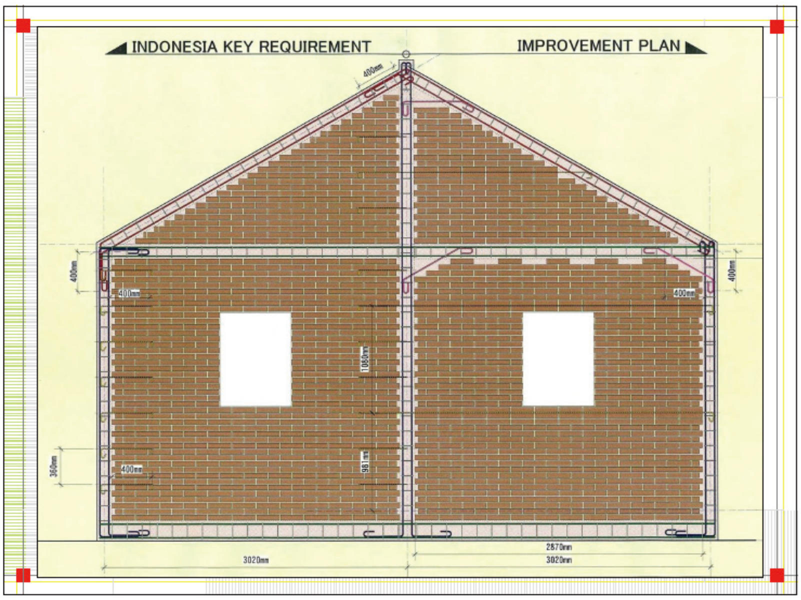
→ Need a long-term & holistic framework to make the most of the improvement of the reconstruction work.

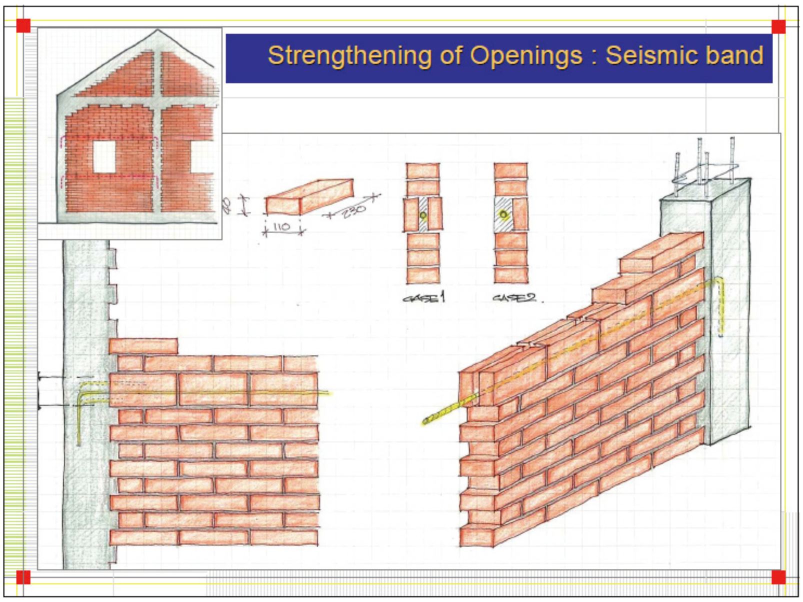
10

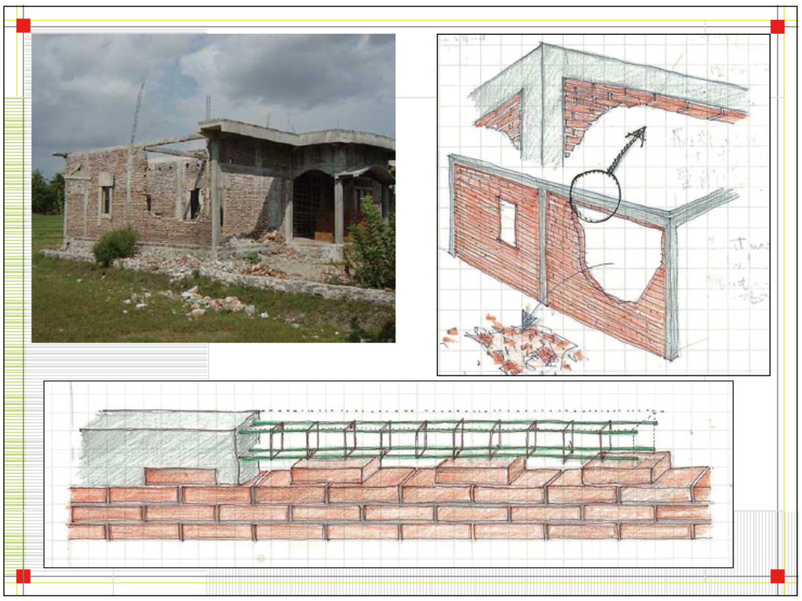
2.11. Proposal of practical design/technology of safer confined masonry structures

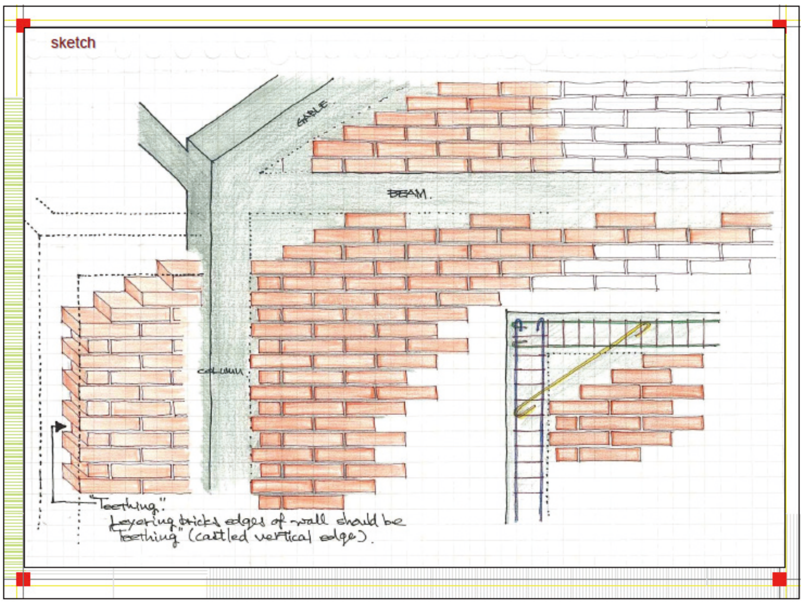
(Mr.Hiroshi Imai)

枠組み組積造の実践的な耐震性向上のための提案（建築研究所　専門研究員　今井　弘）




Strengthening of Openings : Seismic band
110
230
CASE 1
CASE 2




sketch
GABLE
BEAM.
"Teething."
Layering bricks edges of wall should be "Teething" (castled vertical edge).

Cyclic loading experiments

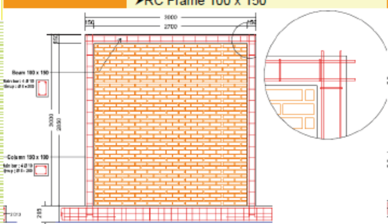
- March, 2008:
  Three specimens at Gadja University (USM) in Yogyakarta, Indonesia
- February-March, 2009:
  Nine specimens at Bandung Institute of Technology (ITB) in Bandung, Indonesia

7

Nine specimens were Conducted at Research Institute Human Settlement, (RIHS) Bandung, Indonesia

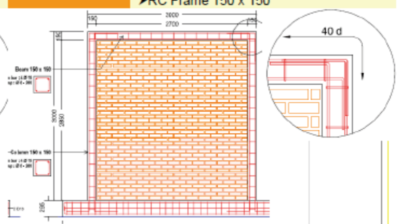
MODEL A

Common type in the Field
- Un-Proper Connection
- RC Frame 100 x 150



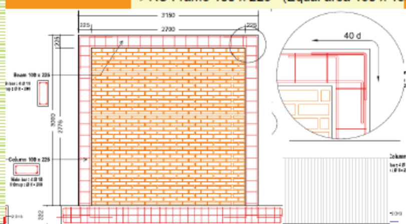
MODEL B

Benchmark Model
- Proper Connection
- RC Frame 150 x 150



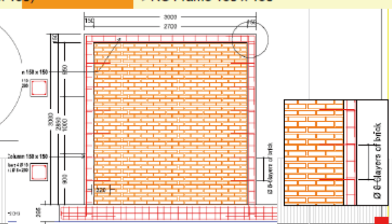
MODEL C

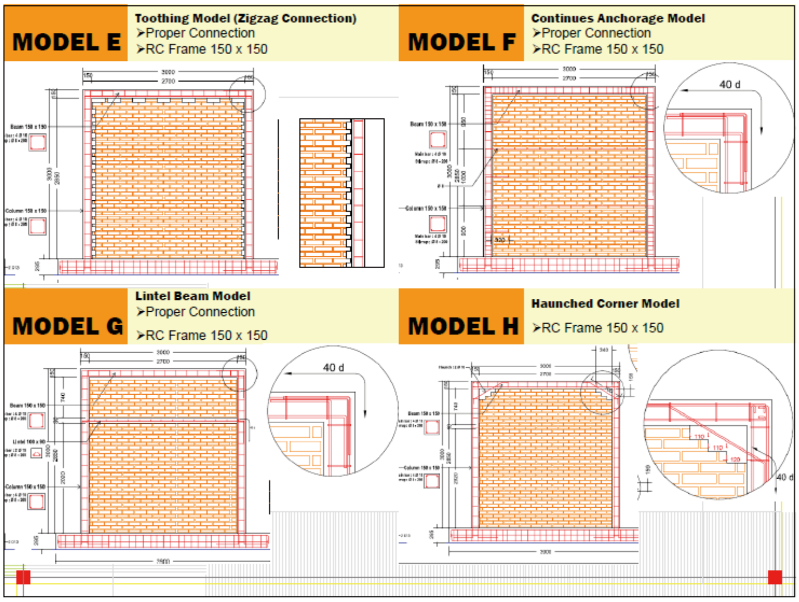
Rectangle Column Model
- Proper Connection
- RC Frame 100 x 225 (Equal area 150 x 150)

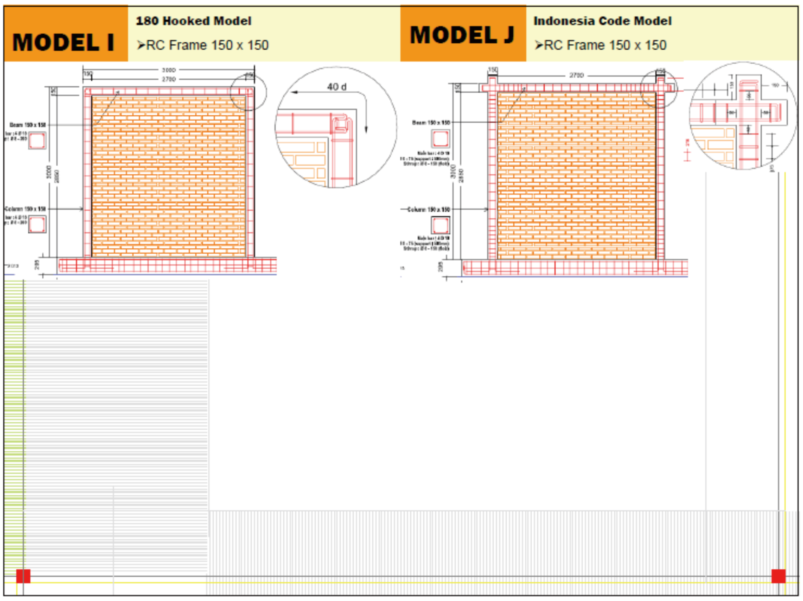


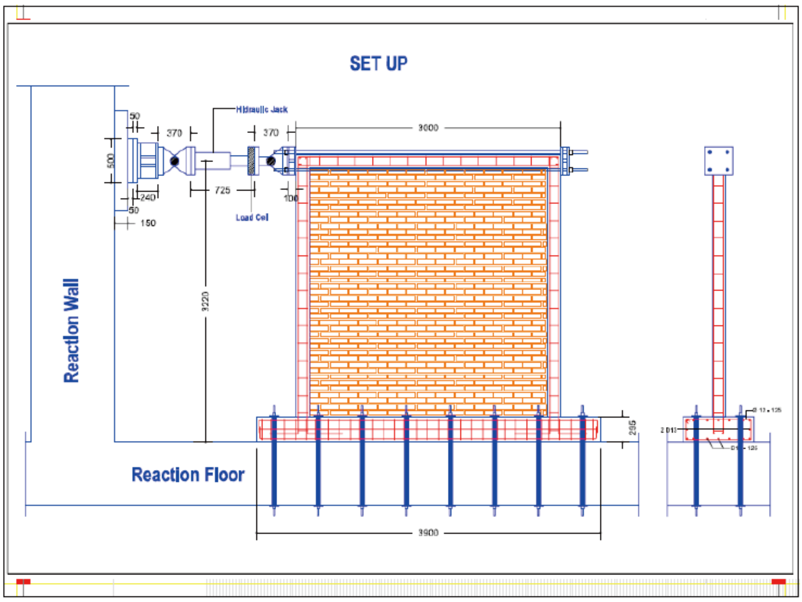
MODEL D

With Anchorage Model
- Proper Connection
- RC Frame 150 x 150




MODEL E
Toothing Model (Zigzag Connection)
➤Proper Connection
➤RC Frame 150 x 150
MODEL F
Continues Anchorage Model
➤Proper Connection
➤RC Frame 150 x 150
40 d
MODEL G
Lintel Beam Model
➤Proper Connection
➤RC Frame 150 x 150
40 d
MODEL H
Haunched Corner Model
➤RC Frame 150 x 150
40 d


MODEL I
180 Hooked Model
➤RC Frame 150 x 150
40 d
MODEL J
Indonesia Code Model
➤RC Frame 150 x 150


SET UP
Hidraulic Jack
Load Cell
Reaction Wall
Reaction Floor
3000
3900
3220
370
370
725
500
240
150
50
100
295

2.12. Summary of cyclic loading experiments on confined masonry in Bandung, Indonesia (Dr. Wahyu Wuryanti, RIHS) / 枠組み組積造壁体の繰り返し加力実験結果の概要(公共事業省人間居住研究所　ワヒュー・ウルヤンティ)

EXPERIMENTAL TEST OF CONFINED MASONRY WALLS SUBJECTED TO CYCLIC LATERAL LOADING

Wahyu Wuryanti
Research Institute For Human Settlements, Public Works -Indonesia
March 2009

