# An Example of Improving Earthquake Safety Project in South-east Asia

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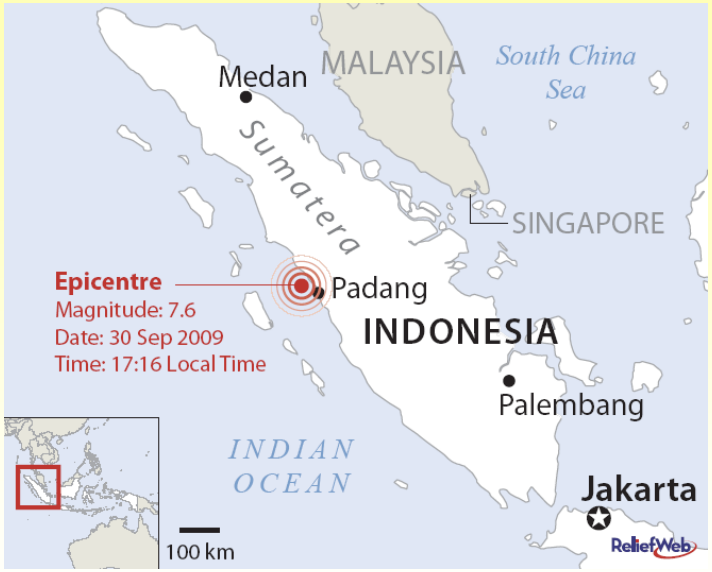
# Introduction

As members of EWBJ (Engineers without Border, Japan), Dr. Okoshi and I co-operated to the seismic-isolation building project of Padang city of Sumatra, Indonesia.

We reported the detail of this project at the US-Japan workshop two years ago.

From this experience, I report about seismic engineering issues of a less-developed country.




2009 Padang earthquake epicenter

# 1 Building structural characteristics in Padang

1. Reinforced concrete(RC) open frames without RC seismic wall

   Flexible structure and large deformation

2. Poor quality control of concrete construction

   Gravel including silt, rough concrete mixing method

3. Reinforcing bar arrangement

   No good detail of hoop/stirrup end

   Main bar irregular bending at column bottom

4. Slim rectangular RC column (One way frame)

   Rigid column/frame in plane direction

   Soft column/frame out of plane direction

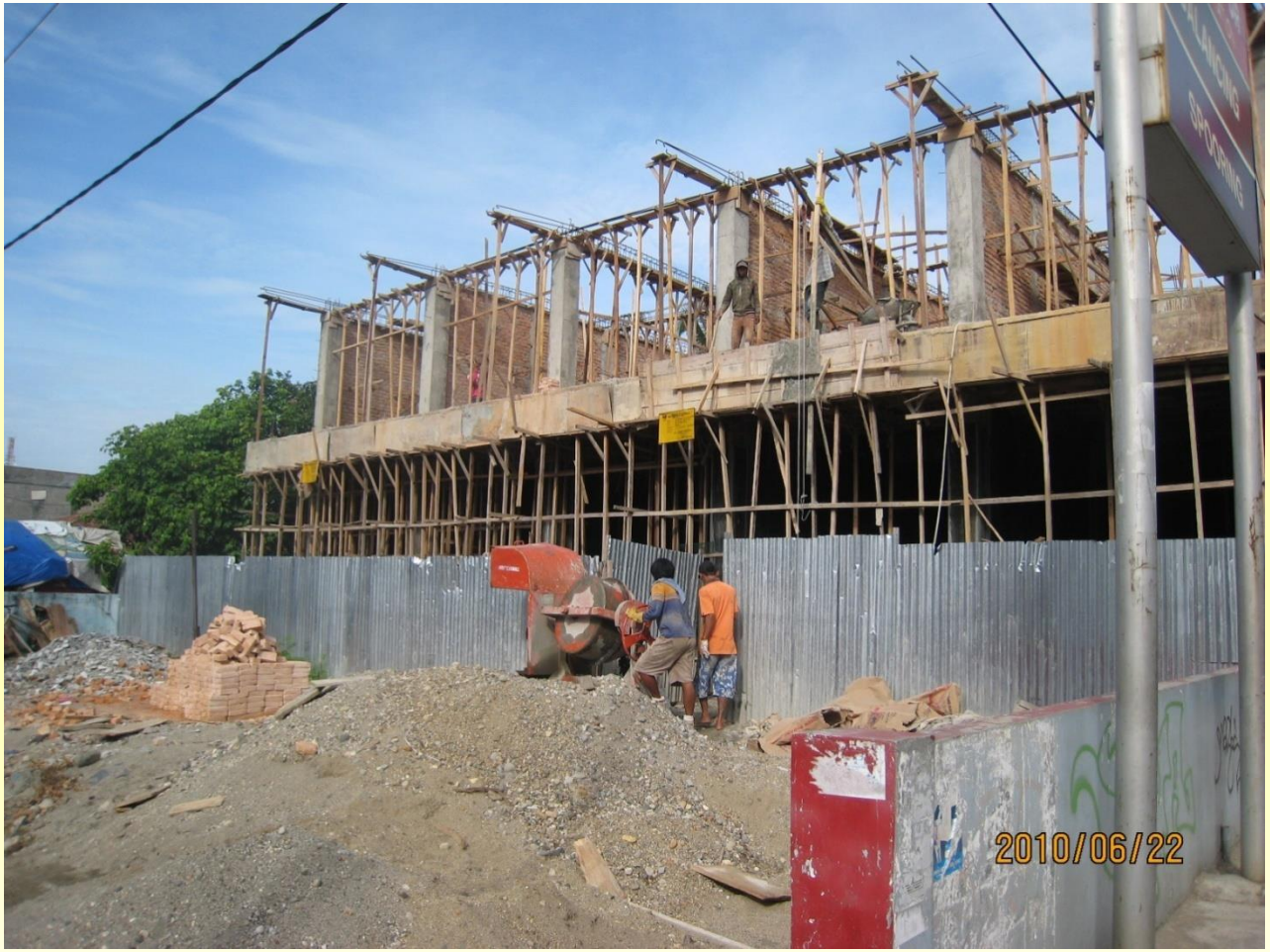
5. Not enough clearance of expansion joint

   Required clearance is satisfied ?

