QUICK REPORT ON DAMAGE INVESTIGATION OF BUILDINGS AND HOUSES DUE TO MAY 27, 2006, CENTRAL JAVA EARTHQUAKE, INDONESIA

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Itinerary of AIJ Building Investigation Team (by M. Teshigawara and Y. Nakano)

06/10(Sat)

11:25 Lv. Narita Airport (JL725)
17:00 Ar. Jakarta Airport
18:15 Check-in (Hotel Nikko Jakarta)
19:00 Member meeting (with short information exchange with The Daily Jakarta Shimbun)

06/11(Sun)

07:40 Lv. Hotel
08:10 Ar. Jakarta Airport
11:00 Ar. Yogyakarta Airport (GA430)
11:30 Media Center
12:00 Lv. Media Center
12:25 Earthquake Observation Station at Wates (Stasiun Geofisika Klas I Yogyakarta, about 25 minutes west from the Yogyakarta city center)
13:40 Check-in Hotel (Hyatt Regency)
14:20 Briefing by Indonesian Colleagues from Bantul Regency Office
15:45 Lv. Hotel for sites
16:00 Quality Hotel (Interior damage observed but no significant structural damage)
16:15 Jayakarta Hotel
16:45 Amongrogo Sport Center
17:15 University of Economic Science (STIE: Sekolah Tinggi Ilmu Ekonomi Kerja Sama)
17:40 Finance and Development Audit Agency (BPKP: Badan Pengawasan Keuangan dan Pembanguan, JL Parangtritis Yogyakarta)
18:40 Ar. Hotel

06/12(Mon)

08:30 Lv. Hotel
09:10 Islamic University of Indonesia (Universitats Islam Indonesia)
Presentation on EQ resistant housing concept by Prof. Sarwidi (Vice Rector)
10:45 Lv. University
11:30 Bantul Regency Office
(Major damage was rapidly increased after Bantul)
12:10 Tempel Elementary School (SD Tempel at Bambanglipuro, Kecamatan Baglipuro)
12:25 Bambanglipuro 2nd Middle School (SMP 2 at Bambanglipuro, Kecamatan Baglipuro)

13:05 Imogiri
14:50 Parangtritis
15:10 Parangtritis 2nd Elementary School (SD 2 Parangtritis at Parangtritis, Kecamantan Kretek）
15:35 Quick observation at Jetis
15:45 School at Trimulyo (SLB-PGRI Trimulyo, Kecamatan Jetis)
15:55 Kembangsongo 2nd Elementary School (SD 2 at Kembangsongo)
16:45 Finance and Development Audit Agency (2nd visit)
17:40 Ar. Hotel

06/13(Tue)

07:30 Lv. Hotel
08:00 Head Quarter of Countermeasure for Earthquake and Merapi Volcano Disaster at Jogonalan, Kabupaten Klaten (HQ located at the former Sugar Museum)
10:05 Traditional stone masonry house at Muruh, Kecamatan Gantiwarno
10:50 Sawit Elementary School (SD Sawit at Gantiwarno, Kecamatan Gantiwarno)
11:15 Katekan Elementary School (SD Katekan at Katekan, Kecamatan Gantiwarno)
12:05 Jabung and central Gantiwarno
12:25 Pesu Elementary School (SD Pesu at Pesu, Kecamatan Wedi)
13:40 Prambanan
14:35 Pereng Elementary School (SD Pereng at Pesu, Kecamatan Prambanan)
15:20 Steel bar shop in Yogyakarta city
15:40 Construction site of houses in Yogyakarta city
16:10 Ar. Hotel

06/14(Wed)

AM Summarizing investigations
14:00 Lv. Hotel
14:30 Ar. Yogyakarta Airport
16:30 Ar. Jakarta Airport (GA433)
18:00 Check-in Hotel (Hotel Nikko Jakarta) / Summarizing investigations

06/15(Thu)

AM Summarizing investigations
15:00 JICA Indonesia Office
17:00 Ministry of Public Works
21:00 Ar. Hotel

06/16(Fri)

08:00 Summarizing investigations
10:00 PII (The Institution of Engineers, Indonesia)
13:00 The Embassy of Japan in Indonesia
14:30 Summarizing investigations
18:30 Lv. Hotel
24:25 Lv. Jakarta Airport

06/17(Sat)

