Bengkulu & West Sumatra Earthquakes, September 12, 2007, Structural Damage Report

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INTRODUCTION

On Wednesday, September 12, 2007 at 18:10 PM, Bengkulu and its surrounding areas were shaken by an earthquake. According to USGS (United States Geological Survey), the epicenter of this earthquake is at sea, 4.517°S, 101.381°E with 30 km depth and the magnitude was 8.4 Mw. The epicenter is 129 km South-West from Bengkulu. Right after the earthquake occurred, BMG (Badan Meteorologi dan Geofisika) issued a tsunami warning. The warning was not based on the alert from the early warning system that was installed along the West Sumatra province coast. The warning was merely based on "play safe" basis. However, one hour after the warning was issued, no tsunami was observed.

Another big earthquake occurred the day after, on Thursday morning, September 13, 2007 at 06:49 AM with epicenter at 2.526°S, 100.963°E, magnitude 7.8 Mw and 10 km depth in Mentawai region as can be seen in Figure 2. A third one occurred at the same day, at 10:35 AM with epicenter at 2.223°S, 99.563°E, magnitude 7.1 Mw and 10 km depth. It is not clear whether the last two earthquakes were aftershocks or whether the first earthquake triggered other earthquakes.

N0	Date	Time	Latitude (S)	Longitude (E)	Magnitude	Depth (km)
1	9/12/07	18:10:26	4.517	101.381	8.4 Mw	30
2	9/12/07	20:02:07	2.963	101.34	5.7 Mb	35
3	9/12/07	21:40:01	3.202	101.344	6 Mb	10
4	9/12/07	23:37:00	3.109	101.395	5.9 Mb	11
5	9/13/07	6:49:01	2.526	100.963	7.8 Mw	10
6	9/13/07	8:26:33	2.039	99.730	5.8 Mb	10
7	9/13/07	9:30:01	1.639	99.696	5.9 Mb	10
8	9/13/07	9:51:31	2.049	99.790	5.5 Mb	10
9	9/13/07	10:35:26	2.276	99.593	6.5 Mb	10
10	9/13/07	10:35:26	2.223	99.563	7.1 Mw	10
11	9/13/07	12:23:20	1.667	99.678	5.5 Mb	10
12	9/13/07	20:10:20	2.621	100.965	5.6 Mb	52
13	9/13/07	22:08:52	4.292	101.257	5.6 Mb	10
14	9/13/07	23:09:09	3.247	101.439	6.2 Mw	3
15	9/13/07	23:59:26	2.118	99.978	5.5 Mb	35
16	9/14/07	8:02:06	3.772	101.721	5.9 Mb	35
17	9/14/07	8:02:06	3.696	101.844	5.5 Mw	35
18	9/14/07	11:03:44	2.228	100.024	5.5 Mb	35
19	9/14/07	13:01:34	4.108	101.219	6.4 Mw	35
20	9/15/07	21:45:29	2.886	101.104	5.5 Mw	35
21	9/16/07	8:15:38	2.808	101.034	5.2 Mw	38
22	9/16/07	18:37:43	2.931	101.112	5.3 Mw	35

Figure 1.: The epicenter of the main-shock September 12, 2007 earthquake and the aftershocks.

