RECOVERY COOPERATION FOR PADANG EARTHQUAKE DAMAGE BY SEISMIC ISOLATION BUILDINGS DESIGN

EWBJ (Engineers without Boarder, Japan)
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Abstract

At September 2009, the earthquake of M7.6 occurred around Padang city of Sumatra, Indonesia. Non-profit-organization EWBJ (Engineers without Border, Japan) have cooperated to research the seismic damage and have proposed for the recovery and strengthening of damaged governmental buildings by the financial support of Japan Platform.
After these, local government of South-Sumatra decided to construct new governmental buildings by the seismic isolation technique and requested to cooperate for EWBJ. EWBJ has cooperated for two seismic isolation building projects with Andalas university engineers of Padang. And two governmental buildings are now under construction.

1 Time-history of the Cooperation

(1) Sep. 2009 Padang earthquake occurred.
(2) Oct. 2009 1st cooperation of earthquake damage research
Earthquake damage s were researched by the association team of EWBJ (Engineers without Boarder, Japan), JSCE (Japan Society of Civil Engineers), JSAEE (Japan Association for Earthquake Engineering).
(3) Dec. 2009 2nd cooperation of earthquake damage recovery
EWBJ members of architectural team (Teramoto & Okoshi) and civil team visited Padang for the cooperation of earthquake damage recovery. Finally two symposiums were held at Padang and Jakarta
(4) Apr. 2010 3rd cooperation for earthquake damage recovery
EWBJ architectural team held a symposium at Padang about the design techniques of seismic isolation buildings. At the end of this visit, EWBJ was requested the design cooperation of five seismic isolation buildings by local government. EWBJ agreed to this and the seismic isolation design cooperation project was started from this time.
(5) May and June 2010 Design of No.1 building (Governor office)
(6) March to June 2011 Design of No.2 building (Public works office)
(7) Now Under construction of two buildings
Japanese isolators and base-plates have been imported from Japan.

2 Padang Earthquake

2.1 Outline of the earthquake

The outline of earthquake is as bellow, and the number of dead persons is 1,100.

(Main shock)	Time	: 30th September 2009 about 19:16
·	Epicenter	: Offshore of Padang, west Sumatra, Indonesia
·	Depth	: 80km
·	Magnitude	: M7.6
(After shock)	Time	: 1st October about 10:52

- Epicenter : Offshore west Sumatra, Indonesia
- Depth : 15 km
- Magnitude : M6.6