OBJECTIVE OF EXPERIMENTAL TEST

- To study performance of confined masonry walls under cyclic lateral loading
- To determine shear strength capacity of confined masonry walls
- To view failure pattern of confined masonry walls
- To propose valuable guidance deal with non-engineering construction design

SCOPE ACTIVITIES

- Making specimen: foundation, brick wall, RC frame
- Strain gauge installation
- Preparation work: specimen and equipment setup
- Test mechanical material properties: concrete, steel bar, mortar, clay brick
- Full-scale testing: specimens subjected to cyclic lateral in-plane load according to displacement control

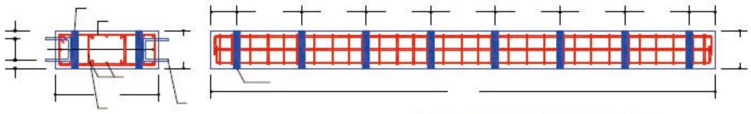
SCHEDULE ACTIVITIES

Description Work	January 2009	February 2009	March 2009
Foundation work			
Bricklaying work			
Strain gauge installation			
Frame concrete work			
Setup specimen and eaquipment			
Testing specimen			

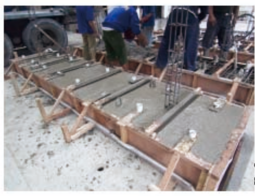
SPECIMEN

- Testing was addressed for ten model specimens with different types of wall connector and detailing reinforcing bar in beam-column joints
- Specimen was composed by red brick masonry with reinforced concrete frame which has total dimension 3000 x 3000 mm^2
- Masonry wall was composed by local product of red brick with size 50 x 95 x 215 mm^3 in average was jointed 15 mm mortar approximately
- Properties material :
  - Strength concrete foundation f'c = 25 MPa
  - Frame concrete used 1 cement : 2 sand : 3 gravel mixture composition volume)
  - Reinforcement plain bar fy = 240 MPa dia. 10 mm for main bar (except model J used deform bar) and dia. 8 mm for stirrup,
  - Mortar with mixture composition cement-sand 1:5

FONDATION OF SPECIMEN



- Typical foundation has size 3900 x 800 x 295 mm^3 (except for model C 332 mm thick)
- Anchor 16 with dia. 50 mm was bolted on floor bed reaction



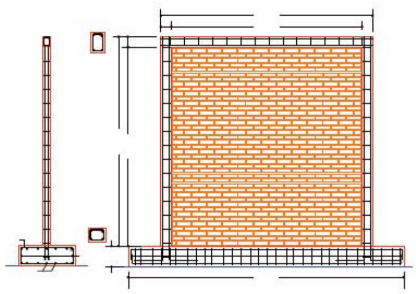
Ø 50 mm

65

165

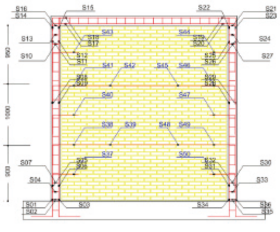
2 D13

Typical Model Specimen



- Columns/beam dimension :
  - Model A: 150 x 100 mm^2
  - Model C: 225 x 100 mm^2
  - Other s : 150 x 150 mm^2
- Reinforcement
  - 9 specimens: main bar 4∅10mm , stirrup ∅8 mm @200
  - Model J : main bar 4D10mm , stirrup end-span ∅8 mm @75 , mid-span ∅8 mm @150

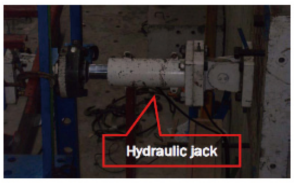
STRAIN GAUGE INSTALLATION

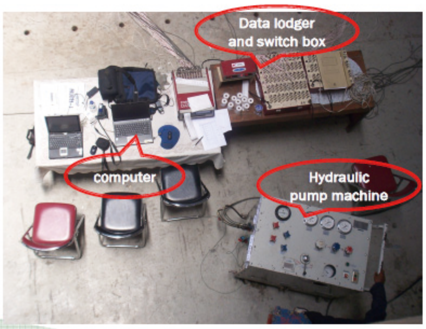


PLACING STRAIN GAUGE FOR MODEL F

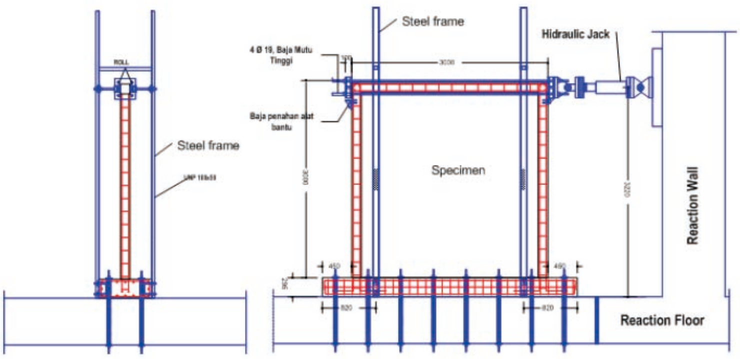
SETUP EQUIPMENT (1)

- Steel frame
- Hydraulic jack capacity 50 tonf
- Hydraulic pump machine
- Switch box data logger 70 channel
- computer





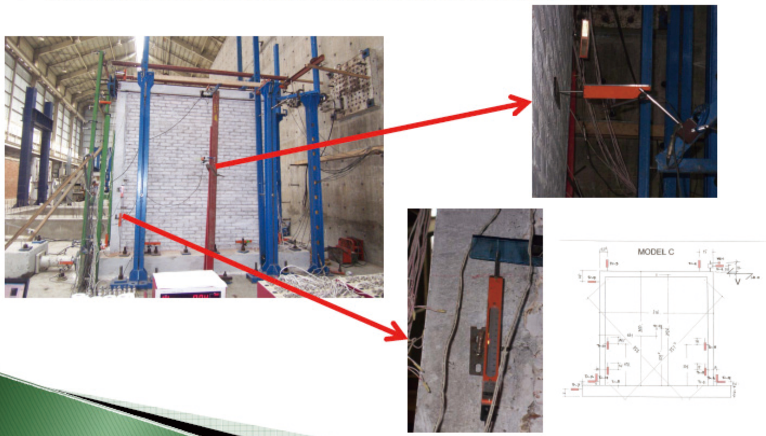
I. SETUP EQUIPMENT



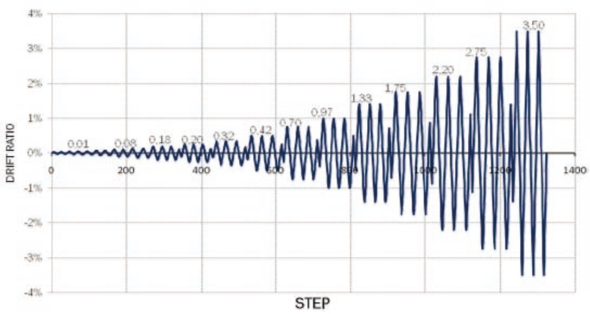
SETUP SPECIMEN AND EQUIPMENT (2)

SETUP TESTING RESULT MEASUREMENT

- lateral and vertical displacement transducers
- strain gauge FLA 6 x 11 mm^2 attached on a reinforcing bar



LOADING PROGRAM



- Load testing follow ACI 374.1-05 Procedure

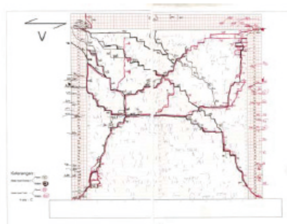
EXECUTION AND COLLECTING DATA

Sequences testing to record cyclic loading with displacement control

OCCURRENCE OF CRACK PATTERN

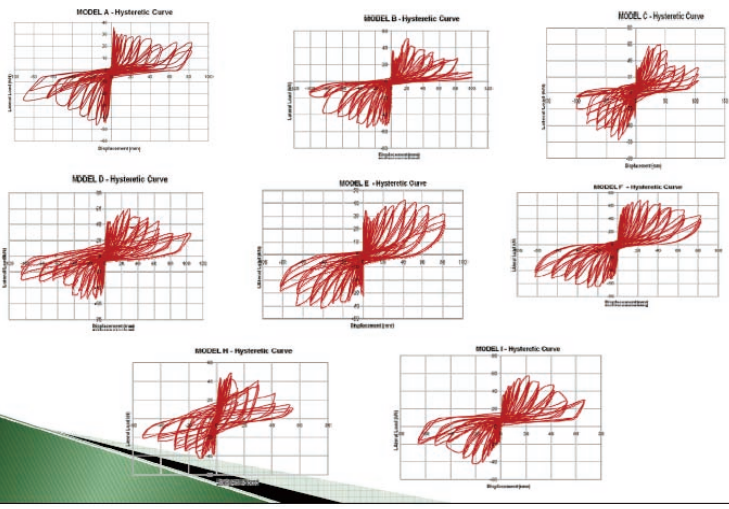
Draw for crack pattern to be clear

Red color for pull loading
black color for push loading



Redraw crack line

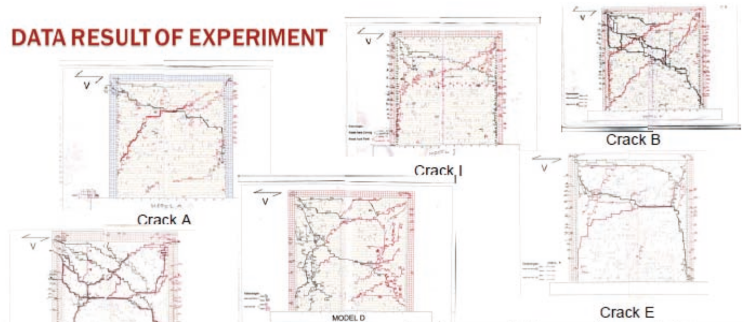
HYSTERETIC RESPONSE OF LOAD-DISPLACEMENT RELATIONSHIP

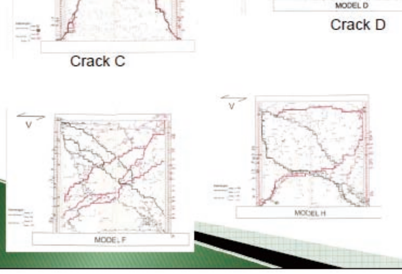


PRELIMINARY ANALYSIS FROM HYSTERETIC CURVE

Model	Characteristic	Condition	Load (kN)		Displacement (mm)	
			(+)	(-)	(+)	(-)
A	End of main bars of beam-column joint was not be bend and without connection between wall and frame	Max/min	35.60	-45.99	2.39	-16.09
		Ultimate	16.08	-17.85	82.29	-83.85
B	Bending at end main bars with 40d length and without connection between wall and frame	Max/min	50.60	-55.02	21.08	-30.2
		Ultimate	4.51	-13.14	100.78	-100.98
C	Similar with model B with frame dimension bigger than model B	Max/min	59.33	-57.37	42.14	-30.02
		Ultimate	14.42	-4.51	105.18	-97.19
D	Connection wall and frame use anchor in brick layers: ∅8 @ 8 layers length 40d. Bending at end main bars of frame with 40d length	Max/min	59.53	-53.35	29.16	-30.04
		Ultimate	23.54	-14.42	64.79	-105.18
E	Toothed outer brick laying for connection wall-frame. Bending at end main bars frame with 40d length	Max/min	41.97	41.78	42.02	-41.72
		Ultimate	7.257	-24.419	41.78	-82.5
F	Anchor ∅8 @ 8 layers length 40d and 2 continue bar ∅8. Bending at end main bars frame with 40d length	Max/min	67.963	-65.707	22.52	-30.04
		Ultimate	31.19	-30.21	105.18	-105.08
G	Lintel 100x90 and Bending at end main bars frame with 40d length	Max/min				
		Ultimate				
H	hunched corner at top masonry and bending at end main bars frame	Max/min	48.64	-42.07	10.52	-23.1
		Ultimate	9.022	-17.56	52.7	-52.52
I	Reinfor[illegible] bar of joint frame is hooked 360^0 and witho[illegible]nection between wall and frame	Max/min	56.49	-41.29	22.48	-18.16
		Ultimate	28.74	-15.30	66.16	-66.04

DATA RESULT OF EXPERIMENT





Model	At wall				At columns			
	Push (+)		Pull (-)		Push (+)		Pull (-)	
	(kN)	Drift (%)	(kN)	Drift (%)	(kN)	Drift (%)	(kN)	Drift (%)
A	26.87	0.04	-22.95	0.04	28.64	0.35	-37.86	0.35
B	34.13	0.05	-27.95	0.04	32.17	0.07	-30.41	0.25
C	29.91	0.04	-28.15	0.04	16.28	0.25	-24.71	0.13
D	31.09	0.05	-32.56	0.05	35.60	0.20	-25.01	0.25
E	30.21	0.07	-24.03	0.07	21.58	0.13	-21.77	0.13
F	30,11	0.04	-31,19	0.04	18.15	0.13	-37.86	0.13
G								
H	36.78	0.07	-38.35	0.05	10.40	0.13	-32.07	0.13
I	21.58	0.02	-13.93	0.02	10.49	0.25	-17.06	0.35

FURTHER ANALYSIS

- Strength capacity
- Ductility
- Stiffness degradation
- Energy dissipation

2.13. Quick report of analysis of cyclic loading experiments on confined masonry in Bandung, Indonesia (Dr. Dyah Kusumasututi, ITB) / 枠組み組積造壁体の繰り返し加力実験結果の解析の概要（バンドン工科大学　ディア・クスマストゥティ）

A Collaborative Research in Feasible and Affordable Seismic Construction

Behavior of Confined Masonry Wall under Cyclic Loading

Preliminary Analysis of Experimental Study

D. Kusumastuti,
I.G.W. Wijaya,
M. Suarjana,
Rildova
and K.S. Pribadi

•Center for Disaster Mitigation, Institute of Technology Bandung (Indonesia)
• Research Institute for Human Settlement (Indonesia)
•Building Research Institute (Japan)

Introduction

- Typical structural system of Indonesian house: R/C frames with confined masonry walls
- Wide range of level of damage of confined masonry walls under earthquake loads due to variation in:
  - Detailing of beam, column, and beam-column connection
  - Quality of materials
  - Construction techniques
- Possible failure types of confined masonry wall: diagonal cracking, sliding shear, corner crushing, diagonal compression, frame failure, etc
- Needs to evaluate structural behavior of different confined masonry walls (common practice) under earthquake loads quantitatively