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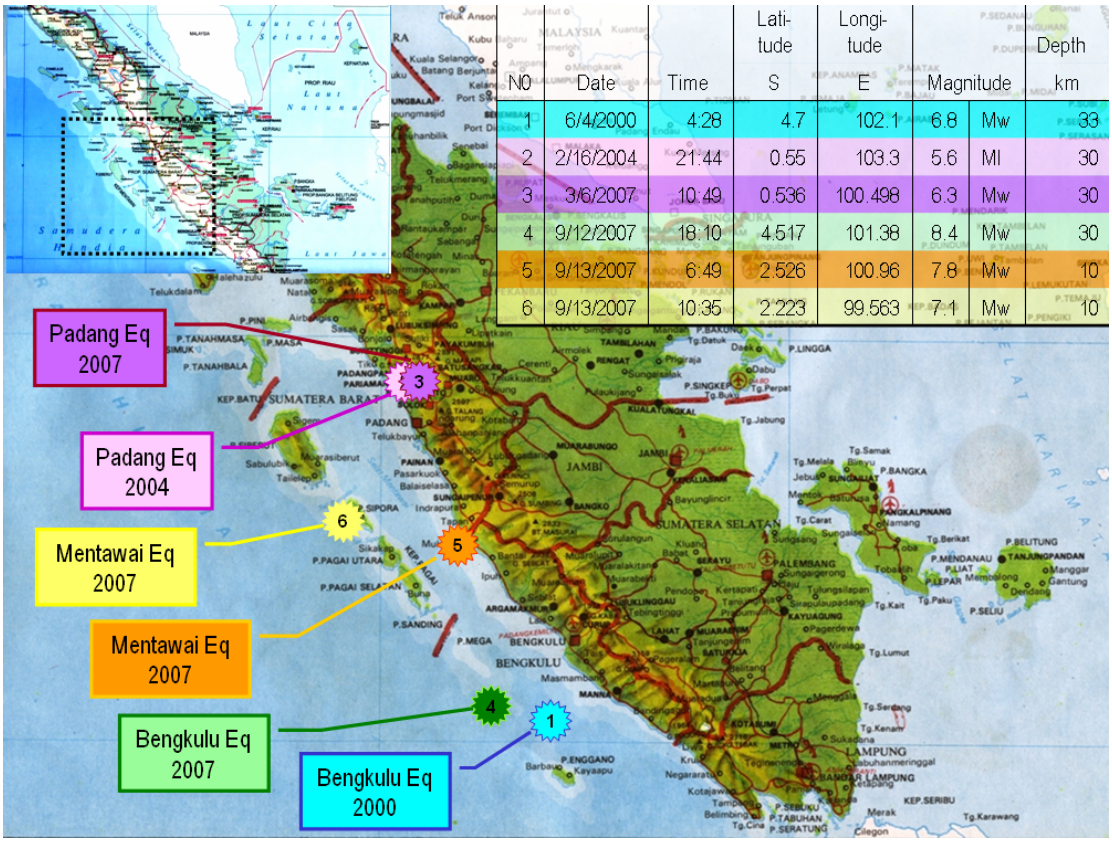
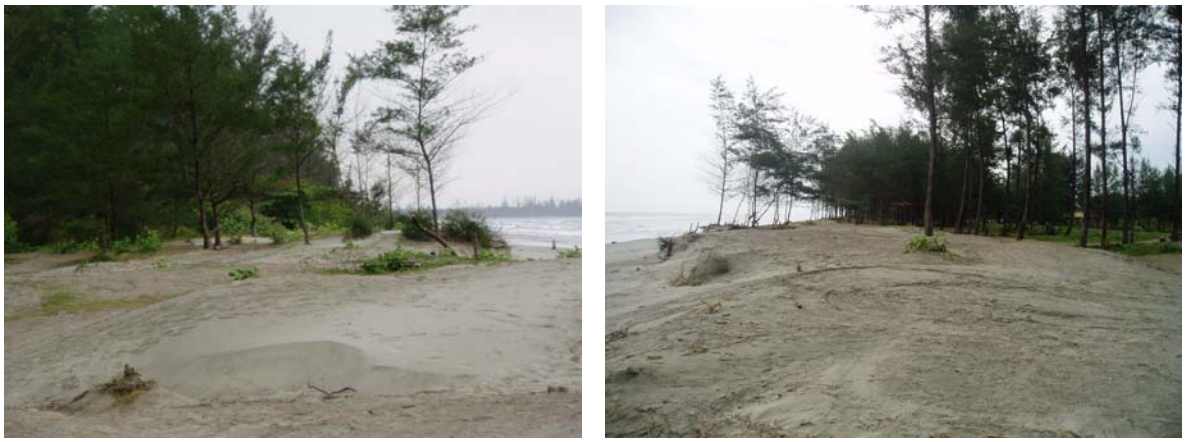


NO	Date	Time	Lati-tude S	Longi-tude E	Magnitude		Depth km
1	6/4/2000	4:28	4.7	102.1	6.8	Mw	33
2	2/16/2004	21:44	0.55	103.3	5.6	Ml	30
3	3/6/2007	10:49	0.536	100.498	6.3	Mw	30
4	9/12/2007	18:10	4.517	101.38	8.4	Mw	30
5	9/13/2007	6:49	2.526	100.96	7.8	Mw	10
6	9/13/2007	10:35	2.223	99.563	7.1	Mw	10

Figure 2.: The epicenters of big earthquakes in Padang and Bengkulu regions from 2000 up to now.

Local people who live close to the beach confirmed that there was no tsunami. For engineers it is difficult to witness traces that a tsunami was triggered by those three earthquakes, not to mention equal to the one that occurred in Aceh (2004) or in South Java (2006). In Padang, according to local people, the early warning system did not work because the system was being maintained when the earthquake occurred. According to them, storm surge like wave occurred during the earthquake, however it did not cause damage and according to them, such a storm surge like waves has been occurring since quite some time and most probably similar to that occurred in several other coastal areas in various regions in Indonesia for the past six months. Some damage occurred, however, they were caused by the earthquake shaken.



