Thematic International Workshop 2007
on Feasible and Affordable Seismic Constructions

Introduction

Simplified Evaluation Method Based on Wall Ratio

Date: July 18(WED), 2007

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Objective

The safety of the non-engineered buildings from earthquakes is a highest priority subject, as you know most loss of life during earthquakes have occurred due to their collapse.

The simple evaluation method that as possible many people have is necessary.

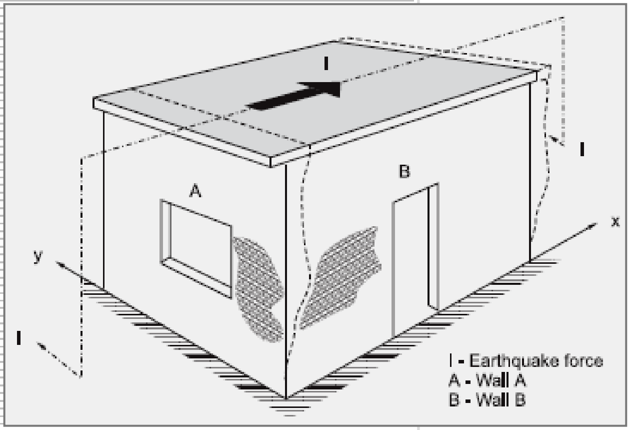
We propose **INITIAL EVALUATION METHOD** for masonry buildings.

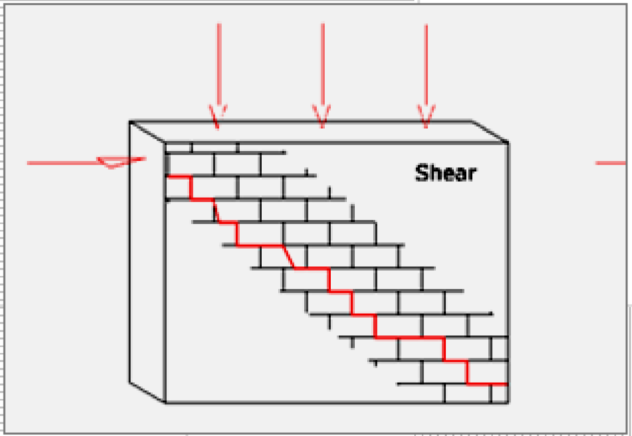
Seismic performance evaluation design method for Existing buildings and New buildings

INITIAL EVALUATION METHOD

One of parameter for masonry structure is **Wall ratio** of building.

Load bearing walls as shear walls are the main lateral earthquake resistant element in masonry buildings.