2.2 World earthquake environment of Indonesia

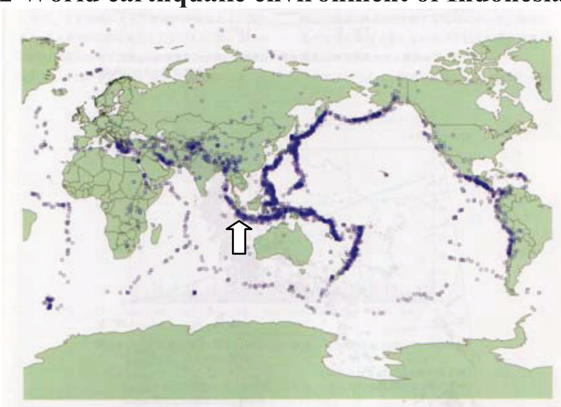


Figure 1. World map of epicenters

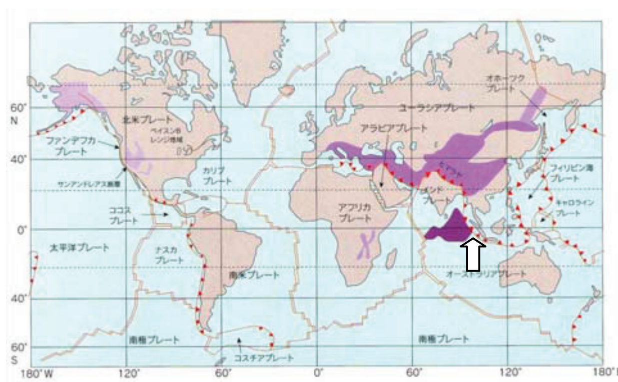


Figure 2. Map of the plates

2.3 Epicenter of the Padang earthquake and Map of the Padang city

Figure 3. Epicenter of Padang earthquake

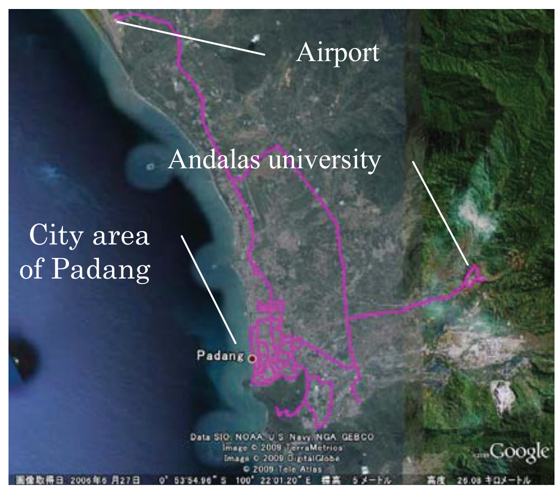


Figure 4. Landscape of Padang district

Figure 5. Landscape of Padang city
Roofs are imaged from water buffalo.

3 Earthquake damage of governmental buildings

3.1 Building damage 1/ Board of audit (BPKP)

Reinforced concrete rigid frame structure of 6-story with brick wall
Damage of exterior brick wall and curtain wall

Figure 6. Photograph of BPKP

3.2 Building damage 3/ Public works office

Reinforced concrete rigid frame of 4-story with brick wall
Shear-crack of reinforced concrete beams connected to the outer columns

Figure 7. Photograph of Public works office (1)

Figure 8. Photograph of Public works office (2)

3.3 Building damage 10/ State government office

Historical reinforced concrete rigid frame with brick wall

Brick wall with curtain wall and hitting of expansion joint

Figure 9. Photograph of State government office

3.4 Building damage/ Andalas university

Falling-down of brick exterior walls, they started to repair using the same method.
Structural engineers may have no right to change this construction method to seismic one.

Figure 10. Photograph of Andalas university

4 Resolution of technical discussion

After the damage research, joint members of EWBJ, RIHS (Research Institute for Human Settlements Agency for Research and Development Ministry of Public Works -Indonesia) and Andalas university have discussed about the damage at 19th November, 2009. Discussion summary was "Summary of Seismic Restoration of Padang Government Buildings (Tentative)" shown bellow.

(Members) EWBJ: T. Teramoto, T. Okoshi RIHS: Maryoko Hadi, Ferri Eka Putra
Andalas University: Fauzan, Professor Febrin A I

4.1 Building structural characteristics in Padang

- Reinforced concrete open frames without reinforced concrete seismic wall/ Soft structure and large deformation
- Slim rectangular reinforced concrete column/ Rigid column(frame) in plane direction/ Soft column (frame) out of plane direction
- Not enough clearance of expansion joint/ Required clearance is satisfied ?
- Poor quality control concrete construction/ Gravel including silt, concrete mixing method

- Reinforcing bar arrangement/ Detail of end of hoop and stirrup/ Main bar irregular bending at column bottom

4.2 Non-structural members in Padang

- Brick walls/ Walls without reinforcement/ Designed without engineering by structural engineers or architects/ Stair room wall (important for safety of evacuation), Exterior wall
- Ceiling/ Decay of old wood ceiling frame, Hanging wire without bracing

4.3 Summary of structural damage investigation

- Shear failure of short column
- Compression failure of top/bottom of column by bending moment
- Destruction of top and bottom of column
- Damage caused by building irregularity/ Setback or eccentricity of planning
- Soft story/ Energy & damage concentration at some story (inclination or collapse)
- Brace effect of stair-slope-slab/ Failure of supporting beam
- Column damage caused by brick wall crack/ Brick wall crack penetrated attached column.
- 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.

4.4 Summary of non-structural damage investigation

- Brick wall/ Out of plane direction collapse/ Shear crack damage/ Dangerous falling of exterior brick wall
- Hitting of buildings/ Less expansion-joint clearance made hitting and finally weaker one or both were damaged.
- Exterior wall and glass cladding/ Exterior walls not connecting to brick wall were almost safe.

4.5 Summary of structural damage investigation

- Shear failure of short column
- Compression failure of top/bottom of column by bending moment
- Destruction of top and bottom of column
- Damage caused by building irregularity Setback & eccentricity of plan
- Soft story/ Energy & damage concentration at some story (inclination or collapse)
- Brace effect of stair-slopping slab Failure of supporting beam
- Column damage caused by brick wall crack/ Crack of brick wall penetrated attached column.
- 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.