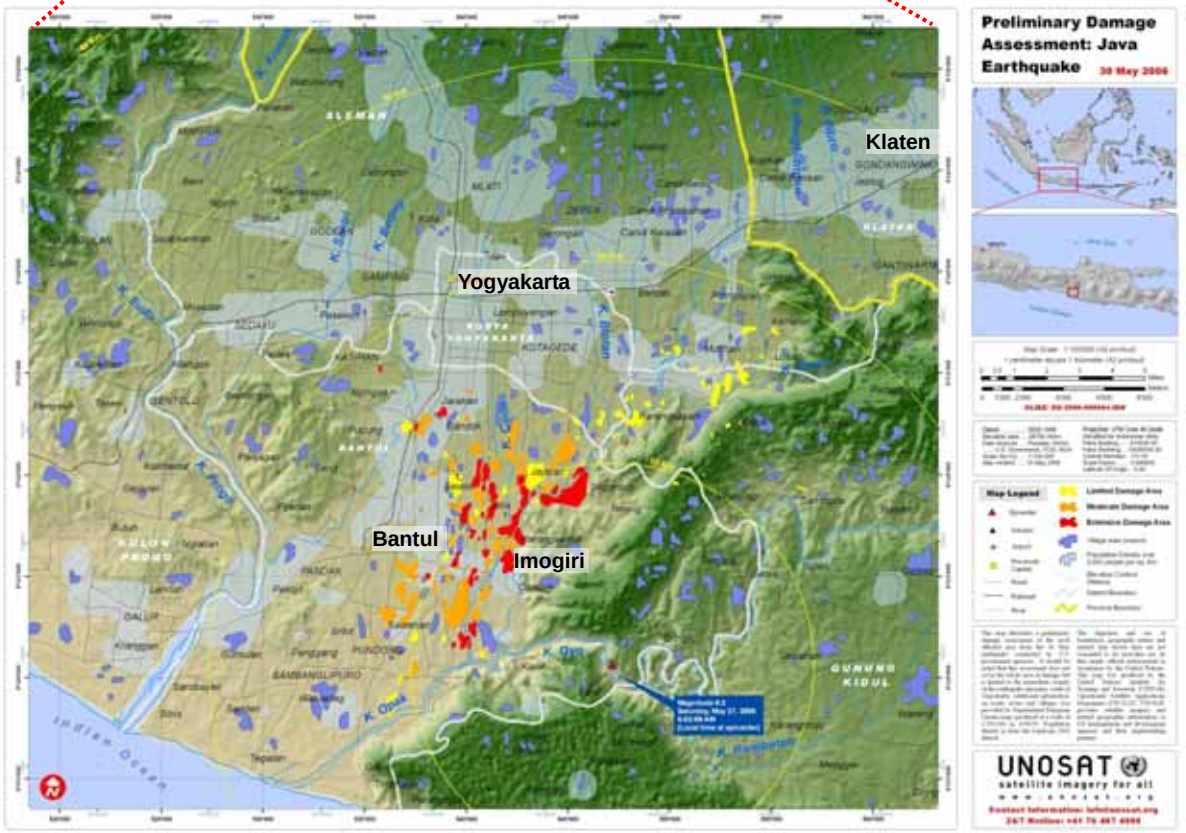
09:45 Ar. Narita Airport (JL726)

Investigated Buildings

	Abbreviation*	Building
1	-	Jayakarta Hotel
2	-	Amongrogo Sport Center
3	STIE	University of Economic Science (STIE Kerja Sama)
4	BPKP	Finance and Development Audit Agency (BPKP)
5	S-1	Tempel Elementary School (SD Tempel at Bambanglipuro, Kecamatan Baglipuro)
6	S-2	Bambanglipuro 2nd Middle School (SMP 2 at Bambanglipuro, Kecamatan Baglipuro)
7	-	Houses in Imogiri
8	S-3	Parangtritis 2nd Elementary School (SD 2 Parangtritis at Parangtritis, Kecamantan Kretek)
9	S-4	School at Trimulyo (SLB-PGRI Trimulyo, Kecamatan Jetis)
10	S-5	Kembangsongo 2nd Elementary School (SD 2 at Kembangsongo)
11	Bamboo House	Traditional houses in Gantiwarno Sub-Regency (Kecamatan Gantiwarno)
12	S-6	Sawit Elementary School (SD Sawit at Gantiwarno, Kecamatan Gantiwarno)
13	S-7	Katekan Elementary School (SD Katekan at Katekan, Kecamatan Gantiwarno)
14	S-8	Pesu Elementary School (SD Pesu at Pesu, Kecamatan Wedi)