# Typical structural system of Padang

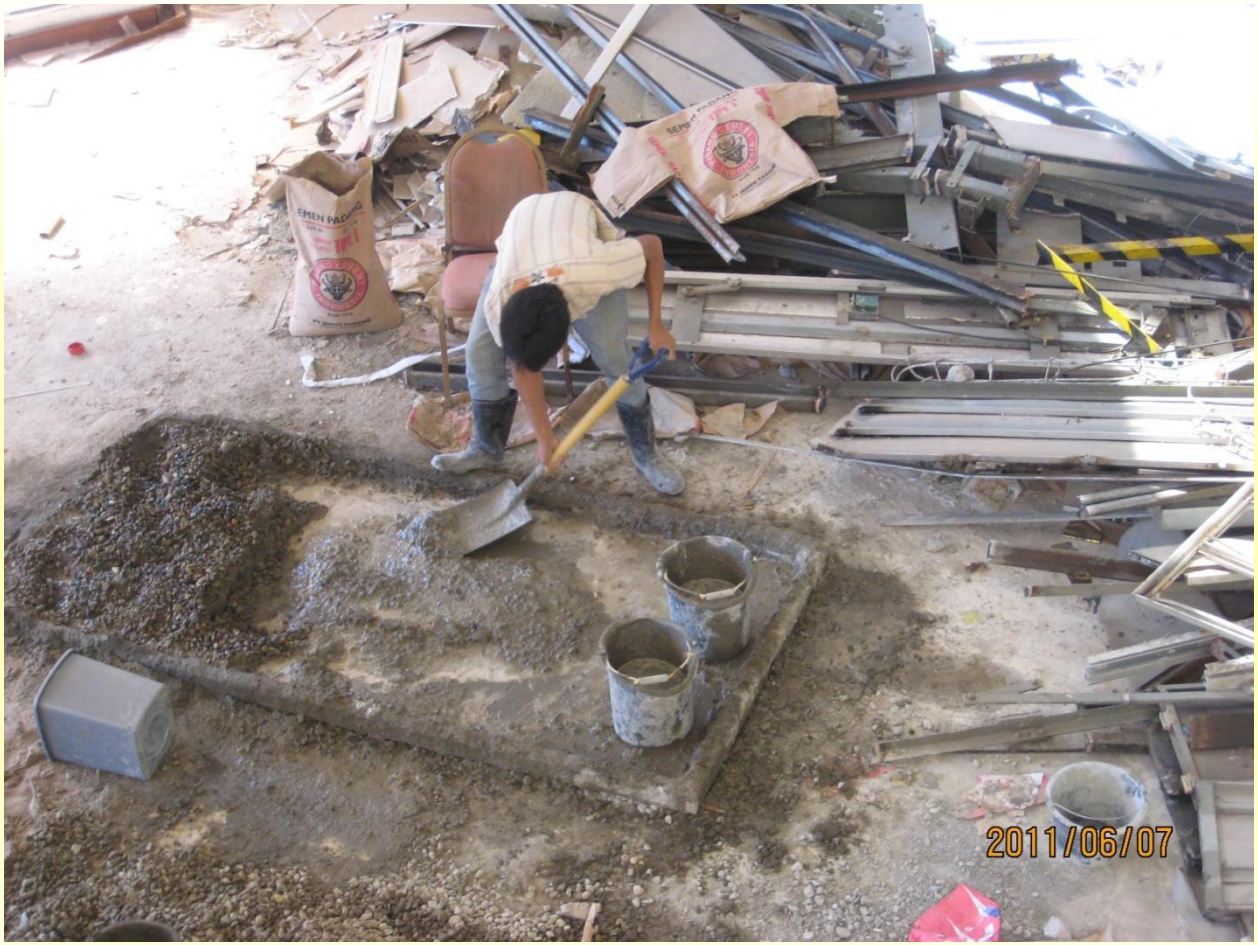

Reinforced concrete column/beam with non-structural brick wall

# Site concrete mixing by a local constructor




Aggregate materials are not good and the sand includes fine mad like silt. Concrete mixing cars are used only in the governmental buildings or big buildings.

# Site concrete mixing by hands




This construction site is the repair one of damaged hotel building.

The hand mixing may be chosen because of small casting concrete amount.