2

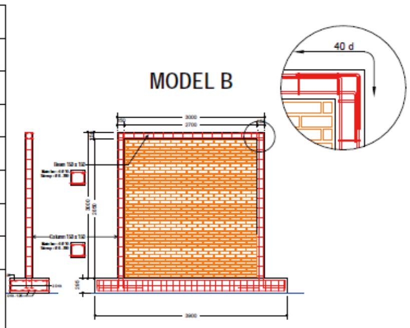
Objective and Expected Outcomes

- Objective:
  - To evaluate in-plane behavior of various confined masonry wall models under cyclic loading
  - To analyze R/C frame confined masonry wall detailing sufficient in resisting earthquake load
  - To propose applicable solution to improve the behavior of confined masonry wall under earthquake loading
- Expected Outcomes:
  - Test results: load vs deformation relationship, damage or failure mode
  - Verification of structural behavior for typical Indonesian housing
  - Development of applicable solution to improve the behavior of confined masonry wall under earthquake loading
  - Development of retrofitting strategy for existing structures

3

Benchmark Model

Model B (Benchmark)	
Column	Dimension: 150 x 150
	Longitudinal rebar: 4ϕ10
	Loop ϕ8 @ 200
Beam	Dimension: 150 x 150
	Longitudinal rebar: 4ϕ10
	Stirrup ϕ8 @ 200
Anchorage	No
Zigzag Connection/ Toothing	No
Concrete Band	No



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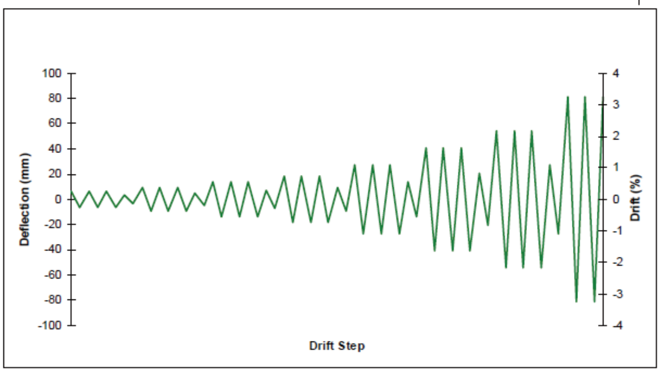
Structural Models

Model	Difference from Model B
A (Smaller Columns/ Common Practice)	• Column and beam dimension: 100 x 150 • Beam-column joint reinforcement detail without hook
C (Equal Area)	• Column and beam dimension: 100 x 225
D (Anchorage)	• Anchorage of ϕ8 @ 6 layers of bricks with length of 40 d
E (Zigzag Connection)	• Toothing vertical and horizontal
F (Continuous Anchorage)	• Continuous anchorage of ϕ8 @ lintel and sill level • Anchorage of ϕ8 @ 6 layers of bricks with length of 40 d in between continuous anchorage
G (Lintel Beam)	• Concrete band with lintel beam of 100 x 90 with 2ϕ8 rebar
H (Haunched Corner)	• Concrete band with haunched beam-column connection on upper corners
I (180° Hook)	• Beam-column joint reinforcement detail with 180° hook

5

Loading History



Reference: ACI 374.1-05

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Model B (Benchmark) Damage and Failure Mode

- Crack pattern suggest that Model B is a confined masonry with shear collapse mechanism
- First cracks developed at the wall, and the complete crack pattern shows truss mechanism
- Columns were bent in-plane outwards, allowing some flexural capacity.
- Flexural behavior of columns is limited by the crushing of concrete near the hook and slippage of longitudinal rebars

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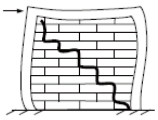
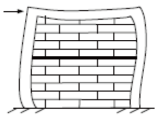
Damage and Failure Mode

- Crack pattern shows that all models are confined masonry, with first crack developed at the wall
- Two types of collapse mechanism were observed, shear mechanism and sliding shear mechanism
- Most models showed **shear mechanism** with diagonal cracks on compression and tension zones
- Models A (smaller columns), E (zigzag connection), and H (haunched) showed **sliding shear mechanism** with horizontal cracks
- Model G (lintel beam) first developed two cross diagonal cracks, above and below lintel beam. After column-lintel-connection was damaged, single shear mechanism was developed from the corners of the wall



Shear Mechanism



Sliding Shear Mechanism

8

Damage and Failure Mode

- Model A (smaller columns) has a combination of shear and sliding shear mechanisms. Shear mechanism developed at upper half of the wall due to failure of beam-column-connection

- Model C (equal area of column) developed shear mechanism. Diagonal pattern is more defined compared to Model B. Columns were deformed and bent in-plane outwards, confirming some flexural behavior of the columns.

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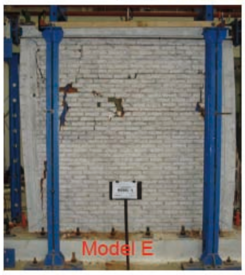
Damage and Failure Mode

- Model D (anchorage) shows that separation of columns and wall was prevented. Most of the column damage occurred at the corners of the structure. Wall cracks are mostly at the area that is clear of anchorage, with vertical cracks occurred at the end of the anchorage, and diagonal cracks still occurred at the wall. Thus, wall separation (vertical cracks) was also developed in addition to regular shear mechanism.
- Model E (zigzag connection) presents more of sliding shear mechanism than shear mechanism. Significant horizontal cracks were developed, and truss mechanism was not developed for this model. Initial cracks occurred at the front of zigzag line which damaged the bond of wall to columns. Then horizontal cracks occurred at the wall and formed sliding shear mechanism.



10

Damage and Failure Mode

- Model F (continuous anchorage) developed diagonal cracks and good shear mechanism. Large displacement occurred prior to collapse and continuous horizontal rebars at lintel and sill levels were able to prevent early collapse
- Model G (lintel beam) first developed two cross diagonal cracks, above and below lintel beam. After column-lintel-connection was damaged, single shear mechanism was developed from the corners of the wall.

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Damage and Failure Mode

- Model H (haunched) shows a combination of shear and sliding shear mechanism. Shear mechanism was developed at the lower half of the wall due to the existence of haunches. Collapse of the structure was caused by shear failure at the bottom of columns.
- Model I (180° hook) shows sliding shear and shear mechanism at the upper half. Sliding shear at the top part due to failure of connection at the upper corners, where no adequate detailings provided for the joints.

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Damage and Failure Mode

- Most models, with the exception of Model A (small columns), showed that columns were bent in-plane outwards, thus were able to develop some flexural capacity.
- Flexural capacity of columns is limited with the crushing of concrete near the hook and slippage of longitudinal rebars.
- Smaller columns at Model A acted as confinement to ensure ductility of the wall. After the wall failed, the lateral force was transferred to the columns, which then failed and caused total collapse of the structure.

Model A

Model B

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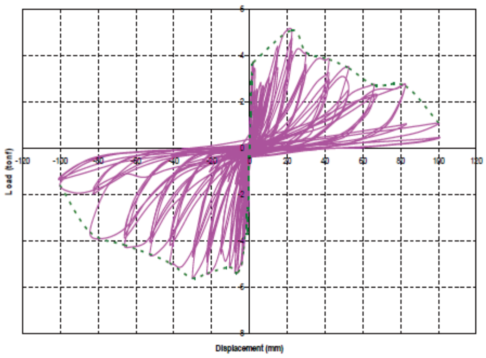
Model B (Benchmark) Hysteretic Curve



- Maximum displacement prior to collapse is 80 mm (2.75%)
- Condition at maximum strength:
  - Lateral load: 5.6 tons
  - Displacement: 22.5 mm (0.75%)
- Condition at 20% strength degradation:
  - Lateral load: 4 tons
  - Displacement: 56 mm (1.9%)
- Low energy dissipation capacity
- Envelope of curve shows some ductility

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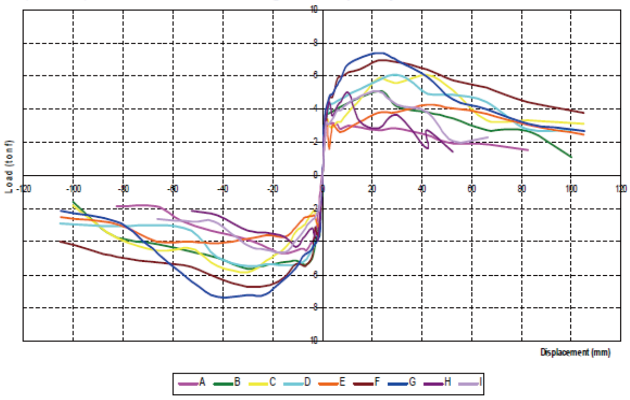
Envelope of Hysteretic Curves

- All models have similar elastic stiffness, except Model A (smaller columns) that is lower and Model G (lintel) that is higher
- Average maximum strength is 5 tons, Model A has least capacity (4 tons) and Model G with highest capacity of 7 tons



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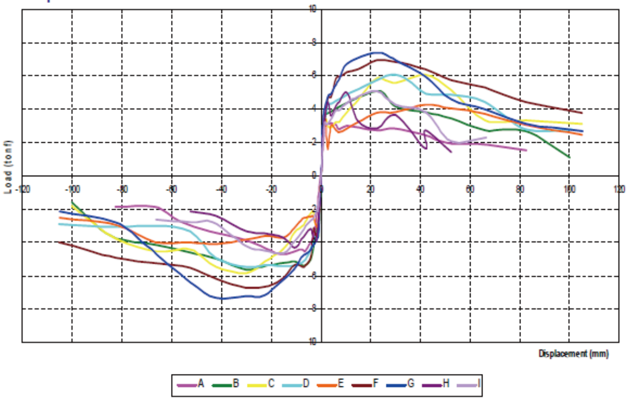
Envelope of Hysteretic Curves

- Model I (180° hook) and Model H (haunched) showed slightly less capacity and less maximum displacement than Model B (benchmark
- For 20% strength reduction, all models have maximum displacement of more than 1.5%, except Model H (haunched) that has maximum displacement of 1%



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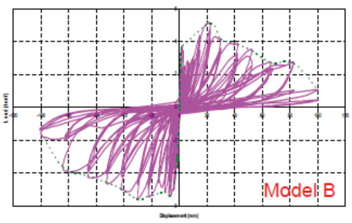
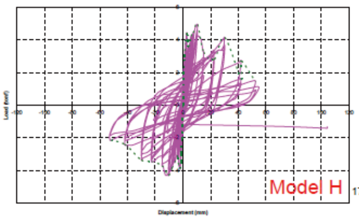
Comparison of Model B (Benchmark) and Model H (Haunched)

- Similar elastic stiffness and capacity (maximum strength)
- Model B has relatively low energy dissipation capacity, Model H that has higher energy dissipation capacity
- Different maximum displacement, Model B has maximum displacement of 1.5%, Model H has maximum displacement of 1%
- After displacement of 1%, Model H has higher strength reduction rate than Model B
- Model H developed lower ductility level compared to Model B





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Remarks

- Variation of column and beam dimension have some effect on structural behavior and collapse mechanism
- Variation of beam-column connection detailing have some effect on structural behavior, especially in inelastic range
- Additional horizontal reinforcement for walls, i.e. continuous anchorage and lintel beam may improve performance of wall
- Additional concrete band, i.e. lintel beam and haunched corners may change collapse mechanism walls, and specific detailing for connection of concrete band to columns/beams may be necessary
- Further research is necessary to better understand the behavior of masonry walls

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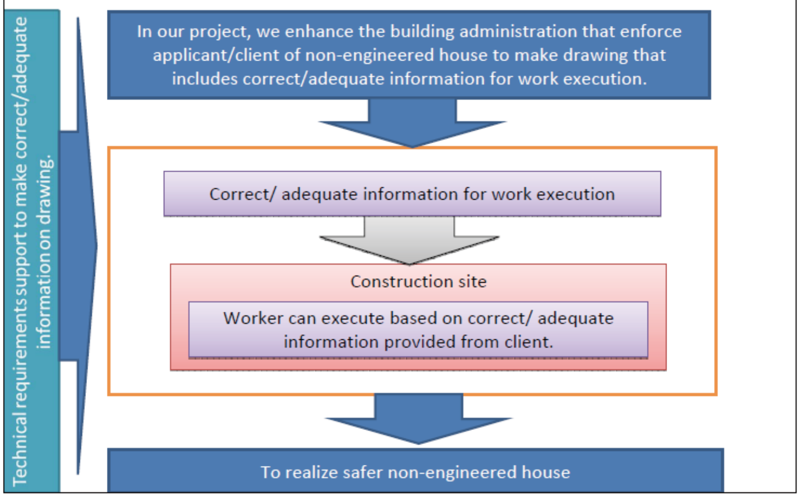
2.14. Comments on cyclic loading experiments in Bandung, Indonesia (Mr. Kazushi Shirakawa, JICA Long Term Expert in Indonesia)

枠組み組積造壁体の繰り返し加力実験についての考察（在インドネシア JICA 長期専門家　白川和司）

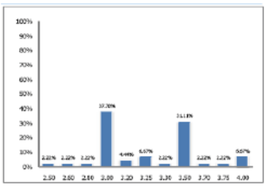
The consideration regarding experiment on cyclic load for confined masonry in Indonesia (The consideration regarding the difference between the wall as test piece and the wall as actual construction site)

SHIRAKAWA, Kazushi
JICA Expert in INDONESIA

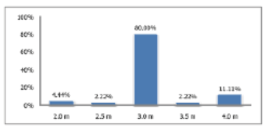
Idea in our project



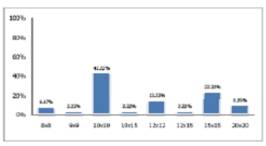
The result of field survey regarding construction method on actual construction site