* Buildings 1-10 and 11-14 are found in Figures A-1 and A-2, respectively. Some building names are shown abbreviated in the figures.

http://www.lib.utexas.edu/maps/cia05/indonesia_sm05.gif



http://unosat.web.cern.ch/unosat/freeproducts/indonesia/UNOSAT_Java_EQ_damage30may06_lowres.jpg

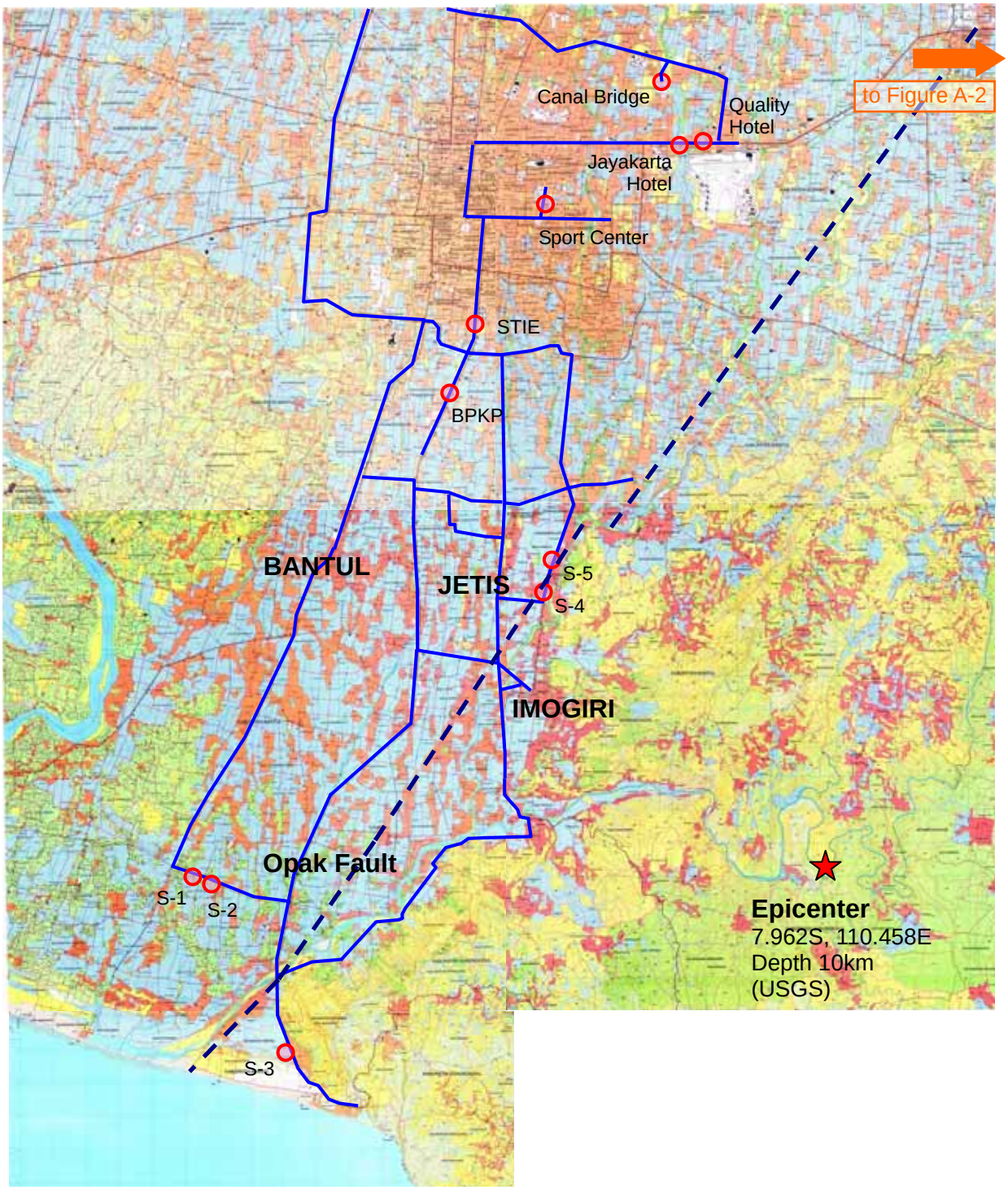


Figure A-1 Route Map (Yogyakarta Province)