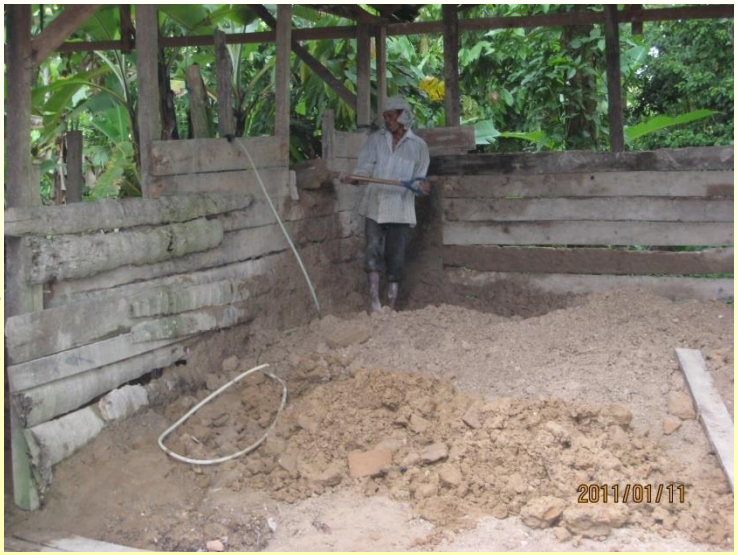
# Site fabrication of steel members

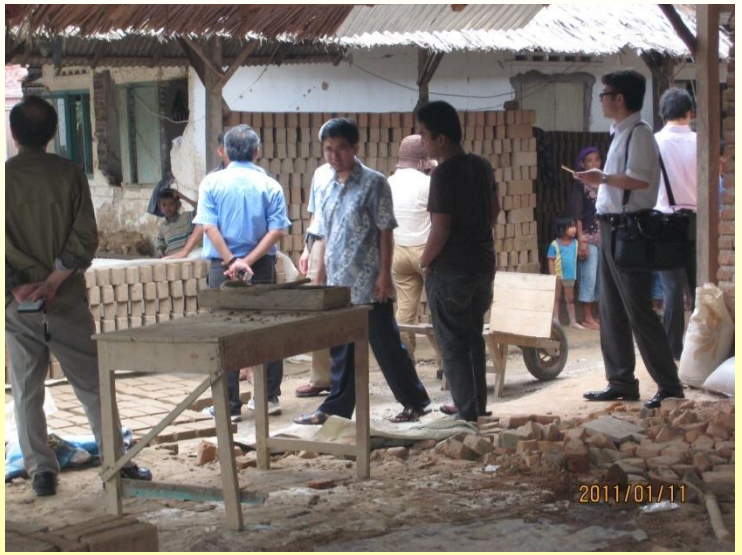


This steel member fabrication was carried out at the construction site without roofs. It rains occasionally in Indonesia. The welding is not good in wet condition.

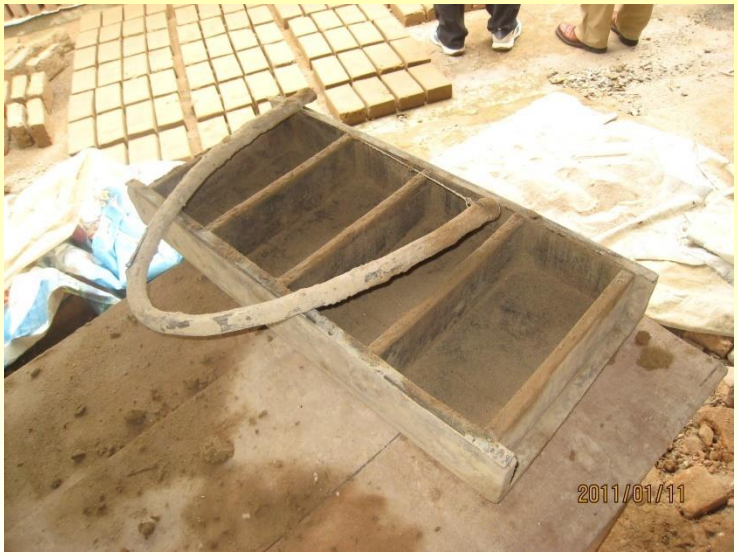
# Brick manufacturing site

Hand mixing




Wooden mold





All works are not industrial ones by human family works.

# 2 Summary of structural damage investigation

**Structural damage by Sep. 2009 Padang earthquake**

1. Shear failure of short column
2. Compression failure of top/bottom of column by bending moment
3. Destruction of top and bottom of column
4. Damage caused by building irregularity

   Setback & eccentricity of plan
5. Soft story

   Damage concentration at some story

   (inclination or collapse)

# 2 Summary of structural damage investigation (Continued)

6. Brace effect of stair slope-slab

Failure of supporting beam or stair slab itself

7. Column damage caused by brick wall crack

Crack of brick wall penetrated attached column.

8. Column-beam connection

Some columns are damaged at column-beam connection because of less hoop and less covering concrete.

Beam bar bond-length was not sufficient for columns with short depth.