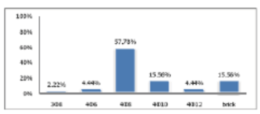
Length of column



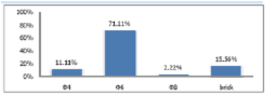
Span



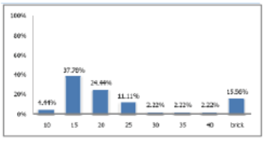
Dimention of column



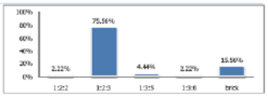
Diameter of longitudinal reinforcement



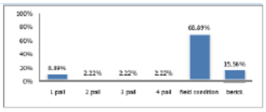
Diameter of hoop



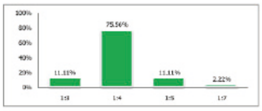
Interval of hoop



Concrete mixing proportion



Water volume for mortal



Mortal mixing proportion

Mortal mixing

Concrete mixing

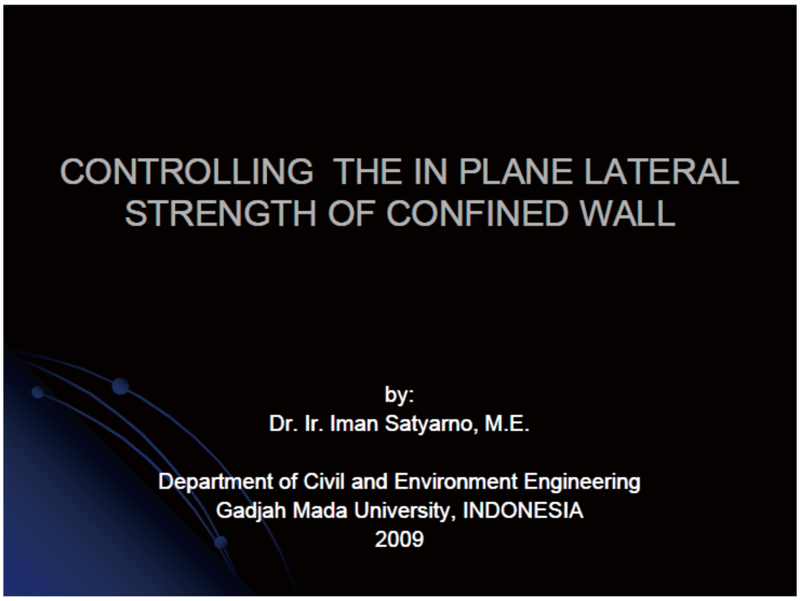
Mortal mixing

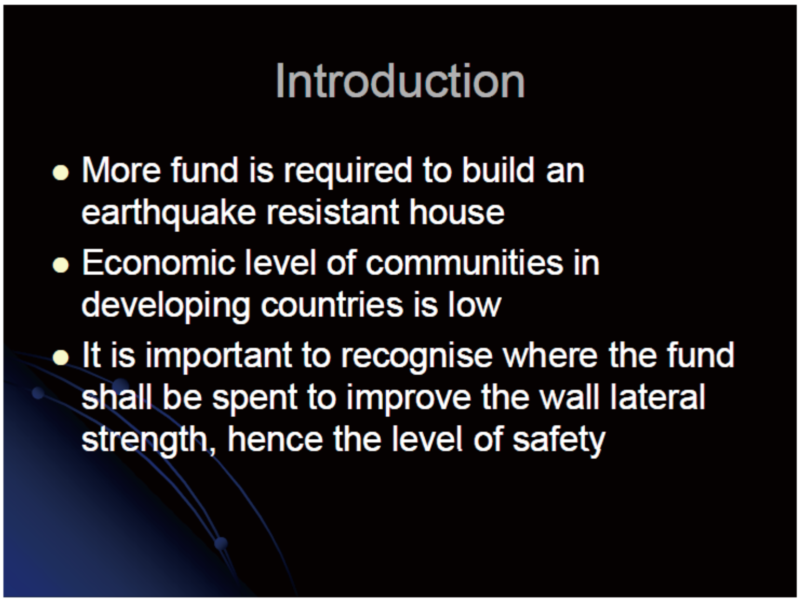
expectation

To reflect the result of field survey for planning test piece

To come up with field survey method for catching actual construction method on site

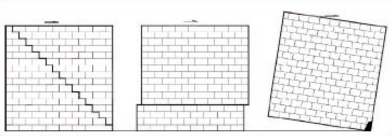
2.15. Summary of cyclic loading experiments on confined masonry in Gadjah Mada University, Indonesia (Dr. Iman Satyarno, Gadja Mada University) / ガジャマダ大学で実施した枠組み組積造壁体の繰り返し加力実験の概要（ガジャマダ大学　イマン・サトヤルノ）





Introduction

- Alternatives spending to improve the wall lateral strength are to increase:
  - reinforcing bar diameter
  - dimensions of confinement elements (column and or beam)
  - infill or wall material strength

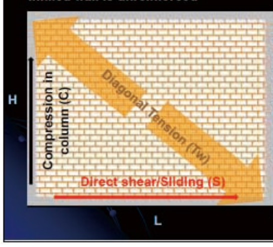


Shear Failure (Tw) Sliding Failure (S) Rocking Failure (T)

(Elgwady, et.al

Failure Type -1

Infilled wall is unreinforced



For square wall:

$F = C = S = Tw/\sqrt{2}$

$C_{max} = A_c f'_c$

$S_{max} = \tau_m L$

$Tw_{max} = f'_{mt} A_{eff}$

where:

f'_c = concrete compressive strength

τ_m = wall shear strength

f'_{mt} = wall tensile strength

A_{eff} = effective wall tensile area

A_c = effective column compressive area

Failure Type -2

Infilled wall is adequately reinforced

For square wall:

$F = T = S = Cw/\sqrt{2}$

$T_{max} = n\ 0.25\ \pi\ D^2 f_y$ or slip

$S_{max} = \tau_m L$

$Cw_{max} = f'_m A_{eff}$

where:

n = number of bar

D = bar diameter

f_y = yield strength

τ_m = shear strength

f'_m = wall compressive strength

A_{eff} = Effective wall compressive are

Theory

- Lateral strength of confined brick masonry wall is controlled by the smallest strength of C, Tw, S, Cw, and T; hence depend on the following parameters:
  - For C: column dimension and concrete compressive strength f'_c
  - For Tw: wall tensile strength f'_{mt}
  - For S: wall direct shear strength τ_m

Theory

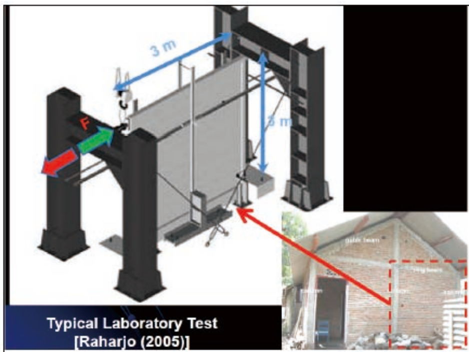
- Lateral strength of confined brick masonry wall is controlled by the smallest strength of C, Tw, S, Cw, and T; hence depend on the following parameters:
  - For Cw: wall compressive strength f'_m
  - For T: number (n), diameter (D), and yield strength (f_y) of longitudinal reinforcing bar

Theory

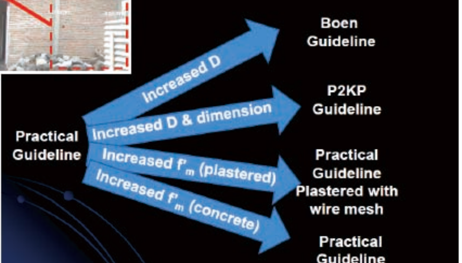
- Parameters that can be controlled by construction workers:
  - Number (n) and diameter (D) of longitudinal reinforcing bar
  - Compressive and tensile strength of wall material (f'_m and f'_{mt})
  - Concrete compressive strength (f'_c)
  - Element dimensions

Theory

- Parameters that can not be controlled by construction workers:
  - yield strength of longitudinal reinforcing bar (f_y)



Typical Laboratory Test [Raharjo (2005)]

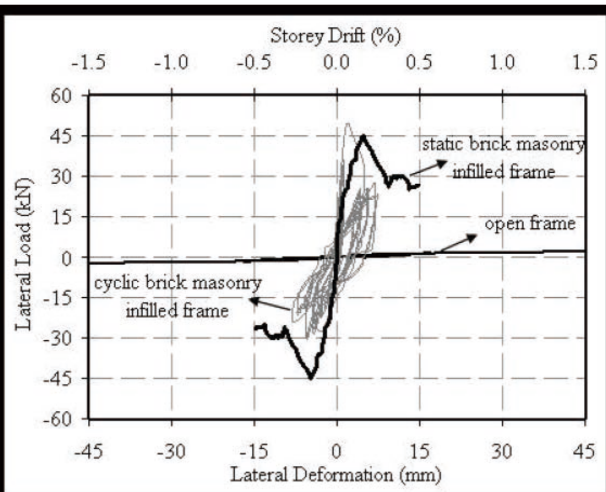


Laboratory Test

Variables of confinement elements in the test specimens

	Column			Note
		Reinforcement		
	Dimension	Longitudinal	Stirrup	
1	10 cm x 10 cm	4 d8 mm	d6 mm-15 cm	Practical guideline*
2	15 cm x 15 cm	4 d10 mm	d8 mm-15 cm	Teddy Boen guideline**
3	15 cm x 15 cm	4 d12 mm	d8 mm-15 cm	P2KP guideline**
4	10 cm x 10 cm	4 d8 mm	d6 mm-15 cm	Practical guideline, plastered 1 pc : 2 sand with wiremesh*
5	10 cm x 10 cm	4 d8 mm	d6 mm-15 cm	Reinforced concrete wall***
	Ring beam			Note
		Reinforcement		
	Dimension	Longitudinal	Stirrup	
1	10 cm x 10 cm*	4 d8 mm	d6 mm-15 cm	Practical guideline*
2	12 cm x 15 cm	4 d10 mm	d8 mm-15 cm	Teddy Boen guideline**
3	12 cm x 20 cm*	4 d12 mm	d8 mm-15 cm	P2KP guideline**
4	10 cm x 10 cm	4 d8 mm	d6 mm-15 cm	Practical guideline, plastered 1 pc : 2 sand with wiremesh*
5	10 cm x 10 cm*	4 d8 mm	d6 mm-15 cm	Reinforced concrete wall***

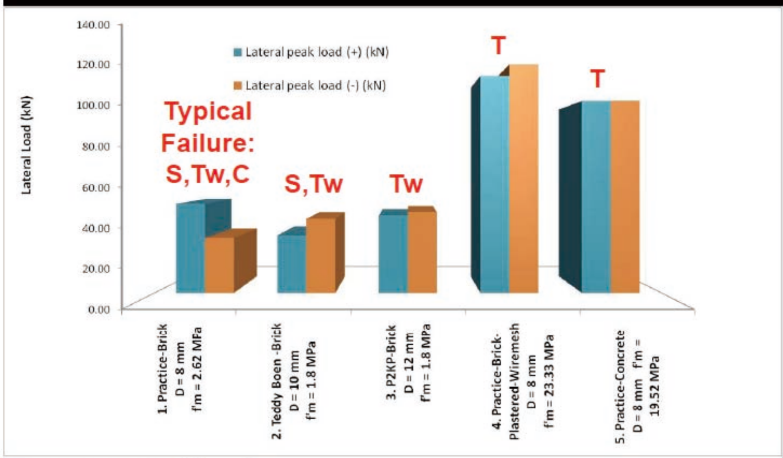
* Brick masonry wall is not anchoraged to the columns and the mortar for the bed joint is made of 1 cement : 6 sand
* The plaster was made of 1 cement : 2 sand, and 2 cm thickness
** Brick masonry wall is anchoraged to the columns and the mortar for the bed joint is made of 1 cement : 4 sand
***Reinforcement of the wall is single layer with 6 mm in diameter and the spacing is 250 mm



Typical test result of lateral load-lateral deformation relationship [Raharjo (2005)]

Test Results

- Practical guideline wall failure types are Tw, S and C.
- Failure types of increased longitudinal reinforcing bar diameter are Tw and S, where wall lateral strength is not significantly improved.
- Failure types of increased longitudinal reinforcing bar diameter and confining element dimension is Tw, where wall lateral strength is not significantly improved.
- Failure type of increased wall material strength, both its compressive and tensile (using reinforcement) is T, where wall lateral strength is significantly improved.



Conclusions

- Common brick masonry wall material strength is quite low (low f'_m and f'_{mt}) and typical failures are Tw and S
- Increasing longitudinal reinforcing bar diameter will not improve the wall lateral strength without increasing the wall material strength
- To compensate the on site imperfectness during construction, it is recommended to plaster the brick masonry wall to improve the safety

2.16. Summary of Collaborative R&D Project and next steps forward (Dr. Yuji Ishiyama)
科学技術振興調整費の研究開発活動とその展開
（北海道大学名誉教授・研究運営委員会委員長　石山祐二）

Summary of Collaborative R&D Project and Next Steps Forward

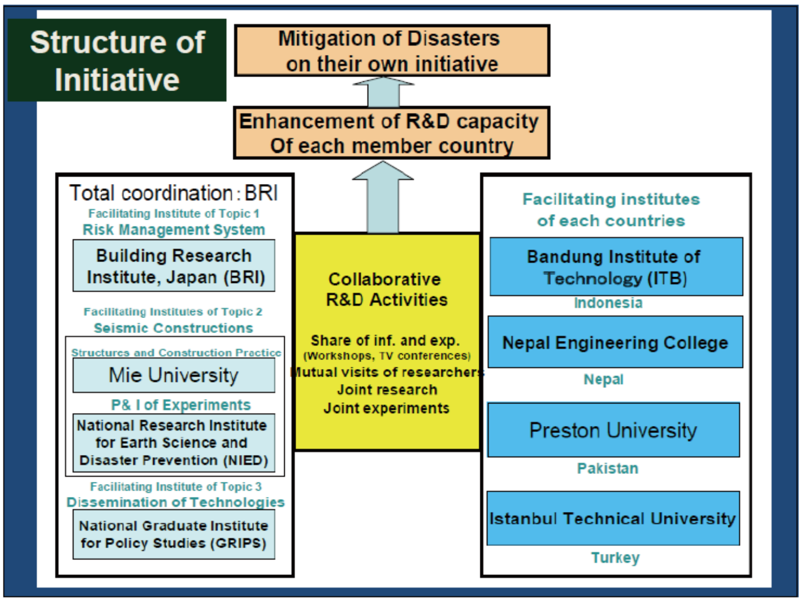
Yuji Ishiyama
Professor Emeritus, Hokkaido University
to-yuji@nifty.com

Japanese Initiative for Mitigation of Earthquake Disasters managed by BRI focusing on Non-engineered construction <Comprehensive Approach>

- Collaborative Research and Development Projects with research institutes in four Asian countries and four Japanese institutes supported by Ministry of Education, Culture, Sports, Science and Technology (MEXT)
- Duration: three years (2006 – 2008)

Japanese Initiative for Mitigation of Earthquake Disasters managed by BRI <Comprehensive Approach>

- Participating organizations: National Institute for Earth Science and Disaster Prevention (NIED), National Graduate Institute for Policy Studies (GRIPS) and Mie University
- Chairperson of Management Committee:
  Dr. Yuji Ishiyama, Professor Emeritus, Hokkaido Univ.
- Counterpart countries: Indonesia, Nepal, Pakistan, Turkey and Peru