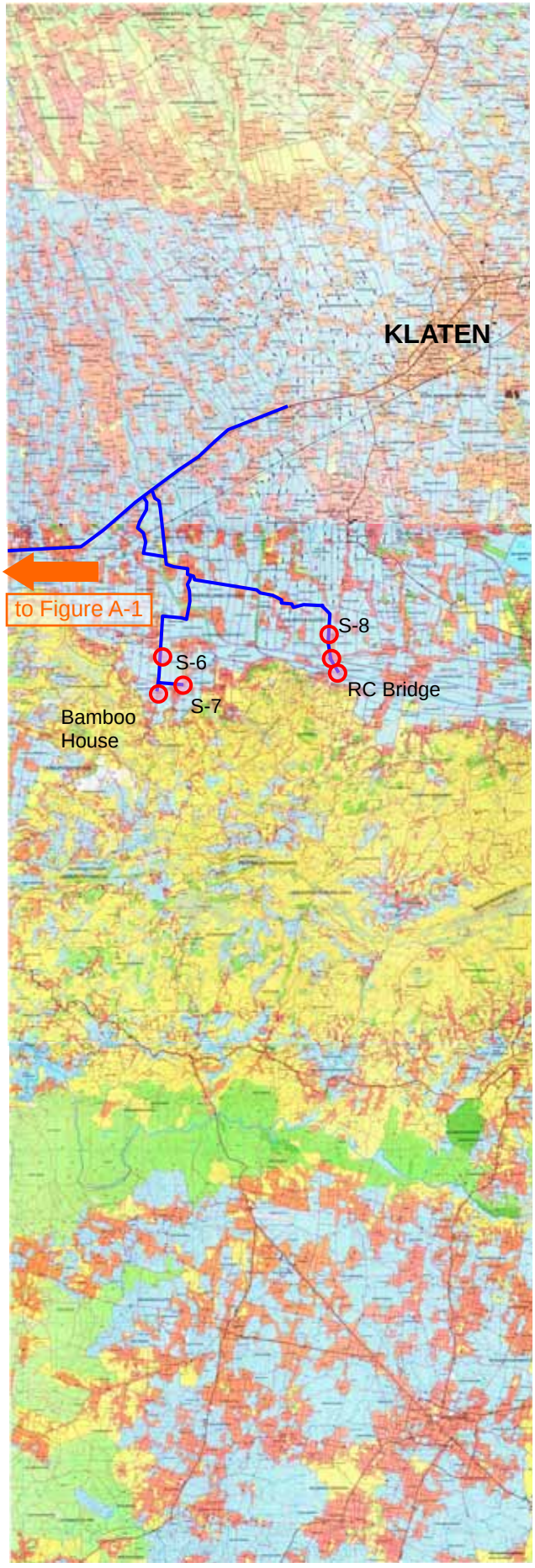


Figure A-2 Route Map
(Central Java Province)

Damage Observations

Jayakarta Hotel (RC 6F)

URM walls (brick walls) in RC frames had damage and a connecting bridge between two adjacent buildings (reception building and lodging building) was damaged at the expansion joint as well as its roof and handrail wall due to pounding. Roofing tiles on a steel truss system fell down through the ceiling board of guest rooms on the top floor, and falling debris were likely to have been life-threatening to guests staying at the time of the earthquake.

<== Lodging bldg. Reception bldg. ==>

<== Lodging bldg. Connecting bridge ==>

Damage to roof system above top story (some column rebars were not anchored to beams)

Amongrogo Sport Center (RC 3F)

Extensive damage was found in cantilever RC columns on the top floor as well as in the roof system. The column damage may be attributed to the inertia force due to shaking, the inward force acting on the columns due to collapse of the roof, and the small amount of reinforcement provided in the columns.


