Transferring lessons from recent massive earthquakes that jolted Indonesia in rapid succession

Quick survey report of the damage caused by the
July 17 2006 South Java earthquake and rehabilitations in the aftermath of the
May 27 2006 Mid Java Earthquake
and
Summary of Strategic Meeting at the Indonesian Ministry of Public Works on Sept. 19, 2006

(Version on Sept. 21, 2006)

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OBJECTIVES

Indonesian people suffered massive natural disasters in rapid succession. At 7:58 in the morning local time on December 26, 2004, a massive undersea earthquake occurred with its epicenter off the west coast of Sumatra Indonesia, causing a series of devastating tsunamis that spread throughout the Indian Ocean, The most reliable estimates have put the world wide number of persons lost at 229,866, including 186,983 dead and 42,833 missing.

A moderate-sized magnitude earthquake occurred in mid Java Island, Indonesia, at 5:53 local time, May 27, 2006. Though its moment magnitude of 6.3 (United States Geological Survey (USGS) and Earthquake Research Institute (ERI), University of Tokyo) calculated for this earthquake was not surprisingly large compared to major earthquakes that have occurred before in this country, Bantul-Yogyakarta area, with Mt. Merapi, spewing hot ash immediately north behind, was seriously ravaged. At least 6,200 people were reportedly killed, more than 30,000 injured. The earthquake was followed by an undersea earthquake again, which took place off the southern coast of Java island on July 17, 2006. The shake felt on the Java Island was not intense enough to cause any immediate casualties, but tsunami smashed into a 180 km stretch of Java's coast line about one hour, killing at least 550 people and leaving at least 229 missing. Though tsunami bulletins were issued and transferred to Indonesia by both the Pacific Tsunami Warning Center, Hawaii (PTWC) and the Japan Meteorological Agency (JMA) twenty minutes before the first tsunami attack, they were not publicized immediately.

Japan is about 4500 km away from Java, Indonesia. But Japanese people cannot view the above-mentioned earthquakes as something that cannot happen in Japan. At 6:37 local time in the morning on June 15, 1891, a massive undersea earthquake happened. The magnitude estimated for the quake was extremely large reaching 8.5 on Richter scale, but shakes felt along the eastern coast of Sanriku did not seem to be large enough to scare people, and probably was at most 2 to 3 on JMA Intensity scale (Usami). The shake was much smaller than that happened in 1889, two years before this event; the 1889 earthquake caused a little tsunami at Miyako and Ofunato. Therefore it never came across minds of people that they would get killer tsunamis, and total 26,000 were killed in the tsunami that smashed eastern coast of Sanriku about 30 minutes after the quake and surged mountain sides up to 20 to 30 m above the sea level. Another big tsunami caused by a magnitude 8.1 earthquake (2:30 AM) struck the same area in 1933, 44 years after the 1889 Sanriku earthquake. This time, the shake was really intense enough to wake up people. But people believed in a superstition that they would not get any tsunami attacks in a sunny day in winter. They again fell asleep, and about 26,000 people were killed in the tsunami flush. The lessons were not completely learned.

Deaths and those missing in earthquakes that happened in Japan in the past century make up 165,000, and among them 143,000, namely 90% of casualties, are only from the Kanto Earthquake of 1923. A massive earthquake is an extremely rare event, but once it does happen, its impact on society can be this large beyond the capacity of government. One good thing among many bad things in the Kanto earthquake was that we got enormous supports from all over the world. Many voluntary contributions came from the United States including total 525 million US dollars in cash. These donations were mostly for quick rehabilitations to be sure, but we should not forget that some of them were used for documenting and compiling the tragic experiences in scientific manner. Based on the resolution of the General Assembly of the League of Nations, 36 nations and organizations donated to the Library of the Tokyo Imperial University. The Earthquake Research Institute of this university was founded two years after the Kanto earthquake.

An earthquake research and information center will be an important facility for people to be prepared for massive earthquakes. But it will not necessarily be in a massive concrete building with lots of facilities. Research facilities are important items to be sure, but the first priority must be put on the idea that all data and lessons obtained at the cost of many lives are to be opened and transferred for interdisciplinary discussions and for rational and quick rehabilitations.