# 3 Summary of non- structural damage

**Non-structural damage by Sep. 2009 Padang earthquake**

1. Brick wall

   Out of plane direction collapse

   Shear crack damage

   Dangerous falling of exterior brick wall

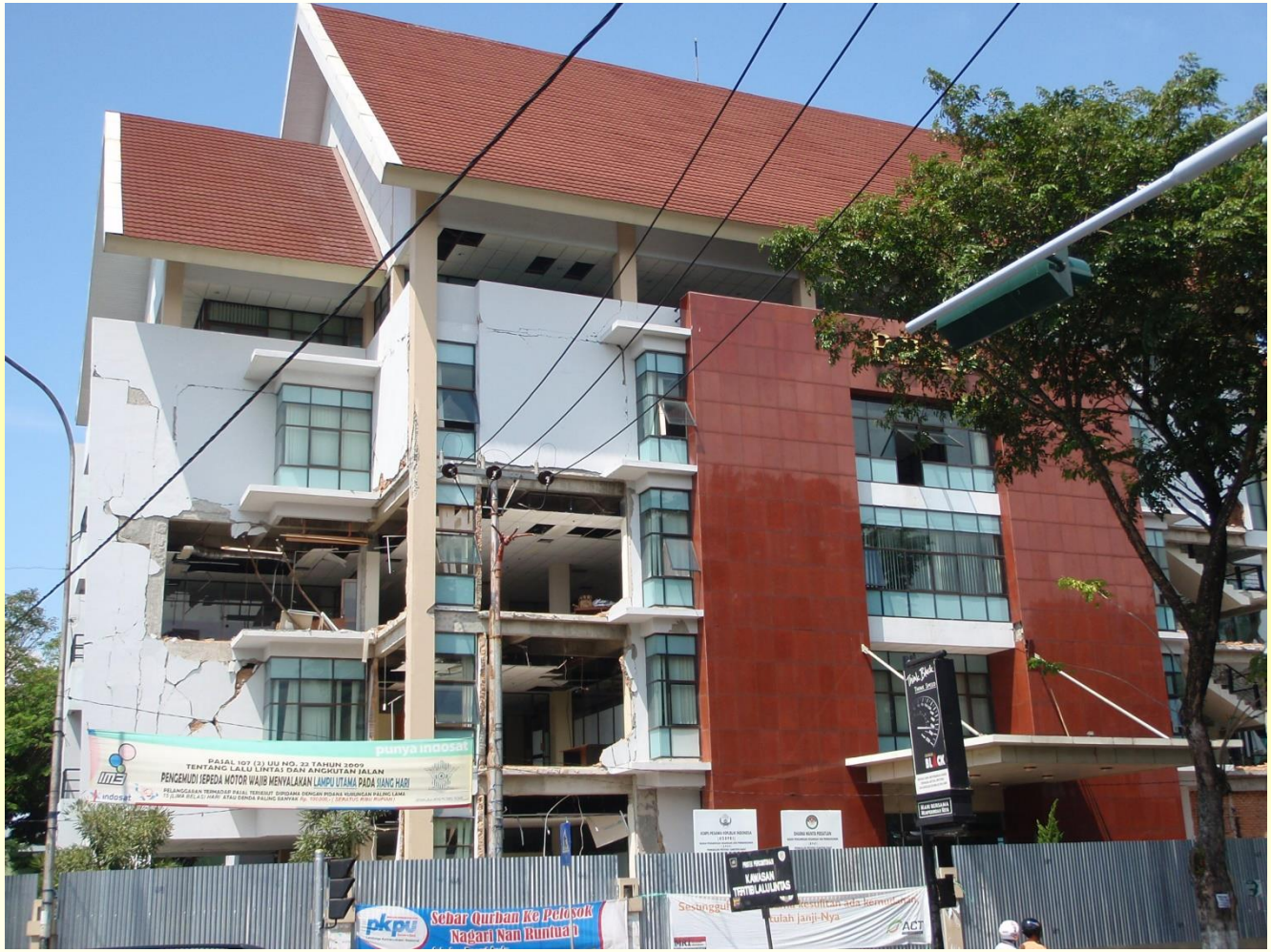
2. Hitting of buildings

   Less expansion-joint clearance made hitting and finally weaker one or both were damaged.

3. Exterior wall and glass cladding

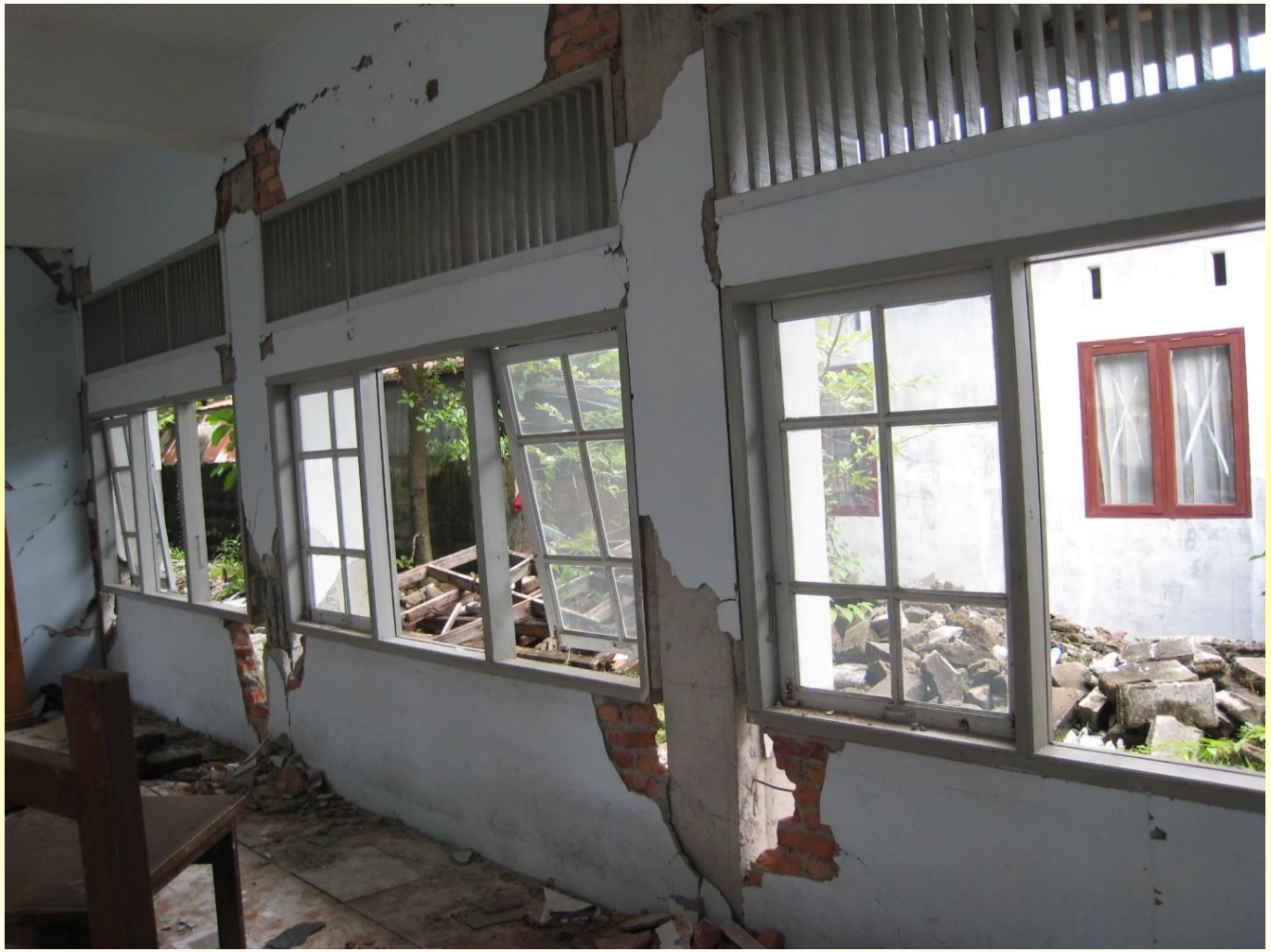
   Exterior walls not connecting to brick wall were almost safe.