Panjang Beach, Bengkulu

Figure 3.: No indication of tsunami along the beach


Pondok Kelapa Village, Lais, North-Bengkulu


Lengayong, Pesisir Selatan, West-Sumatra

Figure 3. (Cont'd): No indication of tsunami along the beach

The damaged places visited are in Bengkulu province and West Sumatra province. The survey team also traced the places along the beach from Bengkulu to Padang. The damage in those areas was scattered. The most damaged area is at Lais in North-Bengkulu and Silaut in Pesisir Selatan, West Sumatra. There were no places / villages which were heavily damaged. The Mentawai islands, which is reported has experienced heavy damage, was not surveyed because of transportation difficulties.

Inspite of the big magnitudes, the earthquake impact was not as big as exposed by newspapers and electronic media. The number of wounded casualties were also not as many as was the case during the Yogyakarta May 27, 2006 earthquake. The health care facilities in Bengkulu and Padang did not experience an influx of wounded casualties. However, the patients in the main hospital in Bengkulu and two hospitals in Padang were unnecessarily evacuated and taken care in tents because the hospitals experienced minor non-structural damages. There was no structural damage in those hospitals, but people and particularly the medical staff were afraid of the aftershocks which were strong and occurred at short intervals after the main shocks. At M. Yunus hospital in Bengkulu, a water pipe from the reservoir was broken. According to medical staff at M. Djamil hospital in Padang, there were also some broken pipes.

Figure 4.: Non-structural damage at M. Yunus hospital, Bengkulu

Figure 5.: Non-structural damage at Bunda Medical Center hospital, Padang, West-Sumatra

Figure 6.: Non-structural damage at M. Djamil hospital, Padang, West-Sumatra

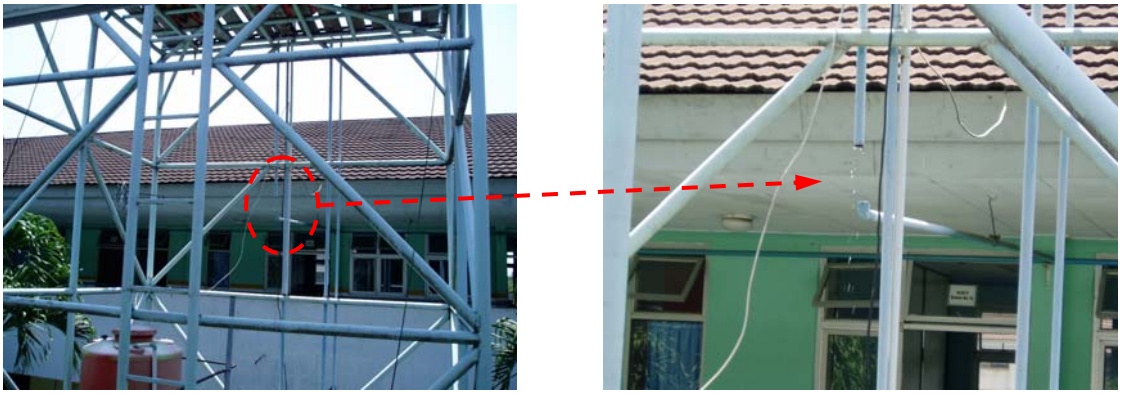


Figure 7.: Broken water pipe at M. Yunus hospital, Bengkulu

Figure 8.: Tents outside M. Yunus hospital, Bengkulu

Figure 9.: Tents outside M. Djamil hospital, Padang, West-Sumatra

Buildings that were damaged or collapsed during the September 12, 2007 and September 13, 2007 earthquakes were mostly masonry non-engineered constructions, consisting of one or two stories houses, shop houses, religious and school buildings. The main cause of the damage buildings are poor quality of construction materials and poor workmanship.

ENGINEERED BUILDINGS

In the earthquake stricken areas, there are very few “engineered” buildings, among others the hospitals and some other government buildings. Engineered buildings consist mostly of Reinforced Concrete Structures combined with masonry walls. Some very few “engineered” buildings were damaged and / or collapsed during the September 12, 2007 earthquake.

In Padang, two showrooms collapsed. In Bengkulu, one “engineered” school building, SMAK Sint. Carolus, was damaged. This building was also damaged due to June 4, 2000 Bengkulu earthquake. One building was demolished and replaced by the new one. In the September 12, 2007 earthquake, the roof of the newly constructed building collapsed.