Basic scheme of R&D

- Platform for collaboration among participating institutes
  - mutual visits
  - events for sharing information and discussion
  - communication by IT tools like video conference system, internet
- R&D components for collaborative work
  - proposals by any people/institutes
  - elaboration of work plan
  - implementation with contribution of all the participating countries
  - achievements should be shared through the Platform and other channels

Research Topics of Collaborative R&D Project for Disaster Mitigation on Network of Research Institutes in Asia

- **R&D focuses on realization of mitigation of disasters**
- **To concentrate conventional houses which is the main cause of human losses**
- **To prepare complete proposal of strategies without "missing ring"**
- **Propose three major topics**
  - **Feasible and Affordable Seismic Constructions**
  - **Strategies for Dissemination of Technologies to Communities**
  - **Risk Management System**

- **Feasible and Affordable Seismic Constructions**

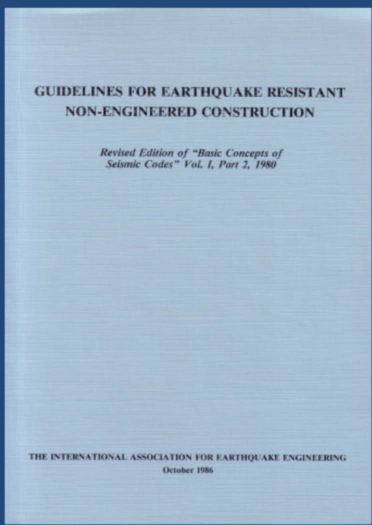
To develop appropriate seismic structures and construction practices, which will be expected to be accepted by communities, and to verify them by a series of joint experiments

- **Strategies for Dissemination of Technologies to Communities**

To develop strategies and tools for dissemination of technologies to people and communities such as consecutive workshops in communities, demonstrations, capacity development of housing facilitators

- **Risk Management System**

To develop systems for evaluation of seismic risks with assumed earthquakes, conditions of buildings etc., and to manage them through development of new strategies to mitigate disasters


GUIDELINES FOR EARTHQUAKE RESISTANT NON-ENGINEERED CONSTRUCTION

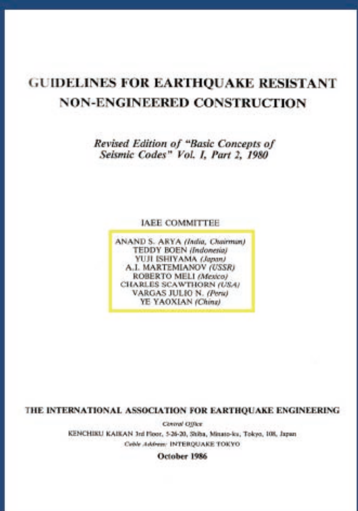
Revised Edition of "Basic Concepts of Seismic Codes" Vol. I, Part 2, 1980

THE INTERNATIONAL ASSOCIATION FOR EARTHQUAKE ENGINEERING
October 1986

Guidelines for Earthquake Resistant Non-Engineered Construction

Revised Edition (1986)

International Association for Earthquake Engineering (IAEE)


GUIDELINES FOR EARTHQUAKE RESISTANT NON-ENGINEERED CONSTRUCTION

Revised Edition of "Basic Concepts of Seismic Codes" Vol. I, Part 2, 1980

IAEE COMMITTEE

ANAND S. ARYA *(India, Chairman)*
TEDDY BOEN *(Indonesia)*
YUJI ISHIYAMA *(Japan)*
A.I. MARTEMIANOV *(USSR)*
ROBERTO MELI *(Mexico)*
CHARLES SCAWTHORN *(USA)*
VARGAS JULIO N. *(Peru)*
YE YAOXIAN *(China)*

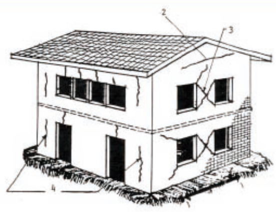
THE INTERNATIONAL ASSOCIATION FOR EARTHQUAKE ENGINEERING
Central Office
KENCHIKU KAIKAN 3rd Floor, 5-26-20, Shiba, Minato-ku, Tokyo, 108, Japan
Cable Address: INTERQUAKE TOKYO
October 1986

- Anand S. Arya (India)
- Teddy Boen (Indonesia)
- Yuji Ishiyama (Japan)
- A. I. Martemianov (USSR)
- Roberto Meli (Mexico)
- Charles Scawthorn (USA)
- Vargas Julio N. (Peru)
- Ye Xaoxian (China)

Table of Contents (158pp)

Down Load

http://www.nicee.org/IAEE_English.php



1-1 Earthquake motion, 2-Horizontal crack in gables, 3-Diagonal cracks due to shear, 4-Cracks due to bending of wall.

FIG.4.1. CRACKING IN BEARING WALL BUILDING DUE TO BENDING AND SHEAR.

ii) A wall can fail as a bending member loaded by seismic inertia forces on the mass of the wall itself in a direction, transverse to the plane of the wall. Tension cracks occur vertically at the centre, ends or corners of walls. Longer the wall and longer the openings more prominent is the damage (Fig.4.1.). Since earthquake effects occur along both axes of a building simultaneously, bending and shearing effects occur often together and the two modes of failure are often combined. Failure in the piers occurs due to combined action of flexure and shear.

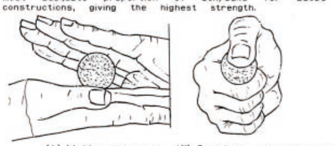
iii) Unreinforced gable end masonry walls are very unstable and the strutting action of purlins imposes additional force to cause their failure. Horizontal bending tension cracks are caused in the gables.

iv) The deep beam between two openings one above the other is a weak point of the wall under lateral in-plane forces. Cracking in this zone occurs before diagonal cracking of piers (Fig.4.2.). In order to prevent it and to enable the full distribution of shear among all piers, either a rigid slab or r.c. band must exist between them.

Easy to understand with many illustrations

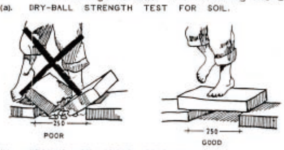
b. Fissuring Control Test

At least eight sandwich units are manufactured with mortars made with mixtures in different proportions of soil and coarse sand. It is recommended that the proportion of soil to coarse sand vary between 1:0 and 1:3 in volume. The sandwich having the least content of coarse sand which, when opened after 48 hours, does not show visible fissures in the mortar, will indicate the most adequate proportion of soil/sand for adobe constructions, giving the highest strength.



(i) Making the ball (ii) Crushing the dried ball

(a). DRY-BALL STRENGTH TEST FOR SOIL.



(b). TESTING OF ADOBE STRENGTH.

FIG.7.3 FIELD TESTING OF STRENGTH OF SOIL AND ADOBE.

Strength Test of Adobe

The strength of adobe can be qualitatively ascertained as follows: After 4 weeks of sundrying the adobe it should be strong enough to support in bending the weight of a man (Fig.7.3.b). If it breaks, more clay and fibrous material is to be added. Quantitatively, the compressure strength may be determined by testing 10cm cubes of clay after completely drying them. A minimum value of $1.2 N/mm^2$ will be desirable.

Applicable at construction site

Principal Points for the Revision

(1) Total number of pages should be kept minimum as the current edition

(2) A few pages to explain the minimum requirements for safer housing will be included at the beginning of each construction type

(3) All should be easy to understand and be applicable at the construction site

If you have interest, please contact

Anand S. Arya : anandsarya@gmail.com

Teddy Boen : tedboen@cbn.net.id

Yuji Ishiyama : to-yuji@nifty.com

CIB : TG75
Establishment of a New Task Group
on Engineering Studies
on Traditional Constructions

CIB (International Council for Research and Innovation in Building and Construction) was established in 1953, aiming to stimulate and facilitate international cooperation and information exchange between governmental research institutes in the building and construction sector.

CIB has developed into a world wide network of over 5,000 experts from about 500 member organizations.

TG75 - Engineering Studies on Traditional Constructions

- Proposal was developed by Dr. Narafu and accepted by the CIB Board in November 2008 (Coordinator of TG 75: Prof. Kenji Okazaki, GRIPS)
- Objectives of the TG 75

  - to collect information on the non-engineered structures in the world to grasp actual designs, materials, construction practices and labor forces, and the past achievements on non-engineered structures

  - to discuss and identify crucial issues to be studied.

  - to propose working programs for the next activities.

  - to organize forums such as workshops, video conferences and web site, for exchange of information, knowledge and views.

Major Activities 2009 - 2011

- 2009
  - Invitation of participation into TG75
  - Identification of the activities, and collection of information
  - Kick-off meeting in Sep. 2009 in Japan
- 2010
  - CIB World Congress in 10-13 May 1020 in UK.
  - Proposal on Activities Programs
- 2011
  - Task Group Report

Please contact Kenji Okazaki : okazakik@grips.ac.jp

3. ANNEX

参考資料

International Video Workshop 2009 on Safer Housing focusing on Confined Masonry Structures

1. Background and Objectives

Mitigation of earthquake disasters is one of the keenest issues common in earthquake prone areas. Safer "non-engineered construction" is one of the most urgent issues because it is the main cause of human casualties. Building Research Institute (BRI) and partner institutes both in Japan and abroad have been working on safer housing since 2005. Confined masonry structures (masonry structures with confinement of small dimension of reinforced concrete columns and beams) are one the most common structure type in the world and we have been working on this. We conducted field surveys and experiments shown below. In the context, BRI organize an international video workshop on confined masonry structures to share the result and achievement of the surveys and experiments and to discuss for proposals of practical design and technologies. We organize the workshop on network of video conference system connecting five countries and provide web streaming services for internet access from anywhere in the world. We expect active participation and contribution of people in research and practice in earthquake disaster reduction.

Research activities on confined masonry structures:

- **Shaking table experiments of full size specimens**

  July, 2008: one specimen at National Research Institute for Earth Science and Disaster Reduction (NIED) in Tsukuba, Japan

  December, 2008: three specimens with different types of reinforcing at Pontificia Universidad Catolica del Peru (PUCP) in Lima, Peru

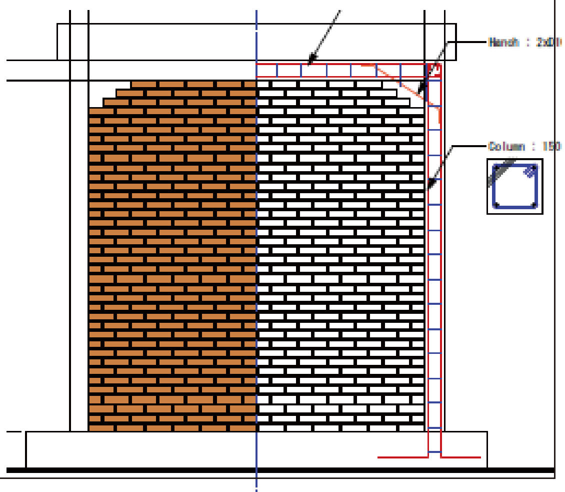


Shaking table experiment at NIED on July 2008

- **Cyclic loading experiments of wall specimens**

  March, 2008: three specimens at Gadjah Mada University (UGM) in Yogyakarta, Indonesia

  February-March, 2009: nine specimens by Bandung Institute of Technology (ITB) in Bandung, Indonesia



Specimen for cyclic loading experiment to verify a proposed reinforcement of connection of columns and beams in Bandung

- **Monitoring of construction procedures and practice on construction sites** for three months by Japanese engineers 2007: construction sites in Yogyakarta, Indonesia and Lime, Peru



BRI and partner institutes held workshops on earthquake disaster mitigation in f/y 2006 and 2007. You can see the outline of them on the web site of BRI at

http://www.kenken.go.jp./english/information/information/event/tokyo-2008/index-e.htm

http://www.kenken.go.jp./english/information/information/event/ws2008/index-e.htm

http://www.kenken.go.jp./english/information/information/event/tokyo-2007/index.htm

http://www.kenken.go.jp./english/information/information/event/tokyo-2006/index.htm

2. Organizers

Building Research Institute (BRI)

3. Supporting organizations

National Research Institute for Earth Science and Disaster Prevention (NIED)
National Graduate Institute for Policy Studies (GRIPS)
Mie University
World Bank Tokyo Development Learning Center (TDLC)
Japan International Cooperation Agency (JICA)
United Nations Center for Regional Development (UNCRD)
Inter-agency Secretariat for International Strategy for Disaster Reduction (UN/ISDR)
United Nations Educational, Scientific and Cultural Organization (UNESCO)

4. Date (Japan Time)

March 23(Monday), 2009 4PM – 9PM (five hours)

5. Venues and schedule

The workshop is to be held on the network of Video Conference System of the World Bank, which connects five countries as below.

Tokyo, Japan (Main Venue)

World Bank Tokyo Development Learning Center (TDLC)

10F, Fukoku Seimei Bldg. 2-2-2, Uchisaiwai-cho, Chiyoda-ku, Tokyo, 100-0011

Tel: +81-3-3597-1333

Map: attached

Map URL: http://www.jointokyo.org/en/location/

Contact person: Terumi Hayashi (thayashi@worldbank.org)

Workshop <Japan time> March 23 16:00 - 21:00

WEB Streaming Services

You can access to the workshop from anywhere in the world with your PC. The address of the web site for WEB Streaming Services will be delivered to you several days before the workshop. Peoples, who would like to join, please register your name, e-mal address and other information by sending **Registration Form** attached to this announcement so as to let us send the address to you.