# Typical brick wall damage by flexible frame




Main damages are falling-out and cracking of brick walls and reinforced concrete members are slightly damaged.

# Seismic damage of columns and brick walls



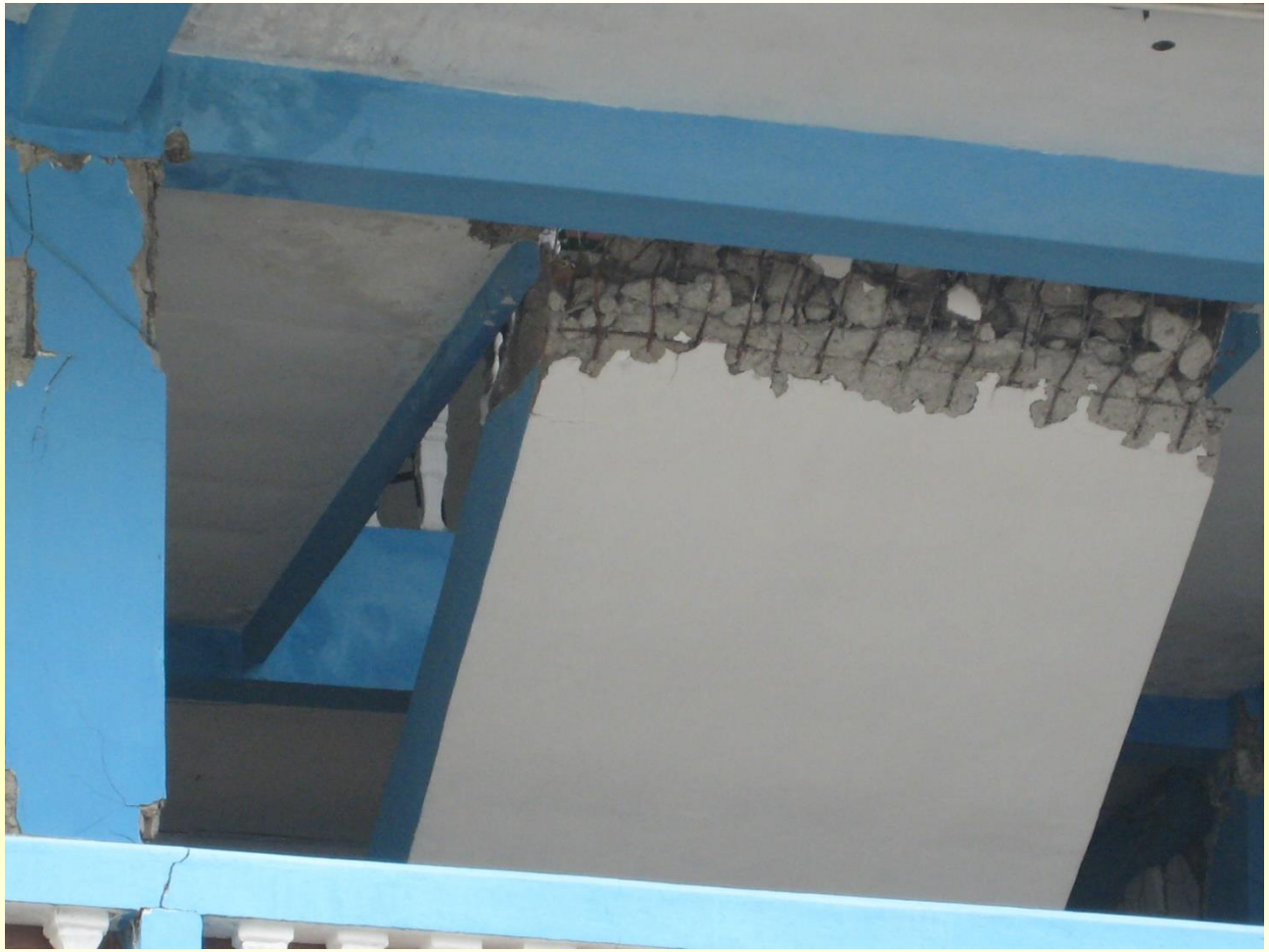
Mainly brick walls are damaged, but reinforced concrete columns are cracked by shear force in case.

# Repair of damaged brick walls



Damaged brick walls were repairing after the earthquake as the same construction method. Maybe the architect decided this repair and the structural engineer did nothing for this.