Amongrogo Sport Center / Collapsed roof system associated with column failure underneath

Heavy damage to RC columns and exposed rebars

University of Economic Science (STIE: Sekolah Tinggi Ilmu Ekonomi Kerja Sama / RC3F - 6F)

The university campus had several multi-story buildings. Serious structural and nonstructural damage was found in most buildings. One 4 story RC building, which was located just across the open square at the entrance gate, lost its first story due to beam-column joint failure. It had 2 URM wall frames while the neighboring 5 story building had 4 URM wall frames and did not collapse.

4 story building with 2 URM walls frames

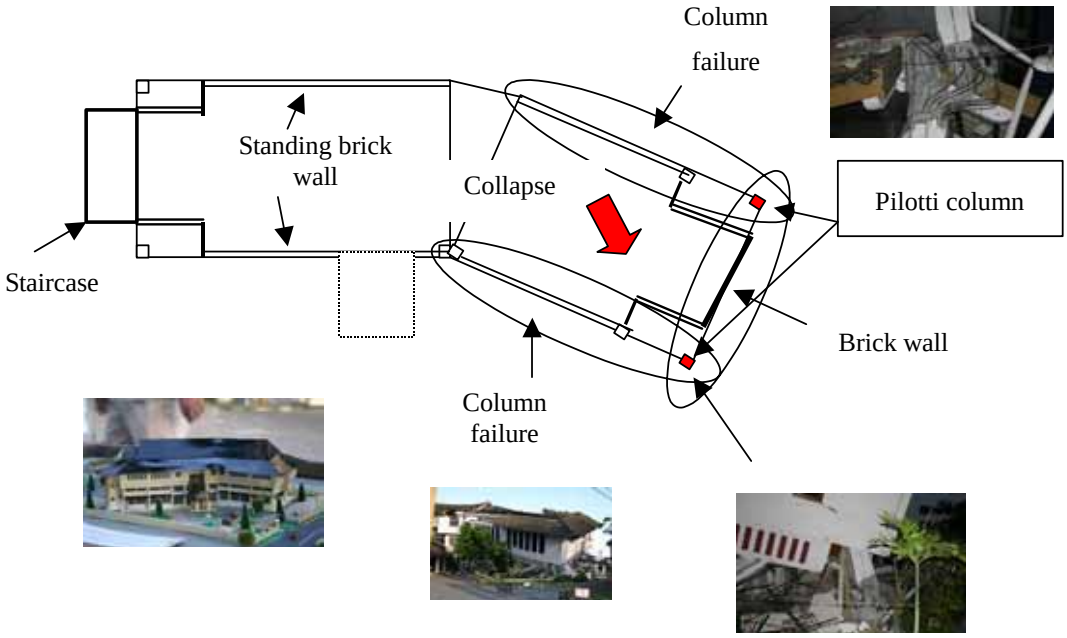
5 story building with 4 URM wall frames

The damage was also attributed to the inadequate detailing of rebar ends placed at the bottom of beams and the insufficient section volume of beam-column joint as compared to the amount of reinforcing bars, which resulted in the pull-out failure of beam rebars at the joints.

University of Economic Science (STIE) / Beam bottom rebars inadequately anchored to joints

Finance and Development Audit Agency (BPKP: Badan Pengawasan Keuangan dan Pembanguan / RC 3F)

The 3 story RC office building lost its first story in the west wing due to beam-column joint failure in the 2nd floor while the east wing survived the shaking with damage to URM walls. Some rebars in columns were lap-spliced at joints, resulting in joint failure. The lateral reinforcement was placed at a space of 25cm to 30cm with 135-degree hooks. The serious damage to the west wing may be attributed to large deformations of soft columns supporting confined URM walls above on the west-end exterior frame and torsional response effects.



Building sketch and typical damage (BPKP)

General view of Finance and Development Audit Agency (BPKP) and collapsed west wing


Beam-column joint failure


135-degree hooks in a column

Tempel Elementary School (SD Tempel at Bambanglipuro, Kecamatan Baglipuro / URM / 1F)

No lintel beams were found and the timber roof truss was directly placed on URM walls. Major damage was found in URM walls and the roof truss, and some ceiling boards fell down in the classrooms.


SD Tempel at Bambanglipuro / Heavy damage to URM wall and fallen ceiling boards

Bambanglipuro 2nd Middle School (SMP 2 at Bambanglipuro, Kecamatan Baglipuro / URM+RC column / 1F)

Each class had 3 bays in the longitudinal direction. No major damage was found in the structure.