Tsukuba, Japan (Sub Venue)

Building Research Institute (BRI)

1 Tachihara, Tsukuba city, Ibaraki, 305-0802

MapURL: http://www.kenken.go.jp./english/information/information/transport/access.html

Map: attached

Contact person: Taiki Saito (tsaito@kenken.go.jp) Tel: +81-29-864-6751

Workshop <Japan time> March 23 16:00 - 21:00

Jakarta, Indonesia (Sub Venue)

JICA INDONESIA OFFICE

SENTRAL SENAYAN II, 14th Floor, JI. Asia Afrika No. 8

Gelora Bung Karno-Senayan, Central Jakarta 10270 INDONESIA

Phone: 62-21-57952112 / Fax: 62-21-57952116

Bandung, Indonesia (Sub Venue)

Bandung Institute of Technology

Jl. Tamansari 64 Bandung 40116, Indonesia

Computer Lab (Com Lab) Building

Tel: +62-22-2500-935

Map: attached

Contact person: Ms. Harukunti (harkunti@kppmb.itb.ac.id)

Yogyakarta, Indonesia (Sub Venue)

Gadjah Mada University

Address: Bulaksumur, Yogyakarta, 55281, Indonesia

Tel: +62-274-562011, 588688

Website: http://www.ugm.ac.id

Contact Person: Mr. Bambang Nurcahyo Prastowo

(E-mail:prastowo@ugm.ac.id)

Workshop <Local time> March 23 14:00 - 19:00

Kathmandu, Nepal (Sub Venue)

JICA NEPAL OFFICE

Block B, Karmachari Sanchaya Kosh Building, Hariharbhavan, Lalitpur, NEPAL (P. O. Box 450, Kathmandu, NEPAL)

Phone: +977-1-5010310 / Fax: +977-1-5010284

Workshop <Local time> March 23 12:45 - 17:45

Islamabad, Pakistan (Sub Venue)

JICA Pakistan Office

Address: COMSATS Building, 3rd Floor, Shahrah-e-Jamhuriat, G-5/2, Islamabad, Pakistan

Tel: +92-51-2829473-8

Map: attached

Contact Person: Mr. Nobuhiro KAWATANI

(E-mail: Kawatani.Nobuhiro@jica.go.jp)

Peshawar, Pakistan (Sub Venue)

North West Frontier Province (NWFP) University of Engineering and Technology Peshawar

Peshawar University Campus Road No. 2 (P.O.Box 814)

Peshawar, Pakistan

Tel: +92-521-842173 Map: attached

Contact Person: Dr. M. Inayatullah Babar (babar@nwfpuet.edu.pk)

Tel: +92- Ph ++92-3219076151/++92-3219122761

Workshop <Local time> March 23 12:00 - 17:00

Istanbul, Turkey (Sub Venue)

Bilgi University Istanbul, Turkey

Contact person: Mr. Akif SINMAZ (E-mail: akifs@bilgi.edu.tr)

Tel: +90-212-311-5201

Ankara, Turkey (Sub Venue)

JICA Turkey Office
Ugur Mumcu Caddesi, 88/6 B Block
Gaziosmanpasa 06700, Ankara, Turkey
Mailing Address: P.K. 117, Kavaklidere 06692, Ankara, Turkey
Tel: + 90-312-447 2530-31-32　Fax: +90-312-447 2534
Map: attached

Workshop <Local time>　March 23 9:00 – 14:00

5. Agenda

March 23 16:00 – 21:00 Japan time

Session /time	Title of presentation	Presenters/facilitator	
16:00	Confirmation of connection of the venues, inauguration	Dr. Tatsuo Narafu	Senior Coordinator for International Cooperation, Building Research Institute (BRI)
16:10	Summary of shaking table experiments on confined masonry in July 2008 in Tsukuba	Dr. Toshikazu Hanazato	Professor, Mie University
16:30	Summary of shaking table experiments on confined masonry in December 2008 in Lima, Peru	Dr. Chikahiro Minowa	Senior Expert, National Research Institute for Earth Science and Disaster Prevention (NIED)
16:50	Introduction of LED image measurement and summary of its application to the shaking table experiments t	Dr. Yasushi Niitsu	Professor, Tokyo Denki University
17:10	Q&A, discussion		
17:25	Report on confined masonry structures in Nepal	Jishnu Subedi	Associate Professor, Nepal Engineering College (nec)
17:40	Report on confined masonry structures in Pakistan	Dr. Qaisar Ali	Professor, NWFP University of Engineering and Technology Peshawar
17:55	Report on confined masonry structures in Turkey	(Tentative) Dr. Ahmet Turer	Associate Professor, Middle East Technical University (METU)
18:10	Construction practice of confined masonry structures in Peru<Report of monitoring survey of construction sites>	Ms. Shizuko Matsuzaki	Ex-Volunteers Association for Architects (EVAA)

18:25	Q&A, discussion		
18:35	break		
18:50	Construction practice of confined masonry structures in Indonesia <Report of monitoring survey of construction sites>	Ms. Keiko Sakoda	Ex-Volunteers Association for Architects (EVAA)
19:05	Proposal of practical design/technology of safer confined masonry structures	Mr. Hiroshi Imai	Research specialist, Building Research Institute (BRI)
19:25	Summary of cyclic loading experiments on confined masonry in Bandung, Indonesia	Ms. Wahyu Wuryanti	Researcher, Research Institute of Human Settlements (RIHS)
19:45	Quick report of analysis of cyclic loading experiments on confined masonry in Bandung, Indonesia	Ms. Dyah Kusumasututi	Bandung Institute of Technology (ITB)
20:05	Comments on cyclic loading experiments in Bandung	Mr. Kazushi Shirakawa	JICA Ling Term Expert in Indonesia
20:20	Summary of cyclic loading experiments on confined masonry in Gadjah Mada University, Indonesia	Mr. Iman Satyarno	Lecturer, Gadjah Mada University (UGM)
20:35	Q&A, discussion		
20:50	Summary of Collaborative R&D Project and next steps forward	Dr. Yuji Ishiyama	Chair person of Management Committee of R&D Project, Professor Emeritus, Hokkaido University
21:00	Closing		

6. Language

English/Japanese (simultaneous translation)

7. Web streaming service

The organizers will provide web streaming services so that people in remote areas also could join Workshop through internet services with his/her own PC. Peoples, who would like to participate in WS by web streaming services, please register in the same way as actual venues according to the instruction in Item 9. The address of web site will be informed several days before WS.

8. Registration for participation

Registration for participation to Workshop should be made by sending Registration Form by e-mail or facsimile to Building Research Institute at following addresses before January 18, 2009.

E-mail address: cm-tokyo-2009@kenken.go.jp
Facsimile: +81-29-864-2989
Telephone: +81-29-864-6641 (Ms. Arakane or Mr. Imai)

9. Attached Materials

Registration Form and Example

Location Maps: Main Venue (Tokyo Development Learning Center)
Sub Venue in Japan (Building Research Institute)
Sub Venues in Indonesia (JICA Indonesia Office, Bandung Institute of Technology)
Sub Venue in Nepal (JICA Nepal Office)
Sub Venues in Pakistan (JICA Pakistan Office, North West Frontier Province (NWFP) University of Engineering and Technology Peshawar)
Sub Venue in Turkey (JICA Turkey Office)

Registration Form

International Video Workshop 2009 on Safer Housing focusing on Confined Masonry Structures

1. Title Dr. Mr. Ms. Others ( )
2. Family name
3. First Name
4. Institution
5. Department, divisions
6. Contact e-mail address
7. Contact Postal Address
8. Contact Number of Telephone and Facsimile
9. City, postal code and Country
10. Choose your participation mode (venue or web streaming) by deleting unnecessary words

*participation at the venue of (Tokyo, Tsukuba, Jakarta, Bandung, Yogyakarta, Kathmandu, Islamabad, Peshawar, Istanbul or Ankara)

*WEB Streaming Services

E-mail address: tokyo-2009@kenken.go.jp
Facsimile: +81-29-864-2989
Telephone: +81-29-864-6641 (Ms. Arakane or Mr. Imai)

Example

Registration Form

International Video Workshop 2009 on Safer Housing focusing on Confined Masonry Structures

1. Title Dr.

2. Family name Kenken

3. First Name Ichiro

4. Institution Building Research Institute (BRI)

5. Department, divisions
   International Institute of Seismology and Earthquake Engineering (IISEE)

6. Contact e-mail address tokyo-2009@kenken.go.jp

7. Contact Postal Address 1 Tachihara, Tsukuba-city

8. Contact Number of Telephone and Facsimile
   Telephone: +81-29-864-6641, Facsimile: +81-29-864-2989

9. City, postal code and Country Tsukuba-city, 305-0802, Japan

10. Choose your participation mode (venue or web streaming) by deleting unnecessary words

*participation at the venue of (Tokyo,)

E-mail address:	tokyo-2009@kenken.go.jp
Facsimile:	+81-29-864-2989
Telephone:	+81-29-864-6641 (Ms. Arakane or Mr. Imai)

枠組み組積造の耐震性向上に関する国際ビデオワークショップの開催案内

＜振動台実験結果、壁体繰り返し加力実験結果、現地建設状況調査報告を中心に＞

１．趣旨

ノンエンジニアドとも呼ばれる庶民住宅についてはこれまで十分な工学的な研究開発が行われておらず、耐震化工法についても十分な成果は得られていない。こうしたことが、2008 年 5 月 12 日中国四川省地震をはじめとして毎年起こる甚大な地震被害に繋がっていると考えられる。

建築研究所は、その中でも世界中に広く一般的に見られる、枠組み組積造（レンガ壁の周囲を小さな断面の鉄筋コンクリート部材で囲った構造。コンファインドメーソンリーとも呼ばれている。）について、連携機関と協力しながら、下記のとおり実験、フィールド調査などを積み重ねて来ている。今般、これらの成果の共有とそれに基づく安全性向上方策について、世界各国の研究者、実務者と検討を行うためビデオワークショップを開催する。開発途上国の防災に関心をお持ちの諸兄の参加を期待している。

＊　枠組み組積造に関するこれまでの主要な取り組み

・　振動台実験：2008 年 7 月つくば市防災科学技術研究所振動台実験（1 体）

2008 年 12 月ペルーカトリカ大学振動台実験（3 体）

2008 年 7 月防災科学技術研究所における振動台実験

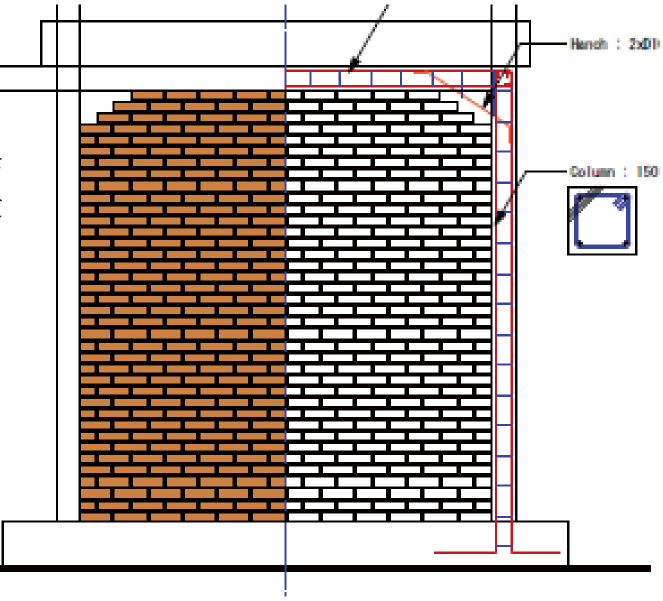
・　壁体試験体の繰り返し加力実験：

2009 年 2 月インドネシア、バンドン市において、バンドン工科大学により、公共事業省人間居住研究所の実験施設を使用して実施（9 体）

＜試験体の例＞

破断することの多い梁と柱の接合部を

補強する提案を検証するための試験体



・日本人技術者による、現地の職人による建設作業の実態把握のための現地モニタリング調査：

2007 年度において、インドネシア及びペルーの事例について実施（各 3 ヶ月間）

インドネシアにおけるノンエンジニアド住宅の建設の状況

＊　これまでの庶民住宅の地震被害軽減の研究の概略

建築研究所では、2005 年度より開発途上国の庶民住宅の地震被害軽減のための研究に取り組み、2006 年度からは文部科学省科学技術振興調整費を得て、防災科学技術研究所、三重大学、政策研究大学院大学をはじめとする多くの研究者の参加を得てこの課題に取り組んできている。その流れの中で、節目毎に国際ビデオワークショップを開催（概要は、下記ホームページ参照）するとともに、2008 年 11 月には、連携機関との共催により 2 日間の国際シンポジウムを開催した。

http://www.kenken.go.jp./japanese/information/information/event/ws2008/index-j.htm

http://www.kenken.go.jp./japanese/information/information/event/tokyo-2008/index-j.htm

http://www.kenken.go.jp./japanese/information/information/event/tokyo-2006/index.htm

http://www.kenken.go.jp./japanese/information/information/event/tokyo-2007/index.htm

２．日時　　2009 年 3 月 23 日（月）午後 4 時～9 時（日本時間）

３．主催者等　　建築研究所

協力：防災科学技術研究所、三重大学、政策研究大学院大学、
国連地域開発センター（ＵＮＣＲＤ）、国際協力機構（JICA）
世界銀行東京開発ラーニングセンター（ＴＤＬＣ）
国連国際防災戦略事務局（UN/ISDR）
国連教育科学文化機関（UNESCO）

４．会場

下記の５ヶ国を世界銀行グロバール・ディスタンス・ラーニング・ネットワークのビデオ会議システムで繋いで実施する。

主会場：世界銀行東京開発ラーニングセンター（東京都千代田区内幸町、富国生命ビル）
＜別添地図参照＞

サブ会場（予定）

国内サブ会場：建築研究所（つくば市）

海外サブ会場：インドネシア（ジャカルタ、バンドン、ジョグジャカルタ）
ネパール（カトマンズ）
パキスタン（イスラマバード、ペシャワール）
トルコ（イスタンブール、アンカラ）

５．ウエブ・ストリーミング・サービス

世界各地からのインターネット接続により、ワークショップの視聴が可能です。
希望される方は、下記 10 により**申し込み登録**してください。**開催日の数日前**に、メールにて**アドレスを連絡**させていただきます。