4.6 Guideline for repair or strengthening of damaged reinforced concrete buildings

- Target of repair or strengthening/ Owners must decide how to retrofit considering the important factor " I" in code with the aids of structural engineers.
  (1) Repair to the building performance before earthquake
  (2) Strengthening satisfying current code (upgrade if necessary)
  (3) Demolishing if damages too large to restoring

- Restoring techniques
  (1) Repairing of structural members
  (2) Jacketing of column/beam
  (3) Wrapping of column/beam
  (4) Installing of reinforced concrete shear wall
  (5) Installing steel brace in reinforced concrete frame
  (6) Installing space (gap or slit between column & wall)

4.7 Guideline for seismic evaluation and seismic retrofit of existing reinforced concrete buildings

- Design methodology
  The only method to check retrofit buildings is to use the current structural design method.
  All members should be checked by the prescribed code and retrofitted members should be evaluated using the strength reduction factor such as 0.8.
  The strength reduction factor should be examined more precisely.

- Story drift
  Non-structural members might be deformable for building deformation Δ.
  Slit between column & brick wall should be greater than Δ.
  Base shear $V=(C*I/R)*W$
  Story drift $\Delta=\mu*\delta$ (less than or eq. 1/50)
  where μ: ductility factor
  δ: story drift for V (elastic value)

4.8 Future cooperation between Indonesia and EWBJ

- Consulting to governmental buildings retrofit
- Development of seismic evaluation standard
- Education of structural engineer

5 No.1 building/ Governor office and Tsunami refuge center

1) Requirement
When the project started, the building design was completed and foundations were under construction. The governor required to grade-up the seismic capacity and the redesign by seismic isolation technique was required for EWBJ with no or less design fee.
2) Outline of building
Structure: Reinforced concrete rigid frame of 4-story with brick wall, pile foundation.
Usage: Governor office from 1st to 3rd story, tsunami refuge area from 4th to roof.
3) Seismic isolation members
Natural rubber isolators 500 ϕ / 35 sets and lead rubber isolators 600 ϕ /18 sets were used.
4) Design works

Isolators, 1st floor structural members, column base and mat-slab were designed by EWBJ using Japanese standard. Dynamic analysis was carried out by Japanese style of 50 cm/sec seismic input using Padang wave. Upper structures were redesigned by local engineers using Indonesian code.

5) Final document by English

Structural drawings, specification, analysis documents and architectural sketches were supplied.

(No.1 building perspective)

Mat slab is under construction. Governor work space has completed already.

Governor office (1F～3F) Tsunami refuge space(4F～RF)
Seismic isolation structure/ Construction was stopped at mat slab.