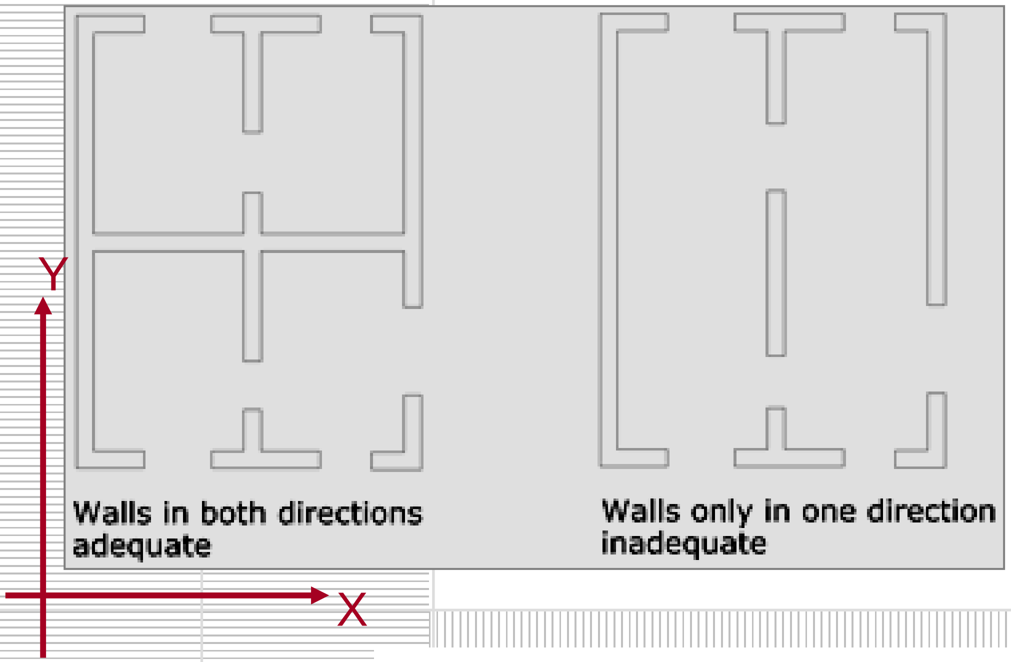


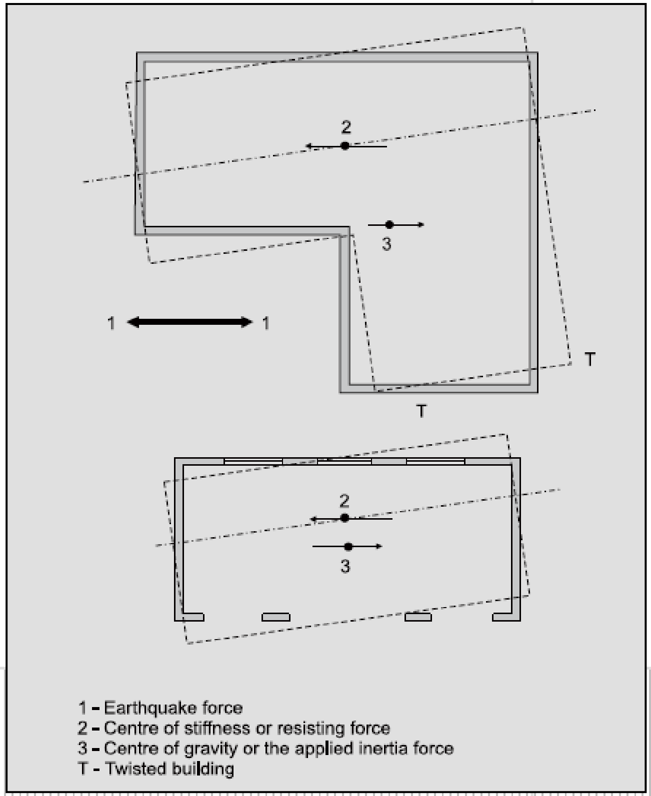
WALL DISTRIBUTION IN PLAN

Criteria, Guideline

Load bearing walls of masonry buildings should be arranged in Plan.

Load bearing wall should be symmetrical and good balance of density along each principal **X-Y** axis in plan, for both stiffness and mass distribution, should be provided in **X-Y** principal direction.





Torsion of unsymmetrical plans

Existing Evaluation Method base on Wall Ratio

CRITERIA FOR SEISMIC RESISTANT DESIGN IN PAKISTAN

5.3.3 Minimum Total Length of Load-Bearing Walls

The ratio of the total length of masonry load-bearing walls in each of the orthogonal directions in plan (excluding openings), to gross floor area shall not be less than (0.25I)m/m2.