# Damage of stair slope-slab



Building story drifts were so large because of flexible frame.

Stair slope-slabs worked such as structural braces and were damaged by the tensile and compressive force.

# 4 Seismic isolation building project in Padang

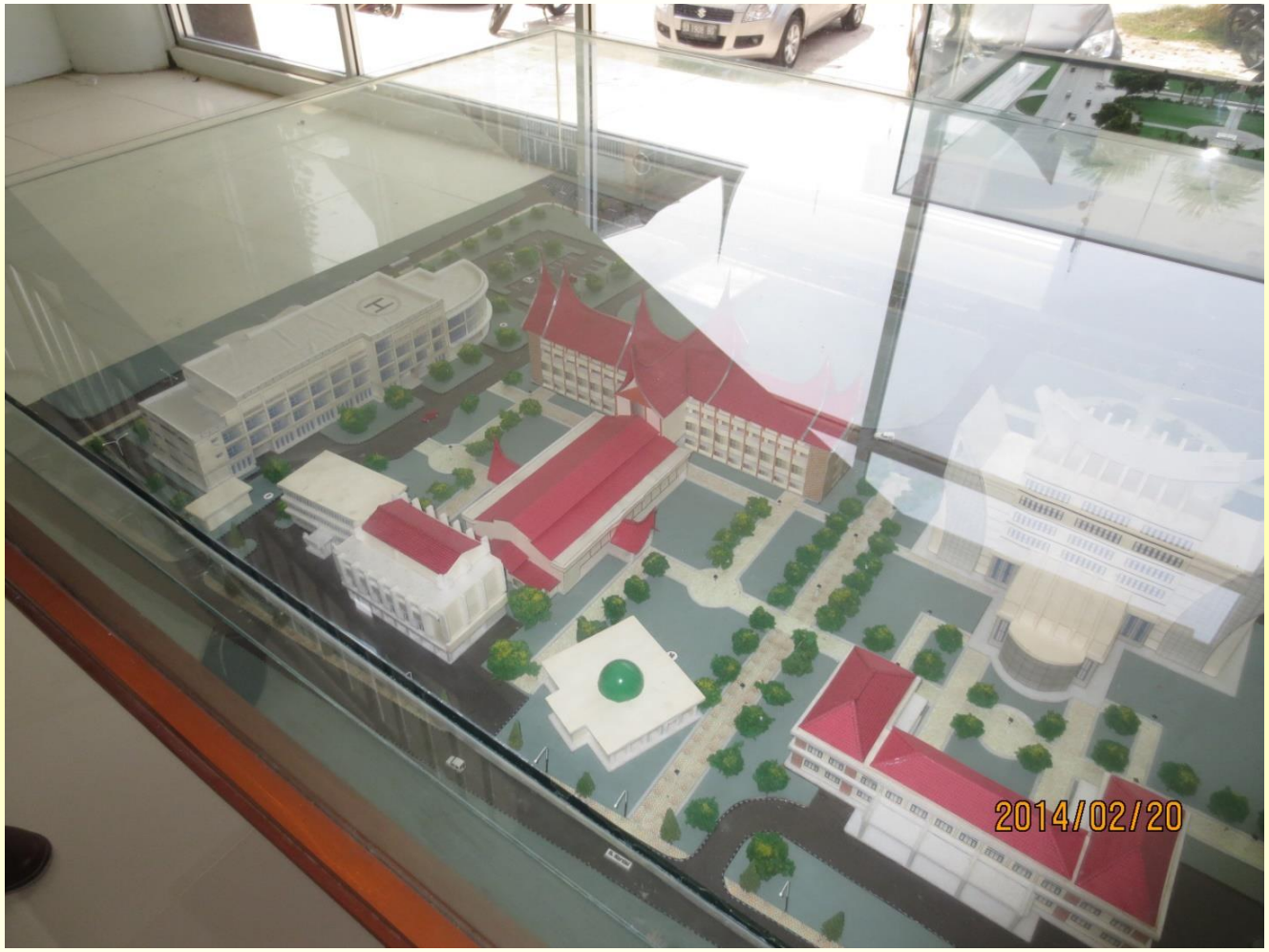
We co-operated to design the governmental “Tsunami refuse building” as seismic isolation structure.

We designed the seismic isolation parts under first-floor only, and proposed the seismic design force of upper structure.

The structural design of upper structure and foundation was carried out by local engineers of Undalas University.