Governor work space
Completed seismic structure

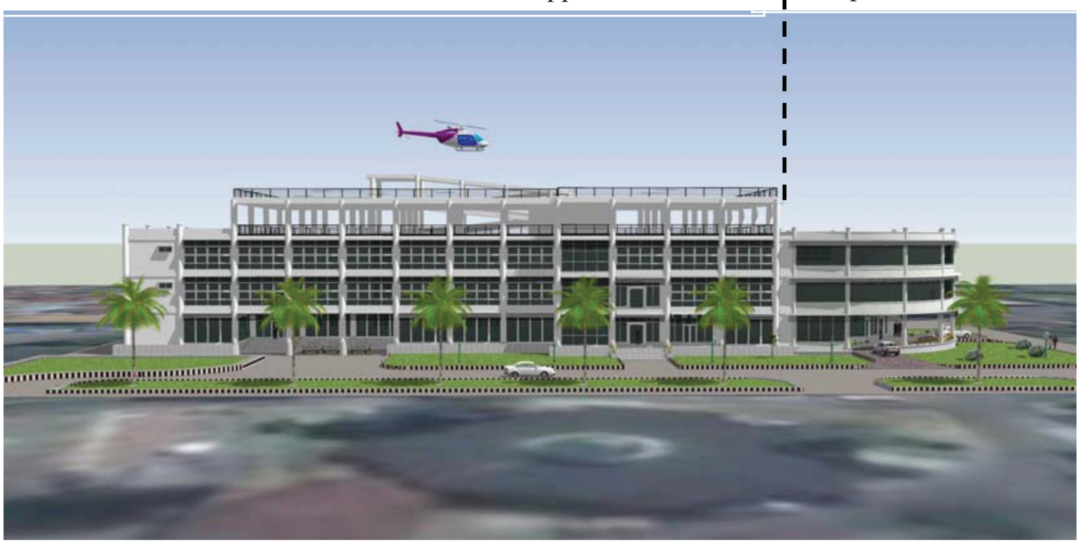


Figure 11. No.2building perspective

6 No.2 building/ Public works office

1) Requirement

Rough structural design was done following No.1 building. EWBJ was required to design seismic isolation details with design fee of minimum expenses.

2) Outline of building

Structure: Reinforced concrete rigid frame of 4-story with brick wall, pile foundation.

Usage: Public works office, tsunami refuge space on the roof.

3) Seismic isolation members

Natural rubber isolators 500φ/ 29 sets and lead rubber isolators 600 ϕ / 22 sets, 650 ϕ / 3 sets were used.

4) Design works

1st floor members, column base and mat-slab were designed by Japanese standard. Dynamic analysis was carried out by Japanese style of 50 cm/sec seismic input as No.1 building. Upper structure was designed for base-shear 0.15 by local engineers.

5) Final document by English

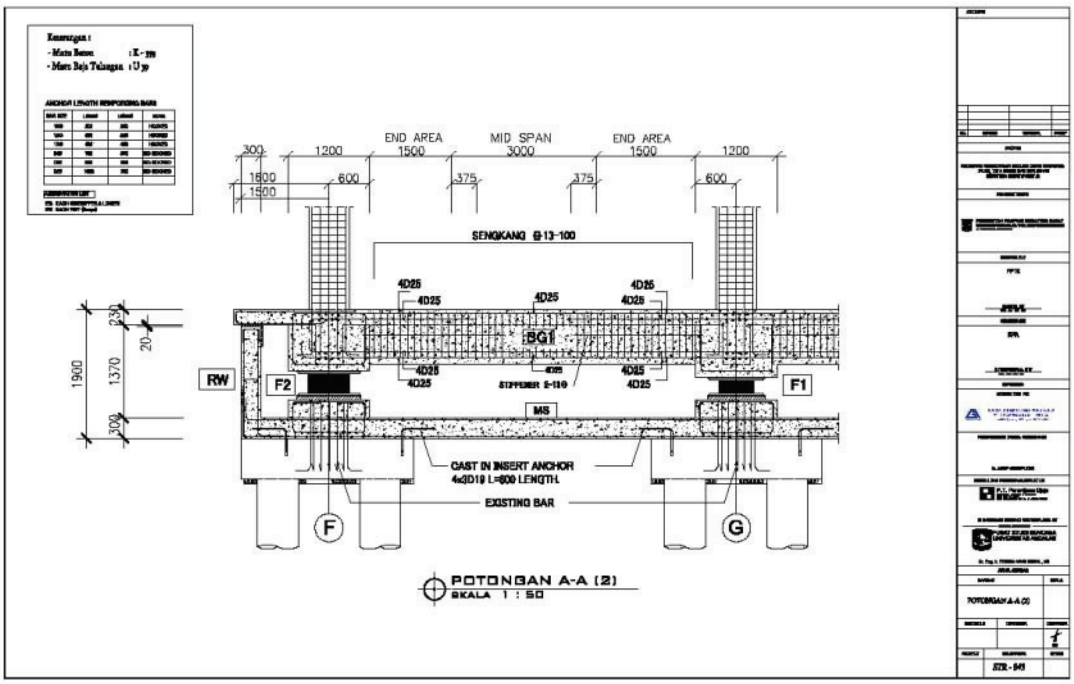
Structural drawings, specification, analysis documents and "Seismic isolation buildings construction standard" by JSSI translated by Okoshi & Teramoto were supplied.