This dispatch of experts from the Japan Society of Civil Engineers (JSCE), the Architectural Institution of Japan (AIJ) and the "Engineers without Borders, Japan" was aimed first to quickly survey areas affected by both the May 27, 2006, Mid-Java Earthquake and the July 17, 2006, South-off Java Earthquake, and second, to discuss with experts from Indonesian responsible organizations including Indonesian Institute of Engineering (PII) and the Ministry of Public Works, tactics for transferring disaster prevention technologies.

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Indonesian Members for strategic meeting (Sept. 19, 2006)

Ms. Lolly Martina Martief, Head of Planning and Development, Agency for Research and Development, Ministry of Public Works

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Ir. Bachtir Siradjuddin, Secretary General, Institution of Engineers, Indonesia
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FIELD SURVEY

This chapter chronologically outlines findings obtained through a quick three-days survey (Sept. 15-17) and comments for rehabilitating affected areas and mitigating earthquake and tsunami-inflicted losses.

RISHA at the Research Center for Human Settlements (RCHS), BANDUNG

“RISHA”, short for instant-healthy-modest-house, is a method developed at RCHS for constructing cost-efficient prefabricated houses, in which precasted reinforced concrete beams are assembled together with bolts and steel plates. A cross-section of RISHA beam consists of a thin web and a lib. The beam can be made in situ. A house with 36 m^2 wide costs about 33 million RP, namely 900,000 RP per square meters. In Banda Aceh, Sumatra, about 7000 RISHA houses have been constructed for tsunami survivors, each 48m^2 wide, costing 60 million RP. A school with 3 class rooms (6*6 m^2 for each) was also built there at the cost of 800 million RP.
RCHS provides any person with a two-days training for RISHA construction on demand.

The questions raided among members follow:
1. Controlling length may be difficult when the RISHA members are assembled together as a pile foundation,
2. RISHA elements are fastened together with bolts. Too tight fastening would cause either cracking or crumbling concrete elements. Too lose fastening would cause serious deformations of assembled structures.
3. Bolts will gather rust.

(a) Two-story RISHA model house: Each structural member is 1.5 m long.

(b) Beam connection; Beams are fastened together with thin tie plates and bolts.

(c) RISHA members can be used as a foundation.

(d) A column is fastened upright with bolts at its bottom end to the foundation.

Figure 1. RIHSA model houses at the Research Center for Human Settlements (RCHS), BANDUNG

Tsunami

Many un-reinforced masonry walls confined within RC frames (CMW) were punched out due to the tsunami serge at Pangandaran. Only remaining were wall panels with interior walls built against them. These interior walls are considered to have behaved as their buttresses (Figure 2).

Glass panes can be easily broken allowing water to flow quickly into houses, where less serious structural damage was found (Figure 3).

Bamboo woven panels were assembled together for tsunami survivors (Figure 4).

Figure 2. Tsunami at Pangandalan punched out brick walls

Figure 3. It may be shop house, front face seems to be windows, these are destroyed in a early stage of Tsunami, water pressure would be released.

Figure 4. Bamboo-woven panels for survivors' houses

An island a little off a coast line can stop sands and other suspended matters immediately behind it, and eventually a thin piece of land sticking out toward the island can be formed. This topography (tombolo, Figure 5) causes tsunami heights to differ from location to location. Tsunami was seemingly higher at locations far away from the island than that immediately behind it.

Figure 5. Satellite imagery of tombolo at Pangandaran (Google Earth)

A road along the eastern beach of this sand dune was lined up by piles of short cylindrical concrete blocks that retain subgrade soils of road. The water stopped inland of the sand dune seems to have flowed back into the ocean through some points. At these points the flows seem to have been fast enough for the sand behind the bottom blocks to be eroded deep (Figure 6).

Figure 6. Cylindrical retaining blocks piled up along the beach.