I : Importance Factor

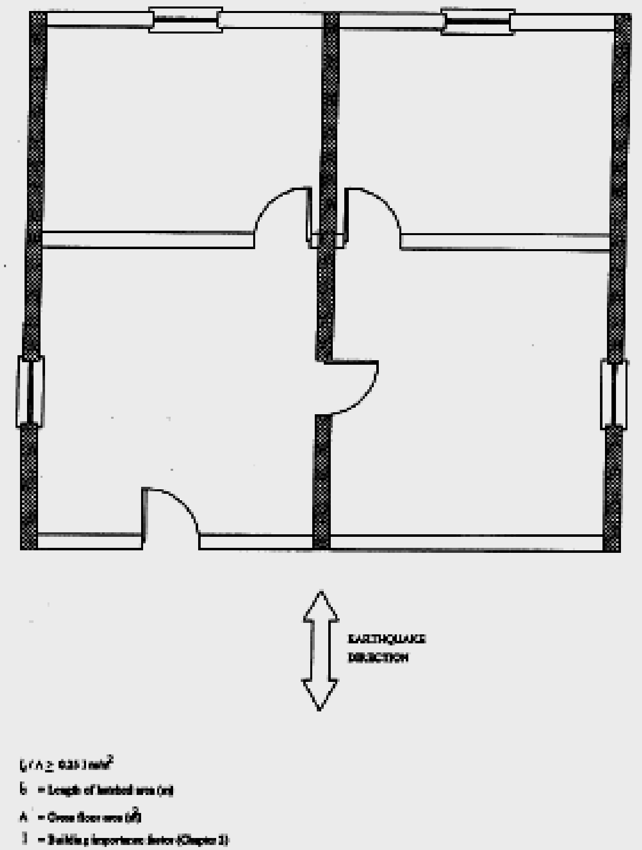


Figure 5-1

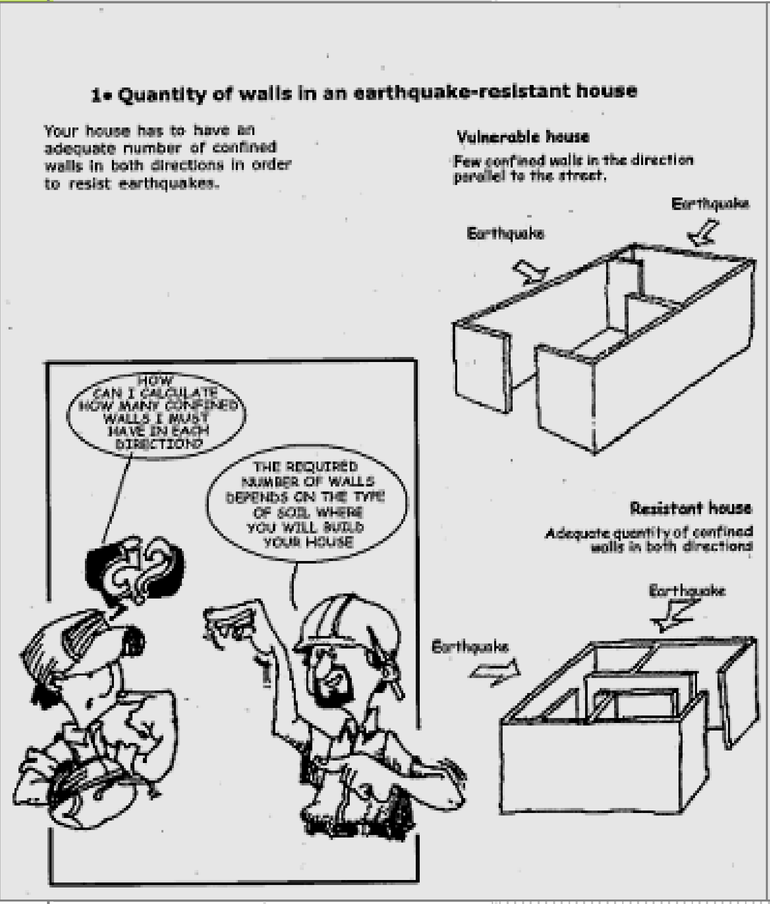
0.25m/m2 x 0.23m(wall thickness) = 0.0575 = 5.75%

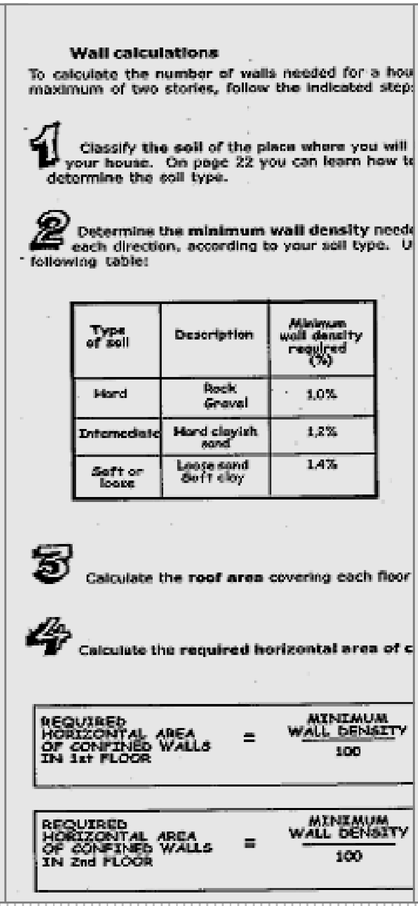
Existing Evaluation Method base on Wall Ratio