６．議事次第（案）　　時刻（説明時間＋Q&A）　　　進行：建築研究所　楢府龍雄

16:00(10)　接続状況確認、開会（趣旨、次第確認）　　建築研究所　楢府龍雄

16:10(20)　2008 年 7 月振動台実験（つくば市　防災科学技術研究所）結果の概要
三重大学　花里利一

16:30(20)　2009 年 12 月震動台実験（ペルー　カトリカ大学振動台）結果の概要
防災科学技術研究所　箕輪親宏

16:50(20)　振動台実験の画像計測手法の概要と計測結果の概要
東京電機大学　新津靖

17:10（15）　意見交換

17:25(15)　ネパールにおける枠組み組積造について
ネパール工科大学　ジシュヌ・スベディ

17:40(15)　パキスタンにおける枠組み組積造について
ペシャワール工科大学　カイザル・アリ

17:55(15)　トルコにおける枠組み組積造について
（予定）中東工科大学　アフメッド・トゥレー

18:10(15)　ペルーにおける枠組み組積造の建設の実態（現地モニタリング報告）
NPO 法人都市計画・建築関連 OV の会(EVAA)　松崎志津子

18:25(10)　意見交換

18:35(15))　休憩

18:50(15)　インドネシアにおける枠組み組積造の建設の実態（現地モニタリング報告）
NPO 法人都市計画・建築関連 OV の会(EVAA)　迫田恵子

19:05(20)　枠組み組積造の実践的な耐震性向上のための提案　　建築研究所　今井弘

19:25（20）　枠組み組積造壁体の繰り返し加力実験結果（インドネシア　公共事業省人居住研究所）の概要　公共事業省人間居住研究所　ワヒュー・ウルヤンティ

19:45(20)　枠組み組積造壁体の繰り返し加力実験結果の解析の概要
バンドン工科大学　ディア・クスマストゥティ

20:05(15)　枠組み組積造壁体の繰り返し加力実験についての考察
在インドネシア JICA 長期専門家　白川和司

20:20(15)　ガジャマダ大学で実施した枠組み組積造壁体の繰り返し加力実験の概要
ガジャマダ大学　イマン・サトヤルノ

20:35(15)　意見交換

20:50(10)　科学技術振興調整費の研究開発活動とその展開
北海道大学名誉教授・研究運営委員会委員長　石山祐二

21:00　閉会

６．言語

日本語及び英語（日英の同時通訳を行います）

７．その他

東京主会場では飲み物、スナックを用意します。

８．参加の登録

参加を希望する方は、下記により、本案内に添付されている**登録票をメール又はファックス**により建築研究所に**2009 年３月 16 日(月)**まで送付し、参加登録をお願いします。

メールアドレス：tokyo-2009@kenken.go.jp
ファックス：　029-864-2989
＜問い合わせ：　029-864-6641 (荒金又は今井)＞

９．　添付資料

・参加登録票
・　主会場地図（東京開発ラーニングセンター、建築研究所）、インドネシア副会場地図（JICA ジャカルタ事務所、バンドン工科大学）、ネパール副会場地図（JICA ネパール事務所）、パキスタン副会場地図（JICA パキスタン事務所、ペシャワール工科大学）、トルコ副会場地図（JICA トルコ事務所）

参加登録票 Registration Form

枠組み組積造の耐震性向上に関する国際ビデオワークショップ 2009

International Video Workshop 2009 on Safer Housing focusing on Confined Masonry Structures

11. 称号　　Dr.　Mr.　Ms.　Others (　　　　)

12. 苗字（英語併記）

13. 名（英語併記）

14. 所属機関（英語併記）

15. 所属部署（英語併記）

16. メールアドレス（確実に連絡できるもの）

17. 住所（確実に連絡できるもの）

18. 電話、ファックス番号（確実に連絡できるもの）

19. 都市名、郵便番号、国名

20. 参加希望　(参加のタイプ（会場又はｳｴﾌﾞ・ｽﾄﾘｰﾐﾝｸﾞ）、会場名の不要な文字を削除してください)

(ア)会場での参加

日本：	東京	つくば	
インドネシア：	ジャカルタ	バンドン	ジョクジャカルタ
ネパール：	カトマンズ		
パキスタン：	イスラマバード	ペシャワール	
トルコ：	イスタンブール	アンカラ	

○ウエブ・ストリーミング・サービスによる参加

E-mail address: tokyo-2009@kenken.go.jp
Facsimile:　029-864-2989　問い合わせ(電話):　029-864-6641 (荒金、今井)

参加登録票 Registration Form

枠組み組積造の耐震性向上に関する国際ビデオワークショップ 2009

International Video Workshop 2009 on Safer Housing focusing on Confined Masonry Structures

21.称号　Dr.

22.苗字（英語併記）　建研　（Kenken）

23.名（英語併記）　一郎　（Ichiro）

24.所属機関（英語併記）　建築研究所
Building Research Institute (BRI)

25.所属部署（英語併記）　国際地震工学センター
International Institute for Seismology and Earthquake Engineering (IISEE)

26.メールアドレス（確実に連絡できるもの）tokyo-2009@kenken.go.jp

27.住所（確実に連絡できるもの）　つくば市立原１番地

28.電話、ファックス番号（確実に連絡できるもの）
電話 029-864-6641　ファックス 029-864-2989

29.都市名、郵便番号、国名　つくば市、〒305-0802、　日本

30.参加希望　（参加のタイプ（会場又はｳｴﾌﾞ・ｽﾄﾘｰﾐﾝｸﾞ）、会場名の不要な文字を削除してください）

(ア)会場参加
日本：　東京

E-mail address: tokyo-2009@kenken.go.jp
Facsimile: 029-864-2989　問い合わせ(電話): 029-864-6641 (荒金、今井)

枠組み組積造の耐震性向上に関する国際ビデオワークショップ 2009
International Video Workshop 2009 on Safer Housing focusing on Confined Masonry Structures

2009（平成 21）年 3 月 23 日

March 23, 2009

開催場所 Venue：

世界銀行東京開発ラーニングセンターTokyo Development Learning Center (TDLC), The World Bank

住所 Address:

〒100-0011 東京都千代田区内幸町 2-2-2 富国生命ビル 10 階

10F, Fukokuseimei Bld., 2-2-2 Uchisaiwai-cho, Chiyoda-ku, Tokyo 100-0011

電話 Tel: 03-3597-6650（代表）

FAX: 03-3597-6695

交通 Transfortation

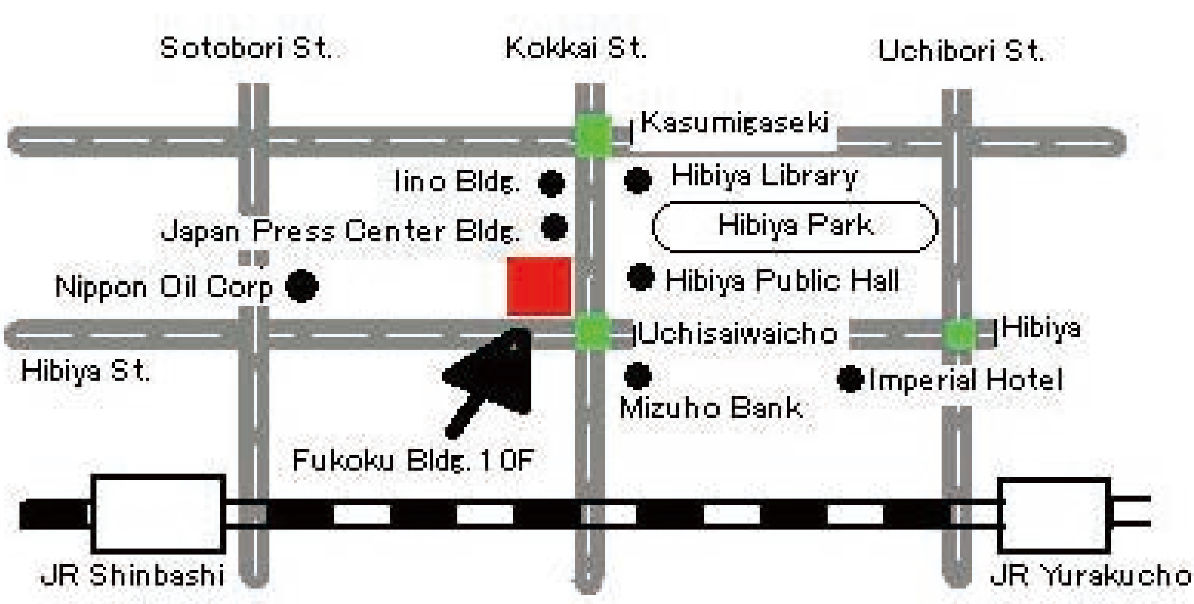
・JR 山手線、京浜東北線 新橋駅 日比谷口（JR Yamanote Line, Keihin Tohoku Line Shimbashi Station, Hibiya Exit）

・地下鉄 都営三田線 内幸町駅 A6 直結（Subway Toei Mita Line Uchisaiwaicho Station, Exit A6）

・地下鉄 千代田線 霞ヶ関駅 C4 出口（Subway Chiyoda Line Kasumigaseki, Exit C4）

・地下鉄 日比谷線 霞ヶ関駅 C4 出口（Subway Hibiya Line Kasumigaseki, Exit C4）

・地下鉄 丸の内線 霞ヶ関駅 B2 出口（Subway Marunouchi Line, Kasumigaseki, Exit B2）

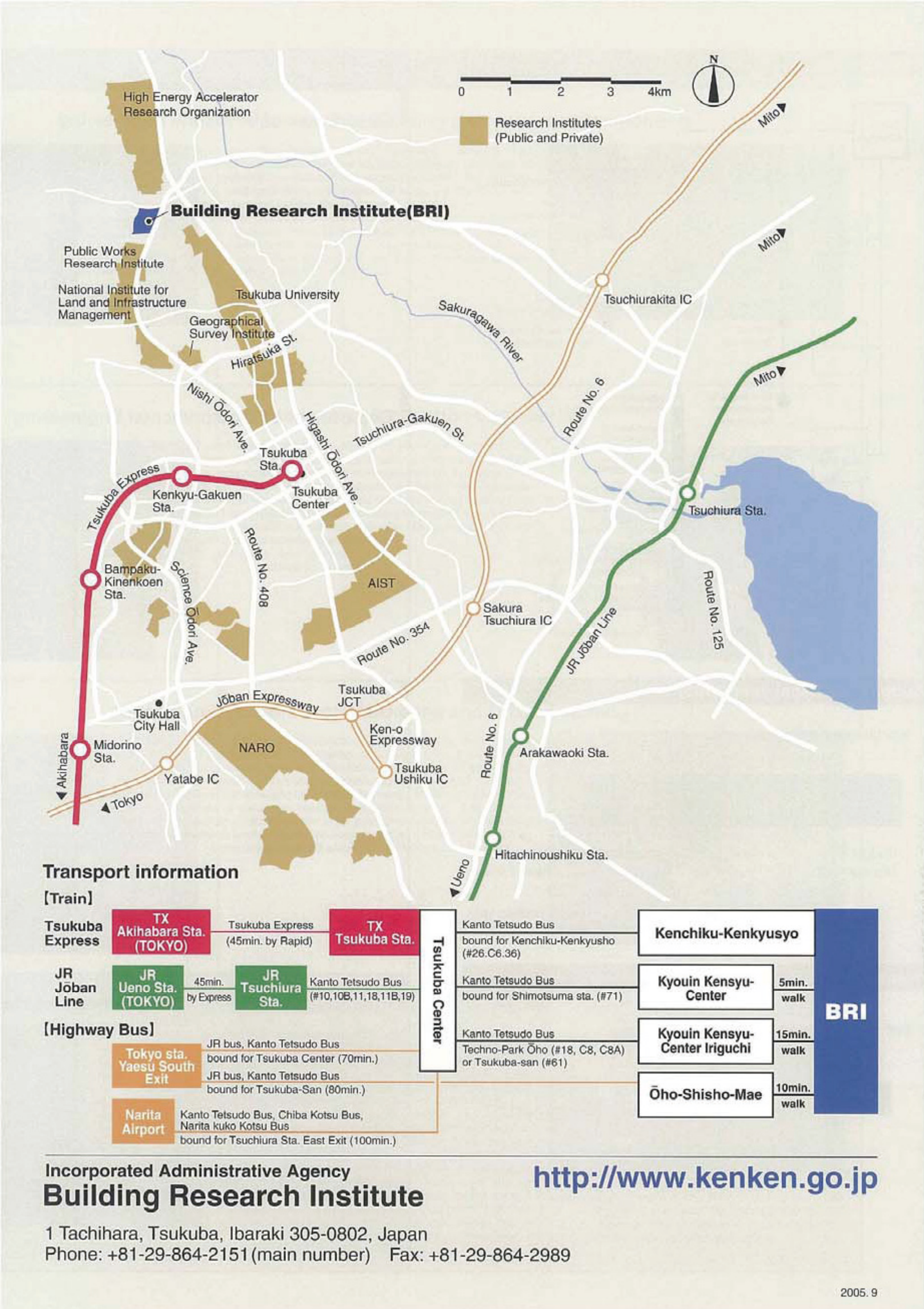


Building Research Institute (BRI)

1 Tachihara, Tsukuba city, Ibaraki, 305-0802

MapURL: http://www.kenken.go.jp./english/information/information/transport/access.html

Contact person: Taiki Saito (tsaito@kenken.go.jp) Tel: +81-29-864-6751

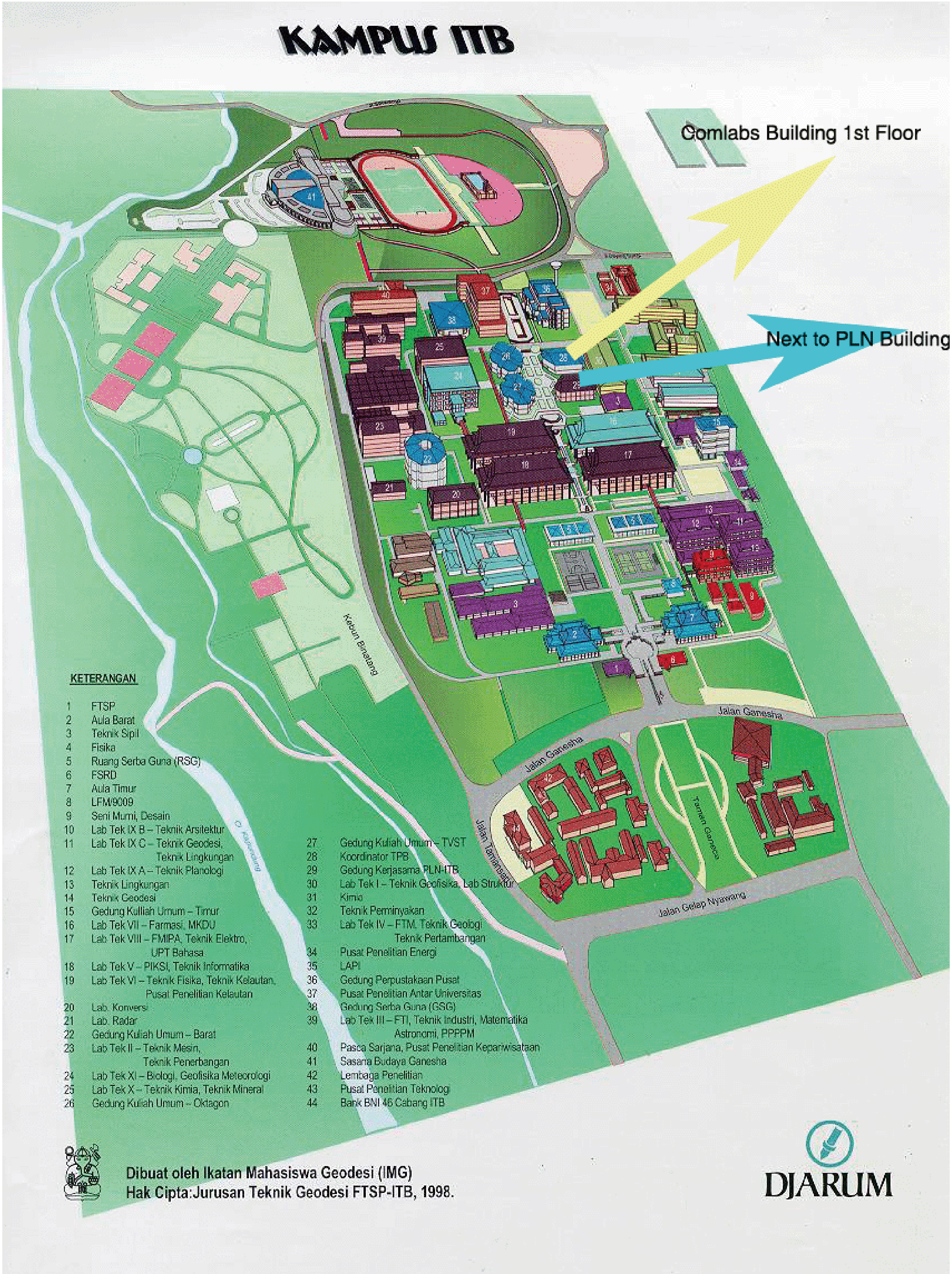


JICA INDONESIA OFFICE

SENTRAL SENAYAN II, 14th Floor, JI. Asia Afrika No. 8
Gelora Bung Karno-Senayan, Central Jakarta 10270 INDONESIA
Phone: 62-21-57952112 / Fax: 62-21-57952116