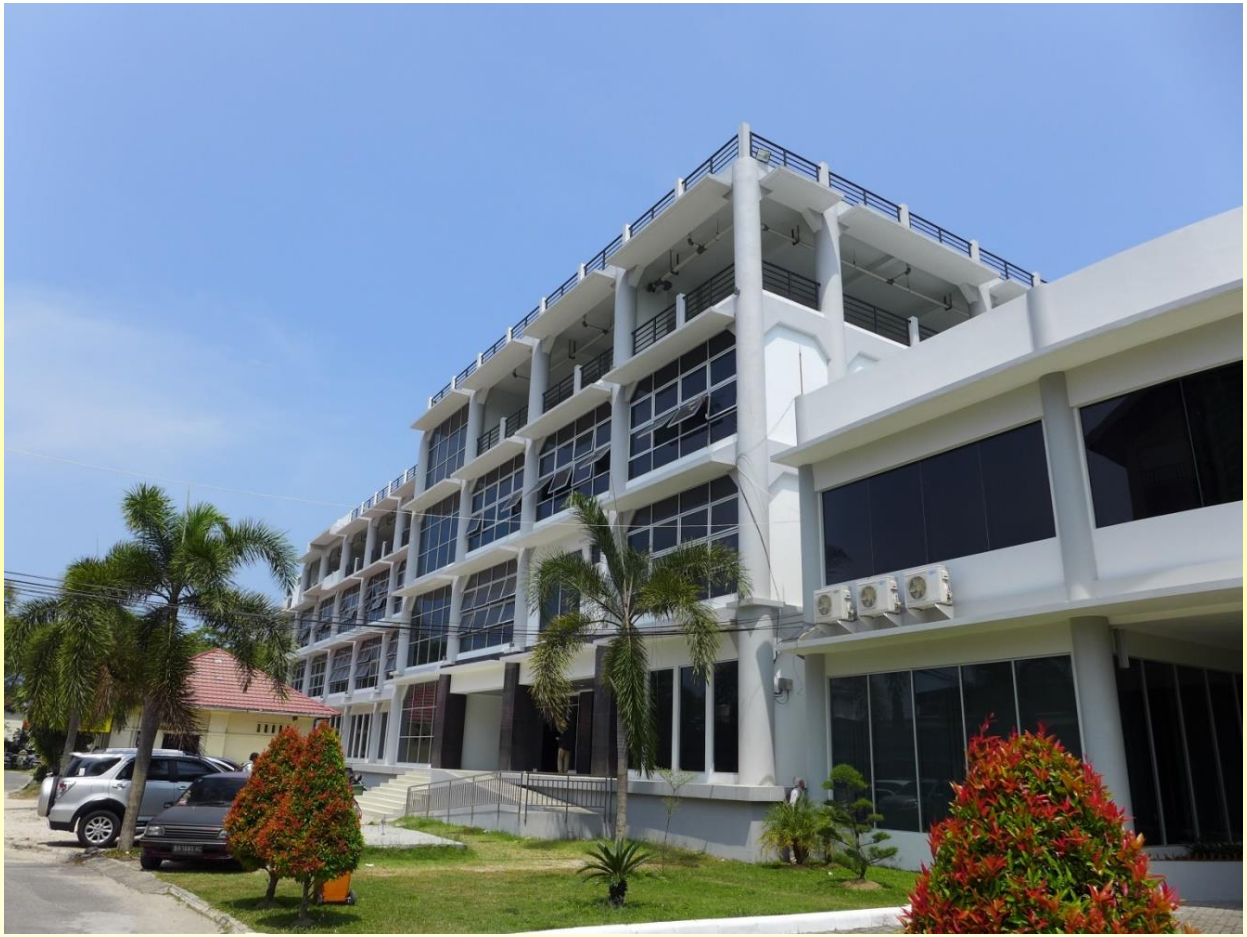
The architectural plan was fixed and the portion lower than first-floor was changed only.

# Tsunami Refuge Building (No.1 building)




Red roof buildings are existing governmental offices of West Sumatra.
The white building is “Tsunami refuge building” with seismic isolation.

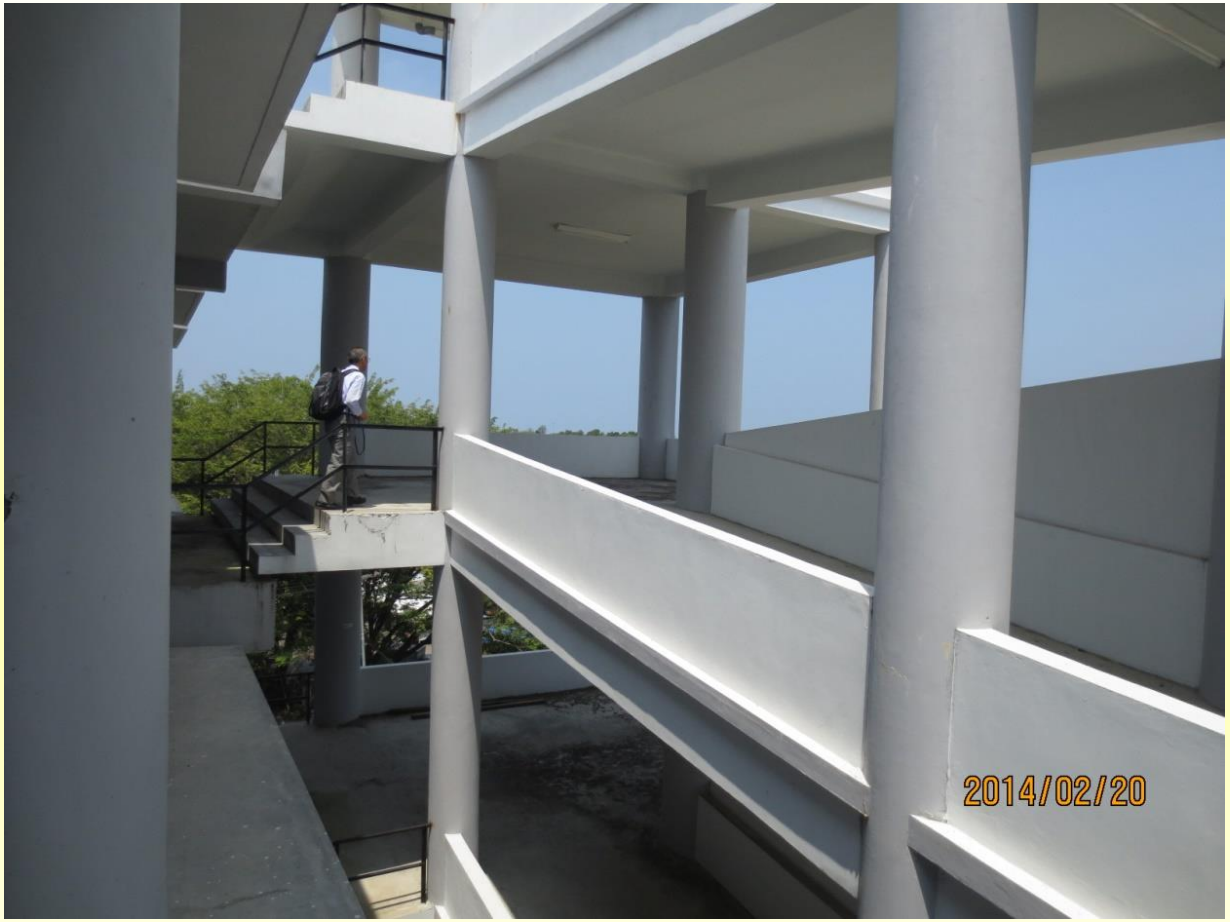
# Building just before completion (1)