Exsample2

CONSTRUCTION AND MAINTENANCE OF MASONRY HOUSES / SENCICO, EERI in PERU

Quantity of walls in an EQ-resistant house





Wall calculations

To calculate the number of walls needed for a hou… maximum of two stories, follow the indicated step…

1 Classify the soil of the place where you will … your house. On page 22 you can learn how t… determine the soil type.

2 Determine the minimum wall density neede… each direction, according to your soil type. U… following table:

Type of soil	Description	Minimum wall density required (%)
Hard	Rock Gravel	1.0%
Intermediate	Hard clayish sand	1.2%
Soft or loose	Loose sand Soft clay	1.4%

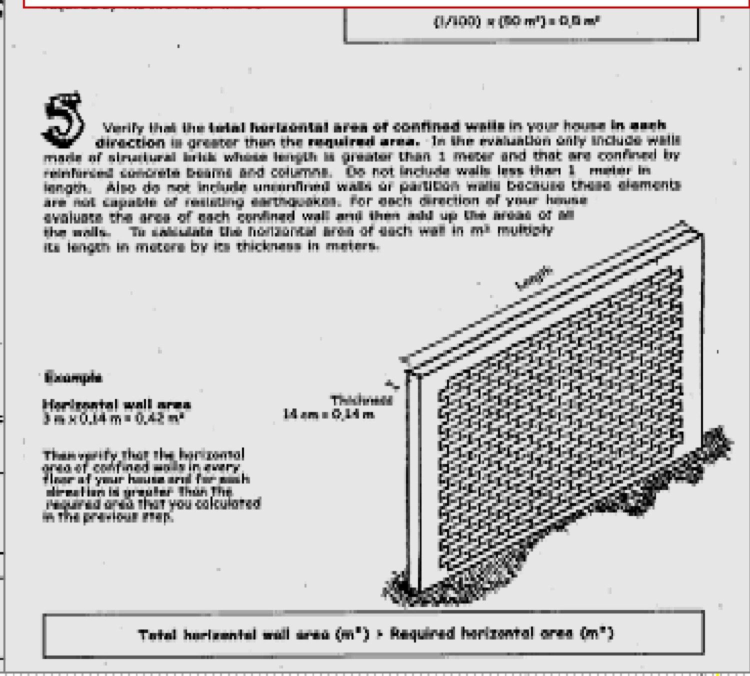
3 Calculate the roof area covering each floor

4 Calculate the required horizontal area of c…

REQUIRED HORIZONTAL AREA OF CONFINED WALLS IN 1st FLOOR = MINIMUM WALL DENSITY / 100

REQUIRED HORIZONTAL AREA OF CONFINED WALLS IN 2nd FLOOR = MINIMUM WALL DENSITY / 100

In the evaluation only include walls made of structural brick whose length is greater than 1 meter and that are confined by reinforced concrete beams and columns.



(1/100) x (80 m²) = 0,8 m²

5 Verify that the **total horizontal area of confined walls** in your house **in each direction** is greater than the **required area.** In the evaluation only include walls made of structural brick whose length is greater than 1 meter and that are confined by reinforced concrete beams and columns. Do not include walls less than 1 meter in length. Also do not include unconfined walls or partition walls because these elements are not capable of resisting earthquakes. For each direction of your house evaluate the area of each confined wall and then add up the areas of all the walls. To calculate the horizontal area of each wall in m² multiply its length in meters by its thickness in meters.

Example

Horizontal wall area
3 m x 0,14 m = 0,42 m²

Thickness
14 cm = 0,14 m

Length

Then verify that the horizontal area of confined walls in every floor of your house and for each direction is greater than the required area that you calculated in the previous step.

Total horizontal wall area (m²) > Required horizontal area (m²)

JAPANESE BUILDING CODE:Earthquake resistant Design for buildings 2001

Two-phase design (Ultimate Strength Design and Limit Stare Design) procedures are used for moderate and severe earthquake motions.

ULTIMATE STRENGTH

The calculations of ultimate strength are used to confirm safety against earthquake. **There are three calculation procedures (rules),** which vary according to differences in the building types.

Route 1 is used for relatively small buildings other than specified buildings. $H \leq 20m$

Route 2 is applied to specified buildings of 31m or less in height.

The aim of designs is to ensure safety against extremely large earthquakes by reducing stiffness distribution and eccentricity along the height, and by ensuring adequate levels of strength, stiffness and ductility using relatively simple concepts.