6.1 No.2 building architectural perspectives

Usage: Public works office (1F-4F), Tsunami refuge space (Roof)

Structure: Reinforced concrete structure of 4-story, seismic isolation structure

6.2 No.2 building structural drawing and photograph of construction site



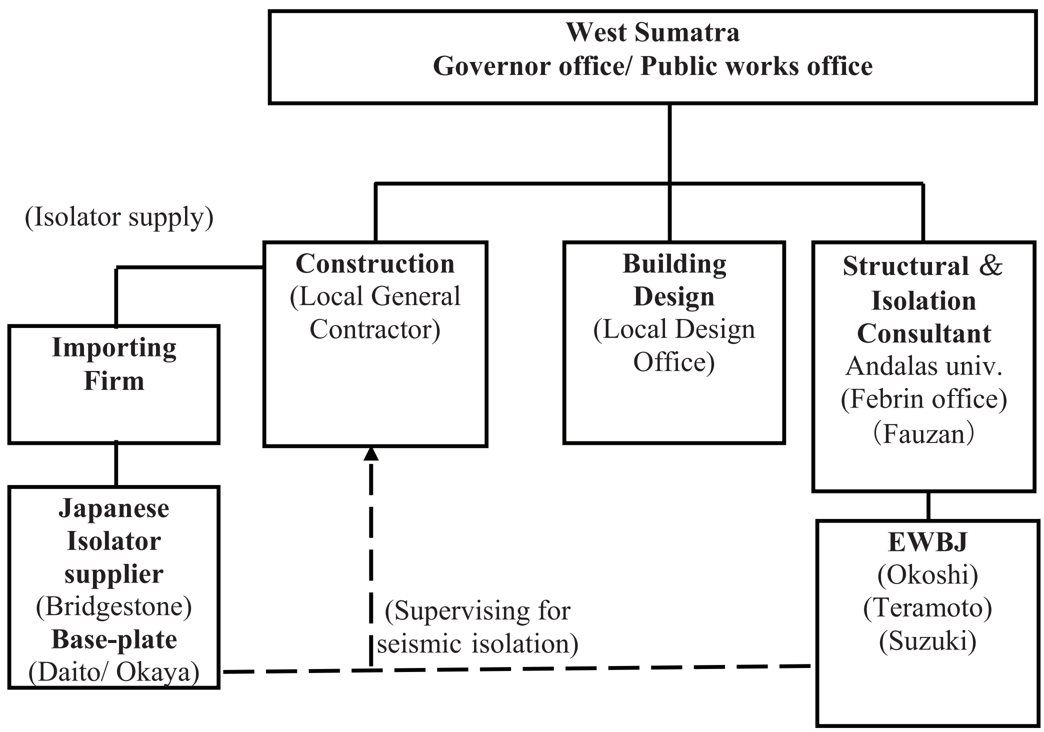
R-bar arrangement of isolator base at 5th May, 2011

R-bar arrangement of mat slab at 6th June, 2011

Figure12. Photograph of No.2 building construction site

7 Cooperation system

EWBJ wanted to contract with the state government but not realized. Finally, EWBJ cooperated with Andalas university engineers without the contract. Consultant fee was transferred from unknown somebody to EWBJ.



8 Evaluation of the cooperation project

(1) No project manager (Who is responsible for final decision.)
Responsibility for architectural, structural, equipment and construction staffs ?

(2) Very rough architectural design (there are only rough planning and perspective.)
Detailed architectural design may be arranged by the client and contractor at the construction stage. For the design change requested by EWBJ, no one reply and no response from the client. (The cost should be responsible for someone replied.??)

(3) No one keep the schedule
No1 building 4F-concrete-casting should be completed until December 2011.
But only mat slab was completed at June 2011, and no one was worried about for this. (Project did not smoothly advanced, but was not gone back.)

(4) Consultant fee
We got some minimum consulting fee for these two buildings. The payment was for structural analysis, structural drawings and the business trip expenses. The balance of the budget of EWBJ is about zero with the aid of JSSI.

(5) First seismic isolation building of Indonesia

One experimental building was constructed before, these buildings are the first seismic isolation buildings in Indonesia.

(6) Cooperation was possible only by Non-Profit-Organization

The client request was very irregular one which was impossible to manage by usual design office. (No payment assurance, short and hard design schedule and less response by client and local engineers.)

(7) Good relationship between the state government and Andalas university

EWBJ made up good relationship between the state government and Andalas university. When they visited Japan, Professor Hamada of EWBJ, Professor Wada of Tokyo Institute of Technology and Dr. Kani of JSSI were helped us so much.

(8) Japanese products exportation

Japanese isolators and base-plates wee exported to Indonesia at the first time. This project may be useful for the popularization of seismic isolation techniques for east-west Asia