4-story building is “Tsunami refuge building” and 2-story building is existing governor’s office.

Outside stair and slope were attached to the main isolated building.

# Building just before completion (2)




This is “Slope building” for running up to refuge, and was designed as a usual seismic structure with expansion joint.

Hand rails between two buildings were connected tightly.

# 5 Lessons from this project

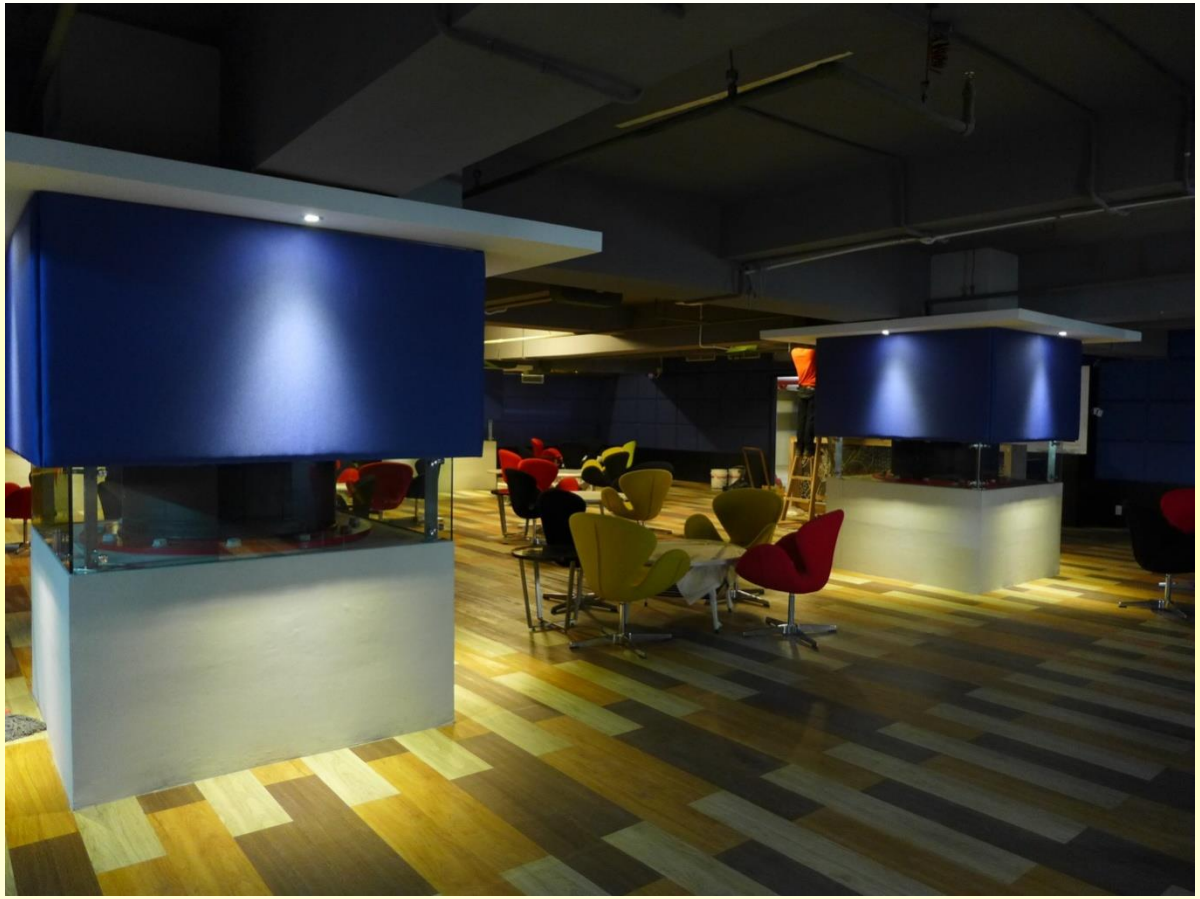
It is difficult to change the existing building construction system of a country, so seismic isolation technique should be useful because it can increase seismic strength not changing the upper structure.

Details of design have changed at the construction stage.
In Indonesia, building owner can change the original design ignoring design intent.

Structural engineers don't supervise at construction stage fully in Indonesia, and they don’t mind the exterior design/construction. In this case, seismic clearances was not enough by innocence of the building owner, exterior designer and construction engineers.

Many persons attended at the meeting including officers, structural engineers and contractors, but I can not recognize who is the key person to make up the final decision.

# New seismic isolation building: IBIS Hotel



This hotel was designed by local engineers.

Isolators are put at the column center of basement-floor.

This space is used for the lounge, so we can enjoy drinks looking smart and beautiful isolators. (Fire proof is ?)