Route 3 represents the seismic calculation route for specified buildings over 31m.

The purpose is to assess the energy absorption capacity based on the elasto-plastic behavior (damping, ductility, etc) of the building during earthquakes, using a coefficient (Ds), and to ensure safety during extremely large earthquakes by providing sufficient energy absorption capacity that will exceed seismic energy inputs.

Route1 for RC structure

Equation

$$\sum 25Aw + \sum 7Ac \geq ZWAi$$

Shear strength of walls + Shear strength of columns *Required Seismic force*

Each direction X, Y

Aw = Total cross section area of walls (cm2)
Ac = Total cross section area of columns (cm2)
Z = Zone factor
W = Combination of Load (kgN/m2)
Ai = A value of a vertical distribution of seismic story shear coefficients in i-th story

$$\tau_w A_w + \tau_c A_c \geq ZWA_i$$

$$\tau_w A_w + \tau_c A_c \geq c_w \Sigma A_f$$

Shear strength of wall

Shear strength of column

$$\tau_w A_w + \tau_c A_c \geq c\, w \sum A_f$$

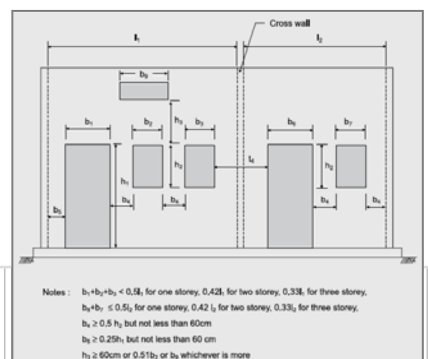
Base shear coefficient

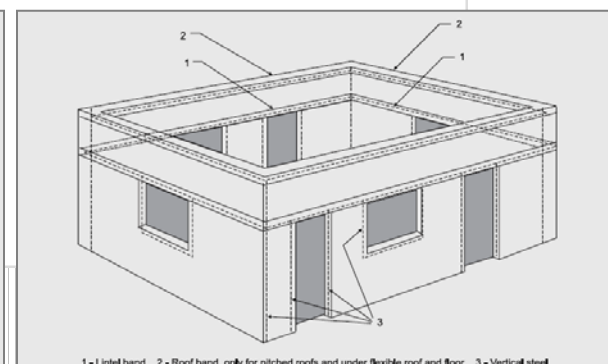
Weight per unit floor Area

Total Area of floor

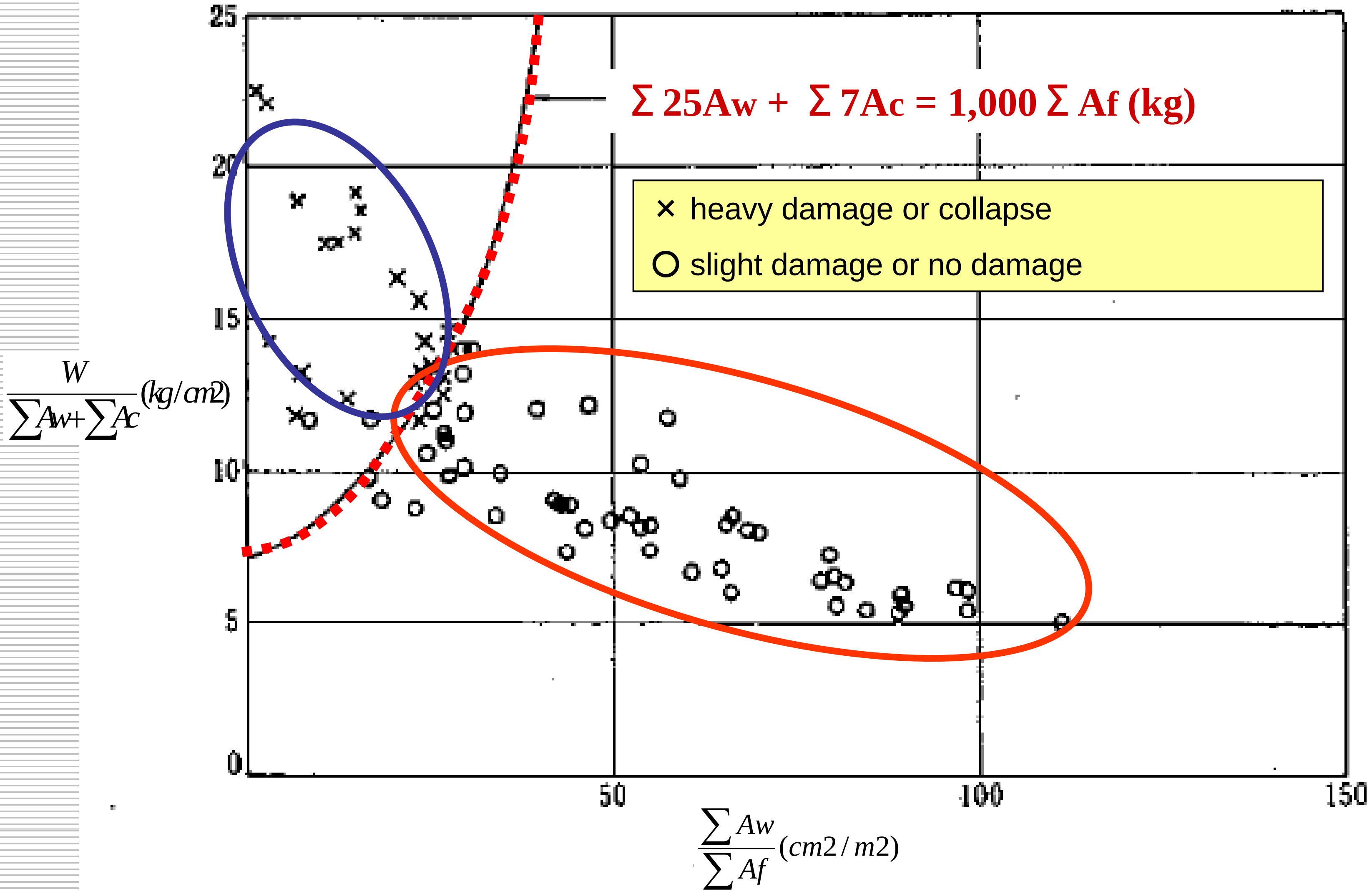
Consider about

- Seismic zone factor
- Importance factor
- Soil condition
- Type of buildings
- Irregular buildings
- Rigidity
- Balance of wall, etc,



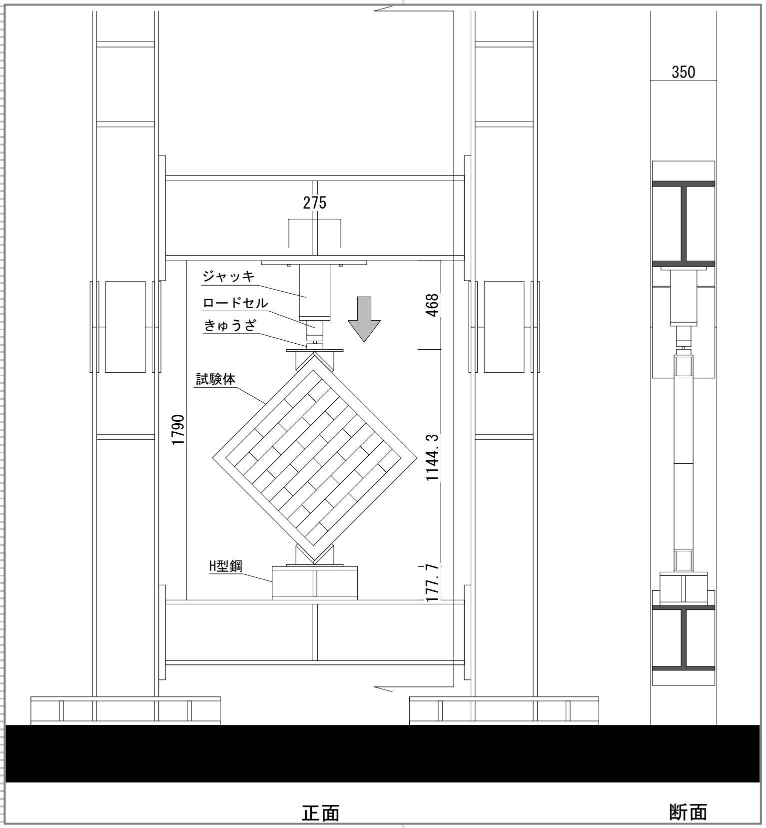


FIELD RESEARCH AFTER EARTHQUAKE

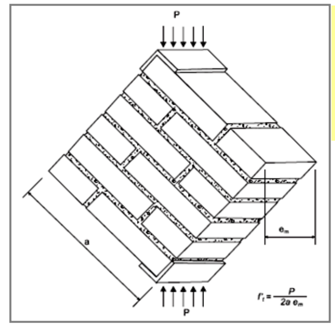


Relationship Route 1 to Field Research by Dr. Shiga after Miyagiken oki earthquake 1978