Tsunami along coast line south of Yogyakarta

Though tsunami surged up about 200 m inland, it was only responsible for damage to some seaside bamboo cottages with thatched roofs. It was fortunate to come out of the aftermath of the May 27 earthquake that the tsunami was not so high as that at Pangandalan. The following pairs of photos below compare the same locations at different times (June 12, 2006 and Sept 16, 2006, before and after tsunami, respectively).

2006.06.12

2006.09.16

2006.06.12

2006.09.16

2006.06.12

2006.09.16 (Under reconstruction)

Figure 7.

Rehabilitations in the aftermath of the May 27, 2006, Mid-Java Earthquake

Schools in Bantul/Imogiri areas

Though reconstruction of schools seems to be hardly speeded up with limited amount of budget, those under reconstruction are generally in a good state of repair. Damaged bricks are all being replaced with either new or intact ones, and they are being confined with RC frames. Roofing systems are much stiffer than those before the earthquake. The following pairs of photos below compare the same schools at different times (June 12, 2006 and Sept 16, 2006, respectively).

2006.06.12 original. SD2 Parangtritis

2006.09.16 repairing. Top ends of walls are connected with RC beams

2006.06.12 SLB-PGRI TRIMULYO

2006.09.16

2006.06.12 cracks are found in the middle column

2006.09.16 Repaired, but method is unknown

2006.06.12

2006.09.16 New school on the left is under construction. The school on the right shows its original structure, No repair work has done yet.

A China organization funds the reconstruction of this school.

Roofing framework and beams along the top ends of walls are seen.

Dwellings

Devastation is seen yet as it was immediately after the earthquake. Holes in many masonry walls punched out in the earthquake were temporally patched up with bamboo-woven panels. Even thatched houses covered up with bamboo-woven panels were seen here and there. Though only a small number of houses are being repaired, they are generally in a good state of repair. Damaged bricks are all being replaced with either new or intact ones, and they are being confined with RC frames. Roofs with traditional joguro-structure are much stiffer than those before the earthquake.

A shop (?) at a corner of crossing of a road leading from Bantul to Imogiri. RC frames confine brick walls.

Beams along the top ends of walls are seen.

House at Parangtritis Beach. RC frame is observed.

Reinforcement.

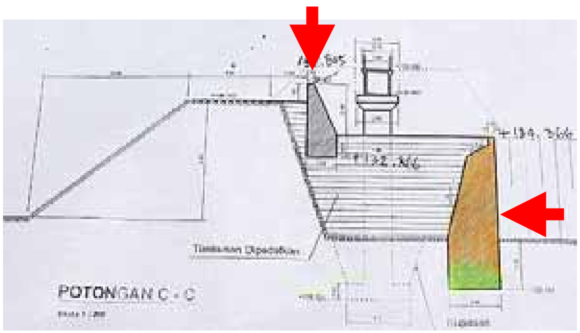
A bamboo house in Bantul

Bamboo-woven products are being sold in Bantul.

Reconstruction of Mataram canal bridge (See JSCE/AIJ Provisional Report):
A bridge of Mataram canal, supplying drinking water and irrigating 19,000 ha of land extending the lower basin of Progo and Opak river, was damaged. Two masonry abutments and four RC piers support a steel box aqueduct of 80m long. RC open channels on both riversides resting on embankments narrow to this aqueduct. The sandy soil mass of the right embankment behind the masonry abutment of about 10m high slid down towards the river. The scar was formed 26 m west behind the abutment immediately beneath a construction joint of the open channel, suggesting that water might have been seeping through the joint into the embankment soil.

Our recommendation was:
Quick restoration of the bridge is a must because of the canal's important functions. Moreover, a road running along the canal resting on the remaining soil mass of the same embankment is under a threat of subsidence. However, a complete reconstruction of the embankment will be just a stop-gap measure, and won't mitigate its geotechnical hazard potential. Even an inch settlement of the embankment will cause cracking of concrete joints, and water will leak again through the joints. A possible and efficient measure may be to replace the embankment with some piers.