SMP 2 at Bambanglipuro, Kecamatan Baglipuro / No major damage found in the building

Houses in Imogiri

Houses in Imogiri were extensively devastated. They were URM structures with timber truss system and roofing tiles on it. URM walls were typically 20cm to 25cm thick with 2 or 1.5 brick units, having a geometry of 26cm x 12cm x 6cm. Since demolitions to reconstruct damaged houses had started in Imogiri, it was not easy to identify which debris were due to shaking and which were not. Those with RC frames to confine URM walls often survived the shaking although they had some damage.

Devastated URM house

Survived house with URM and RC frame

Parangtritis 2nd Elementary School (SD 2 Parangtritis at Parangtritis, Kecamantan Kretek / URM+RC column / 1F)

The school had 2 single story buildings. Each class had 2 bays in the longitudinal direction. Each bay was 3.5m long and the column in the center of each two-bayed frame was 175mm thick and 350mm wide. The eaves of one building were supported by Γ-shaped RC columns with cantilever beam while those of the other were supported by columns provided at the tip of eaves. No major damage was found in the structures. Note that less damage was found in the coastal areas around Parangtritis (to Opak river) than inland areas.

SD 2 Parangtritis / No major damage found in the building

School at Trimulyo (SLB-PGRI Trimulyo, Kecamatan Jetis / URM(+RC column?) / 1F)

Each class had 2 bays in the longitudinal direction. Each bay was 3.5m long. Columns had flexural cracks at both ends. The presence of reinforcing bars was not confirmed at the site since the building had minor cracks and rebars were not exposed.

SLB-PGRI Trimulyo / Cracks found in column ends

Kembangsongo 2nd Elementary School (SD 2 at Kembangsongo / URM+RC column / 1F)

The school was located just north of the school at Trimulyo. The eaves were supported by

Γ-shaped RC columns with cantilever beam, which was similar to SD 2 Parangtritis. The exterior URM wall was damaged and repaired, but no other major structural damage was found in the structure.


SD 2 at Kembangsongo / No major structural damage found in the building

Traditional houses in Gantiwarno Sub-Regency (Kecamatan Gantiwarno)

Traditional stone masonry houses in Gantiwarno Sub-Regency had some damage in masonry walls. They had some RC beams on the wall but no RC columns were provided in the houses. Although they were heavy, the stone masonry walls were thick and long enough to resist and survive the shaking. Another traditional house older than the stone masonry construction had minor damage since they had light bamboo-net walls. The bamboo-net house investigated by the reconnaissance team was older than 70 years.


Stone masonry house with cracks in walls Bamboo-net wall house

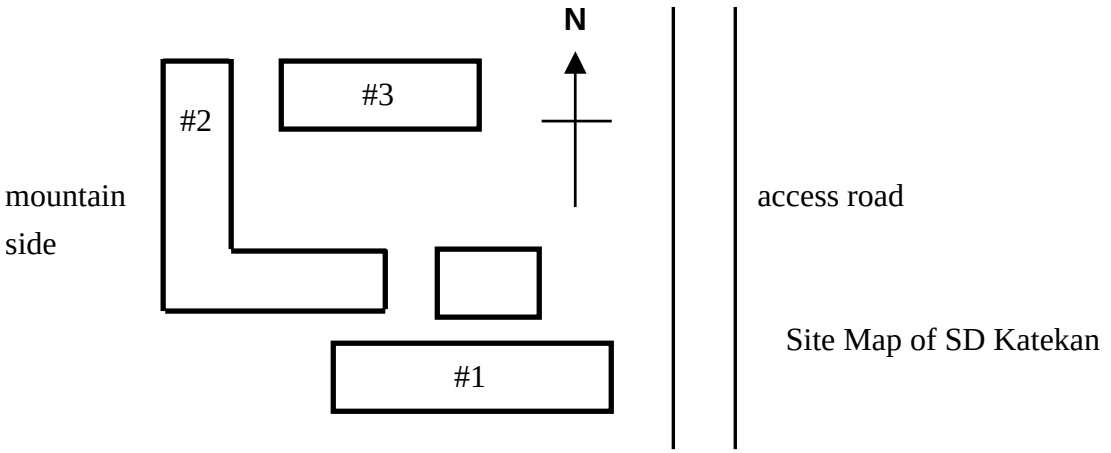
Sawit Elementary School (SD Sawit at Gantiwarno, Kecamatan Gantiwarno / URM / 1F)

The school building most probably had RC columns only at the 4 exterior corners but no columns in the middle of the structure. Each class had 2 bays and each bay was 3.5m long. Extensive damage was found in 20cm thick URM walls and the roof system.