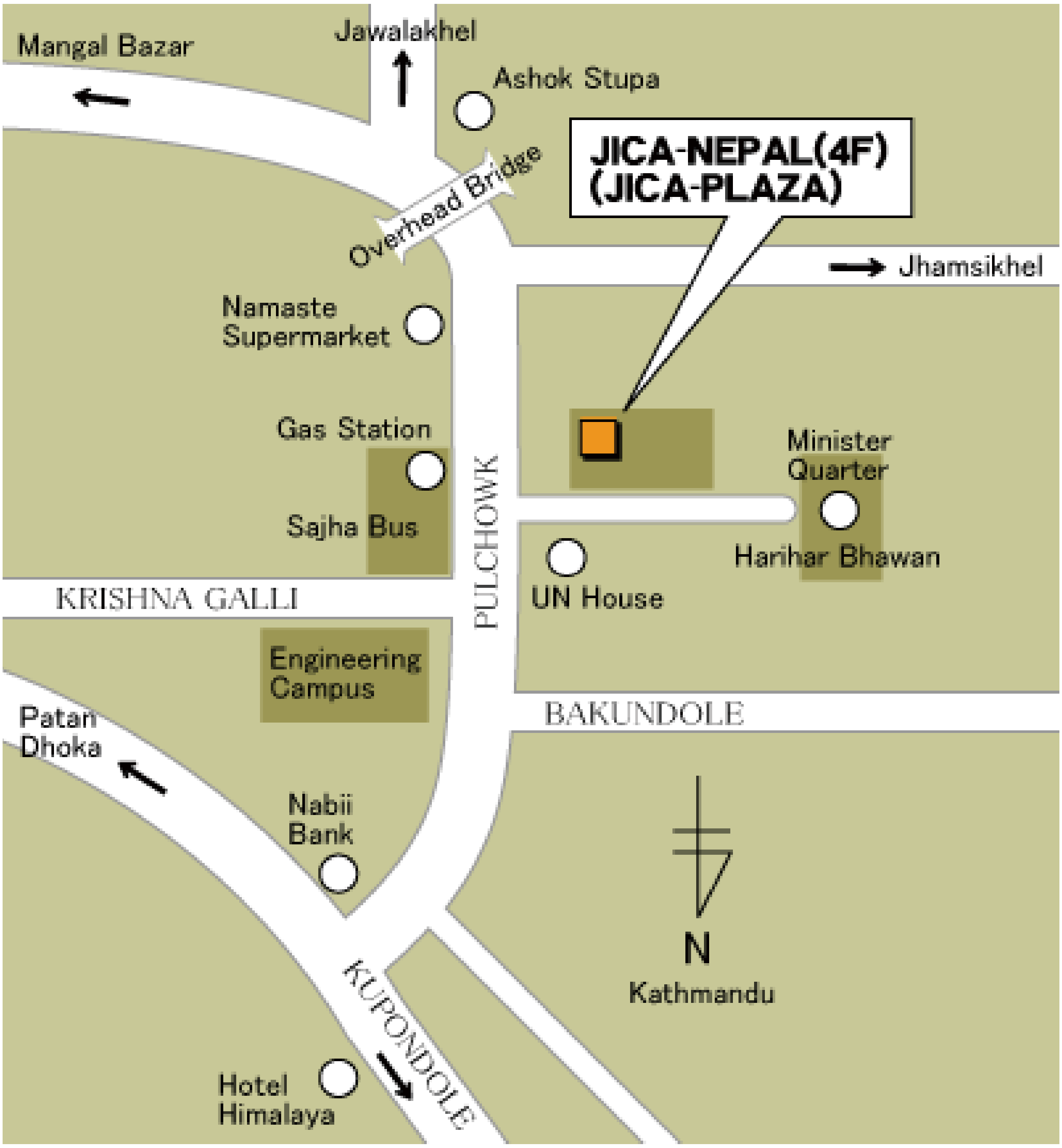
Location Map (Bandung Institute of Technology (ITB))

Jl. Tamansari 64 Bandung 40116, Indonesia
Computer Lab (Com Lab) Building
Tel: +62-22-2500-935



JICA　NEPAL OFFICE

Block B, Karmachari Sanchaya Kosh Building, Hariharbhavan, Lalitpur, NEPAL
(P. O. Box 450, Kathmandu, NEPAL)
Phone: +977-1-5010310　/　Fax: +977-1-5010284



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Contact Person: Mr. Nobuhiro KAWATANI
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North West Frontier Province (NWFP) University of Engineering and Technology Peshwar

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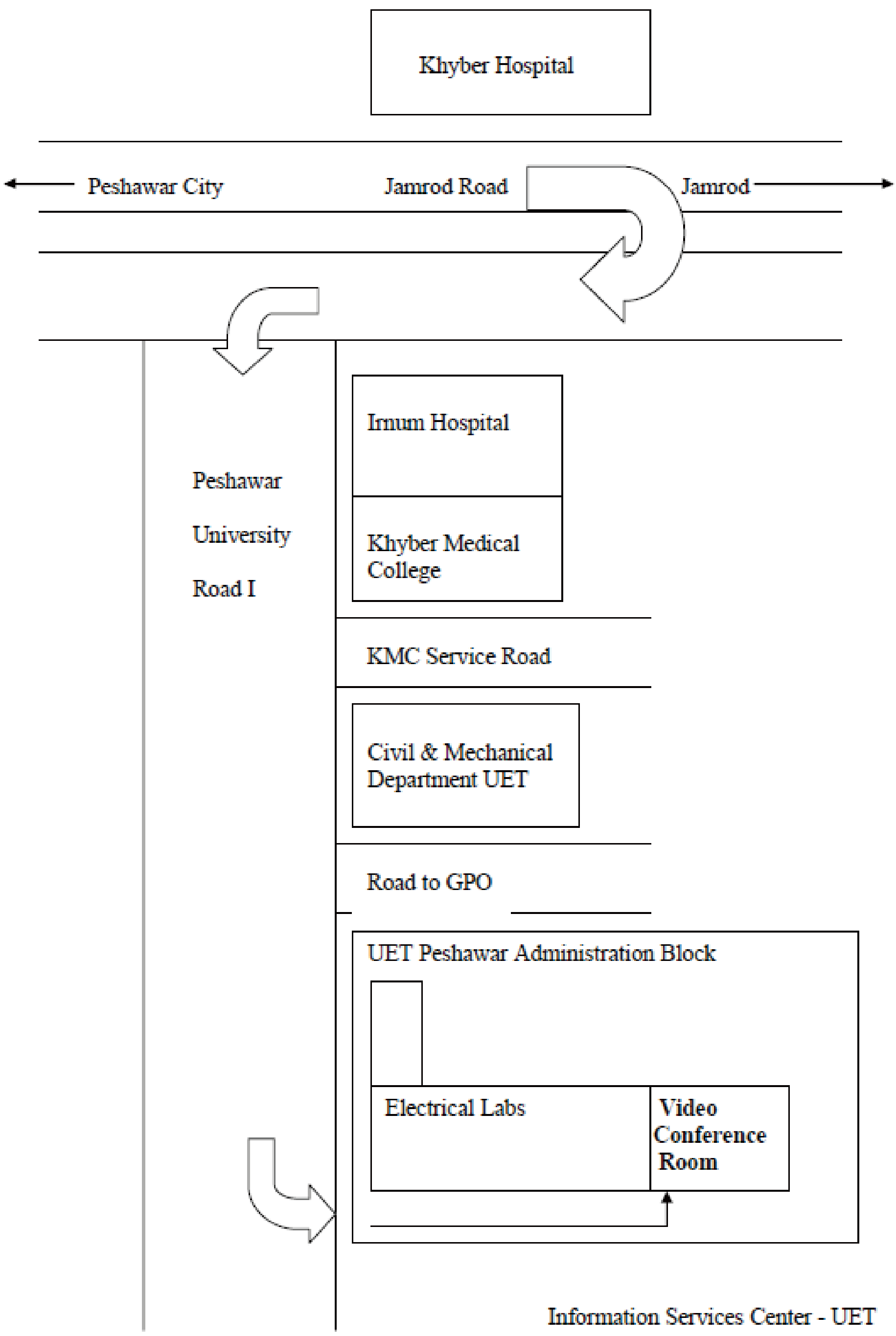
Tel: +92-521-842173
Contact Person: Dr. M. Inayatullah Babar (babar@nwfpuet.edu.pk)
Tel: +92- Ph ++92-3219076151/++92-3219122761

NWFP University of Engineering & Technology, Peshawar – Video Conferencing Room Map



JICA Turkey Office

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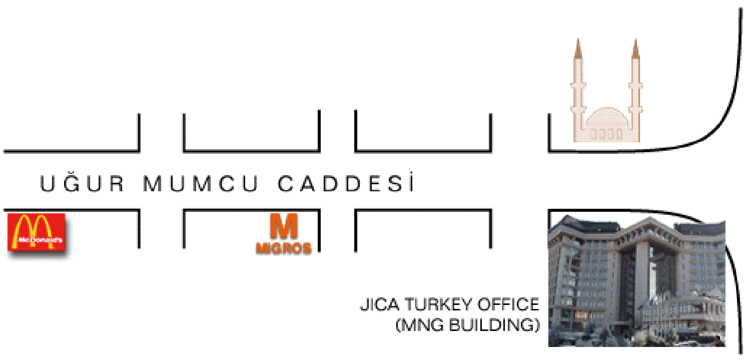

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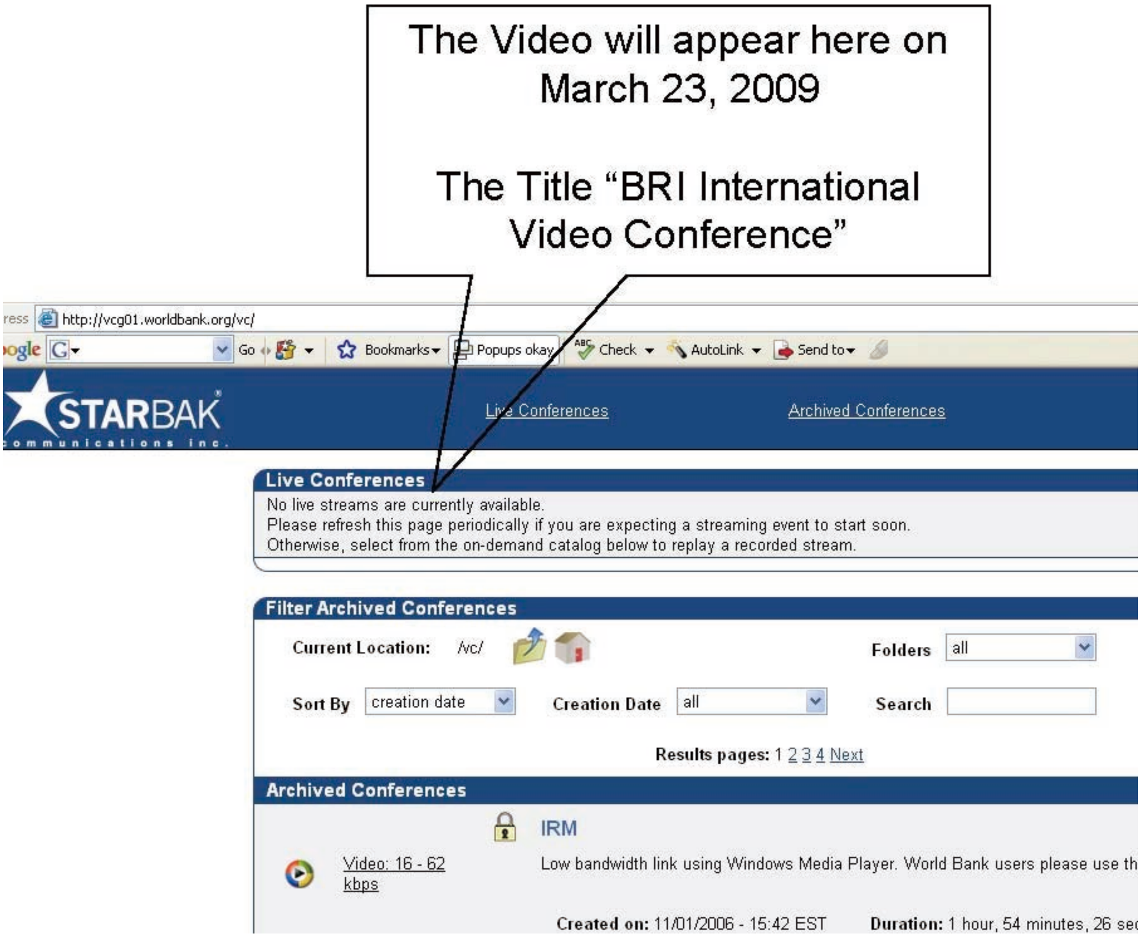

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