Ongoing reconstruction is:
The approach of the canal bridge, an open concrete channel, is now supported by three piers, and therefore this part seems to be rationally reconstructed avoiding possible repetition of embankment erosion due to water leakage. However difficult problem seems to be lying in that a road runs along the canal on the embankment. To fully utilize the remaining embankment, a loading berm is being put at the toe and on the canal bridge side of the embankment to stabilize the slope. This loading berm is retained by about 9.5m high masonry wall standing upright. Eventually piers of the bridge are half embedded in the loading berm. Moreover to make some clearance between the road embankment and the canal bridge, a massive retaining wall is being constructed in between the canal and the road (See photos below).
➔
If the 9.5m high masonry retaining wall with no reinforcement breaks and/or displaced, the piers for the canal bridge can move with the loading berm, causing some damage to the concrete open channel of the canal.



Brief comments

1. Tsunami

Jolts may not be felt as an early sign of tsunami.
The magnitude-9.5 Great Chilean Earthquake of 1960 was the strongest earthquake ever recorded. Its epicenter off the coast of South Central Chile, generated one of the most destructive tsunamis of the 20th century. It spread across the entire Pacific Ocean, and reached Onagawa, north Japan, about 22 hours after the earthquake. In the 6m high tsunami at Onagawa and other towns along the Sanriku coast, 142 persons were killed.
➔ World-wide warning system must be established, and fully utilized.
➔ No way to stop tsunami, though a high tsunami wall can be effective. Just escape.
JFY: Japan has implemented an extensive program of constructing tsunami walls (4-5m high) in front of populated coastal areas. Floodgates and channels can redirect the water from incoming tsunamis, which require careful, quick and difficult operations.

Stopped inland water can flows back into the ocean through some narrow channels. At these channels, soils beneath structures can be eroded deep causing some structures to tilt and/or sink.

Similarities between Japan and Indonesia are to be discussed.
➔ Oga area and either Pangandaran or Cilacap:
Drawing hasty conclusions might not be appropriate regarding the tsunami height distribution.

2. Seismic motions

Are magnitudes often underestimated in Indonesia?
Tsunami in an earthquake is caused when a huge body of water is suddenly displaced by undersea dislocation of soil (faulting). It has been empirically known that a fault can appear on the ground surface when its magnitude reaches some value a little larger than 6. Reportedly (USGS), the tsunami of July 17, 2006, was the direct result of a 7.7 magnitude earthquake offshore in the Indian Ocean, while the estimate in Indonesia was 5.7.
➔ Thorough study will be a must so that estimated magnitudes and tectonic movements are consistent with the features of damage, and design earthquake motions can be rationally discussed.

STRATEGIC MEETING ON SEPTEMBER 19, 2006

Keeping in mind issues of devastating earthquakes that jolted Indonesia in rapid succession, a strategic meeting with Indonesian experts was held on Sept. 19, 2006, at the Ministry of Public Works. As the first stage for transferring knowledge, a seminar will be organized.

1. Schedule

* Someday in February.
Brainstorming Workshop for highlighting problems to be discussed and archived.

* Someday in 2007
Strategic International Seminar for making up a (virtual) Earthquake Information center. The resolution of the seminar will describe basic strategies

After 2007 Seminar
Realization of the plan

2. Involved Organizations and Counterparts

Japan side: JSCE, AIJ and Engineers without Borders, Japan (EWBJ) will be collaborating with counterpart Indonesian organizations.
Indonesian side: The key counterpart organization will be the Agency for Research and Development, Ministry of Public Works, expecting that the agency will spread threads of collaboration in all necessary directions to make up a network. Not only PII but also local governments can be involved.

3. Responsible persons
Chairman: Basuki Hadimuljono Msc, Director General, Agency for Research and Development, Ministry of Public Works
Co-Chairman: Hirokazu IEMURA (JSCE), Professor, Department of Civil Engineering, Kyoto University, and Wahuono Bintard, PII

Board members
Kazuo KONAGAI (JSCE and EWBJ), Professor, IIS, University of Tokyo,
Masaomi TESHIGAWARA (AIJ), Professor, Nagoya University, and
two persons from Agency for Research and Development, Ministry of Public Works and PII, respectively.

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