SD Sawit at Gantiwarno / Collapsed building

Katekan Elementary School (SD Katekan at Katekan, Kecamatan Gantiwarno / URM & URM+RC column / 1F)

The school had 3 buildings, one of them (building #2) was stone masonry structure constructed in the 1970s while the other two buildings (#1 and #3) were URM structure with RC columns. Each classroom of the building #1 had 3 bays, each of which was 3m long. Damage to the roof system and ceiling boards was found in buildings #1 and #3 while cracks in URM stone walls were found in building #2.



Site Map of SD Katekan

Building #1 : URM with RC columns

South side of building #1

Building #1

Building #1 : RC column and beam

Building #2: Stone masonry structure

Damage to corner wall

Pesu Elementary School (SD Pesu at Pesu, Kecamatan Wedi / URM+RC column / 1F)

The school had two buildings, one was seriously damaged in the roof system and the other survived the shaking. Columns having a geometry of 150mm x 150mm with 4-ϕ13 main rebars and ϕ6 hoops were provided between classrooms. Mid-span walls were 150mm thick and 500mm wide. The eaves were supported by the timber truss fastened to RC columns

provided between classrooms.


One building extensively damaged in the roof system


SD Pesu / Exposed rebars in a column supporting roof system above

Findings and Recommendations

(1) Damage to URM walls

Devastating damage was found in URM houses in Bantul Regency, Yogyakarta City, and Klaten Regency, killing residents due to heavy debris of brick walls. URM houses with RC beams and columns confining URM walls, however, were relatively less damaged, even when they were not intact. Providing RC frames to confine masonry walls, therefore, is strongly recommended to reduce structural damage to URM houses.

Educational programs would provide opportunities to train practitioners and to disseminate the important role of confining frames.

(2) Damage to Roof system

Even when a building had minor structural damage, some schools were significantly damaged in their roof system. Since the earthquake occurred early in the morning (5:53 local time), the loss of human lives was minimized. Falling debris such as bricks, ceiling boards, roofing tiles etc. are significantly life-threatening especially to school children. The structure underneath the roof should be rigid and strong enough to properly support the roof system during an earthquake. As pointed out in (1) above, providing RC frames is strongly recommended to provide sufficient in-plane and out-of-plane stiffness and strength to buildings.

(3) Beam-column joints of RC buildings

Concrete spalling at beam-column joints was observed in some RC buildings, exposing buckled longitudinal reinforcement. Some beam bottom reinforcing bars were improperly detailed and pulled out of the beam-column joints. They had 180-degree hooks in the ends but were straightly terminated in the joints without bent anchorage into the joint core concrete. Rigid beam-column joints properly confined with lateral reinforcement and beam reinforcement bent into the joint core to develop its full anchorage are most essential for RC structures to perform successfully during earthquakes.

Congestion of rebars was found in some buildings. Beams and columns therefore should be large enough to provide enough concrete volume at the beam-column joints for sufficient embedment length and anchorage of reinforcing bars.

(4) Pounding

Closely neighboring structures with narrow gaps at expansion joints in between sustained pounding damage. Expansion joints should be therefore designed and constructed properly considering deformations expected during shaking.

(5) Comparison of seismic capacity of buildings and their observed damage

School buildings in the affected areas could be categorized in several structural types. Since they were single story and had simple structural plans, their seismic capacity could be calculated based on a simplified structural model. Comparing the capacity of an identical structural plan with their observed damage in different locations may serve as a tool to estimate the earthquake intensity although strong motion records were not fully available in the affected areas. Furthermore, the obtained results would be of great help to discuss the required capacity of buildings against future earthquakes.

(6) Relationship between city development and damage distribution

Damage observed in the Yogyakarta city seemed localized, although not fully and statistically investigated during this survey, and this may be strongly affected by the development process of the affected areas (old city area, expanded new city area, volcano ash deposit area, former river stream etc.). The background history of the areas may help understand the damage distribution and propose a future city planning as well as reconstruction strategies.