DIAGONAL COMPRESSION TEST



Drawn by MIE UNIVERSITY



To accumulate data of masonry
Each countries, Each methods

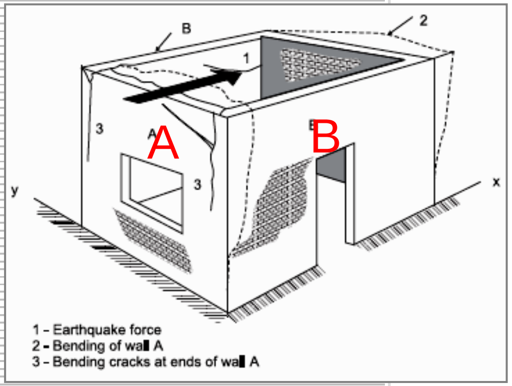
Compression strength → Shear strength

$$A_w \frac{f_t}{b}\sqrt{\frac{\sigma_o}{f_t}+1}$$

Source : Miha Tomazevic /
Earthquake-Resistant
Design of Masonry Buildings

Shaking table test

2007 Box type structure (Wall Enclosure with out Roof) on Shaking Table.



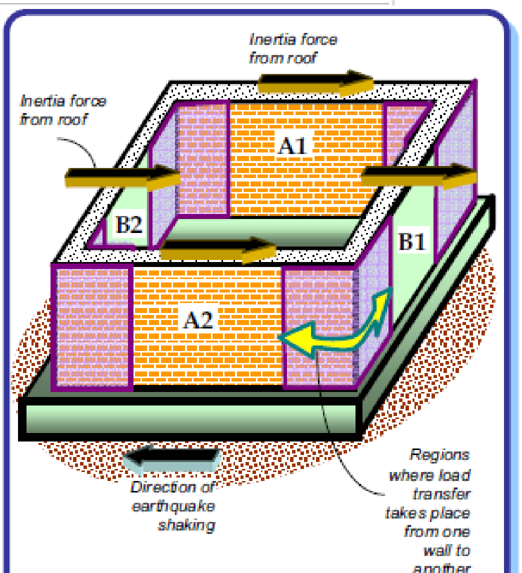


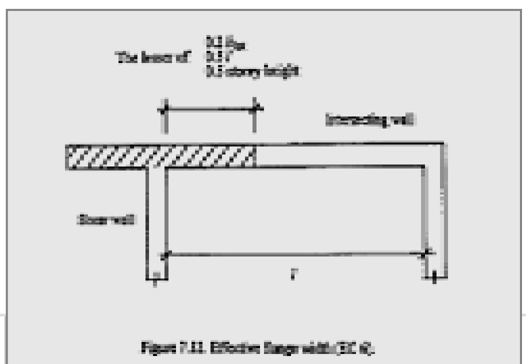
Figure 2: Regions of force transfer from weak walls to strong walls in a masonry building – *wall B1 pulls walls A1 and A2, while wall B2 pushes walls A1 and A2.*

EARTHQUAKE TIPS / IITK

Through the Shaking table experiment, It can be seen that in the action of walls B as shear walls, the walls A will act as flanges connected to the wall B acting as web.

Flanged Sections

The Walls transfer loads to each other at junctions (and through roof).
The walls of composite sections in plan, such as **L,T-shape and cross sections**, can be found in the buildings.
But, **it is very little experimental data is available regarding the seismic behavior of such walls.**



This flanged section are also effected to Out of Plain behavior.
But, large portion of wall not supported by cross wall should be limited by area.

In the future, the shear strength of brick walls should be investigated in more detail.

Through the R & D project, the Data of masonry structure will be accumulated.
Then, We hope to develop
"Simplified Evaluation Method that as possible many people have is necessary"