The main cause of damage and / or collapse was because the buildings were not designed to withstand the seismicity of West Sumatra. Also poor quality of concrete and detailing contributed to the collapse of those engineered buildings. Some other “engineered” buildings suffered minor damage. In general it can be stated that the damage to engineered buildings due to the September 12, 2007 and September 13, 2007 earthquakes were negligible. This is understandable because the epicenter is some 125 km away from the West Sumatra and Bengkulu. As was the case during the Aceh Dec 2004 earthquake, only poorly built engineered buildings were damaged or collapsed.

The damage of SMAK Sint. Carolus, the newly constructed building

Figure 10.: Damage of engineered buildings

SMAK Sint. Carolus

Bengkulu Pos Office

Governor office, West-Sumatra

Figure 10. (Cont'd): Damage of engineered buildings

Telkomsel building, Padang, West-Sumatra

Telkom building, Padang, West-Sumatra

Telkom building, Padang, West-Sumatra

BPKP building, Padang, West-Sumatra

Showroom Hyundai, Al-Hidayah Rd. Padang, West-Sumatra

Showroom Mitsubishi, Padang, West-Sumatra

Figure 10. (Cont'd): Damage of engineered buildings

NON-ENGINEERED BUILDINGS

Almost 95 % of the buildings in the earthquake stricken areas are masonry “non-engineered” buildings consisting of half brick thick confined masonry walls. The confinement consist of reinforced concrete framing, consisting of the so called “practical columns and beams”. “Practical columns”, size 120x120mm with four 10 or 12 mm diameter bars as longitudinal reinforcement and 8 mm stirrups spaced at 150-200 mm, are commonly cast after the construction of the masonry walls is complete, and sometimes the “practical columns” were cast first. “Practical beams”, size 150x200 mm with four 10 or 12 mm diameter bars as longitudinal reinforcement and 8mm stirrups spaced at 150-200 mm, are cast directly on top of the foundation and served as tie beams. Similar beams, size 120x200 mm with four 10 or 12 mm diameter bars as longitudinal reinforcement and 8 mm stirrups spaced at 150-200mm, are cast directly on top of the brick wall and served as ring beams. Almost all buildings have timber roof trusses with galvanized iron sheets roofing. Few buildings used clay tiles for roofing. The buildings mostly used saddle type roof trusses.

Typical concrete compression strengths range from 12.5 MPa to 15.0 MPa with rebar having a yield capacity of 240 MPa. The masonry infill wall is made of 50 x 100 x 200 mm brick using running bond with mortar thickness ranging from 8-15mm. The mortar mix usually consists of ranging from 1 sand: 3 cement to 1 sand: 4 cement. The walls are plastered on both sides with sand and cement mortar of approximately 10 mm thickness. Such type of masonry construction has become a *new culture* all over Indonesia and from past earthquakes it is evident that **provided** they were built with good quality materials and good workmanship, they survived the most probable strongest earthquake in accordance with the Indonesian seismic hazard map. In 1978, the author encouraged the use of such r.c. framing for masonry walls as can be seen in Ref. 29.

Perumnas at Air Manjunto Rd., Bengkulu

Lempuing, Bengkulu

Muko-Muko, North-Bengkulu

Padang, West-Sumatra

Figure 11.: One or two stories masonry non-engineered buildings

However, like in other areas in Indonesia, the reinforcement of the practical columns and beams are mostly not in accordance with the requirements as mentioned earlier. The reinforcing bars detailing are also not appropriately done for earthquake resistance. The buildings are not designed well and constructed based on the wrong prevailing practice. Non-engineered masonry buildings failures due to seismic shaking are caused by out-of-plane bending failure of walls, and / or in-plane shear failure and resulted either in total structural collapse or could result in "typical" damages such as walls tend to tear apart; walls tend to collapse; failure at corners of walls; failure at corners of openings; walls tend to shear off diagonally and additional shear due to twisting or warping for unsymmetrical building. Factors contributing to such failures are weak connection between wall and wall, wall and roof, wall and foundation; seismic forces are not properly transferred into the supporting walls and frames.

In general, the damage and collapse of the non-engineered reinforced masonry buildings during the September 12, 20007 and September 13, 2007 earthquakes are mostly caused by the poor quality of materials and poor workmanship, resulting in, among others poor detailing, poor mortar quality, poor concrete quality, and poor brick laying. It is a common practice that roof trusses are not strongly anchored to the ring beams. Non-engineered buildings in this category include one or two stories houses, house shops, religious and school buildings.

Puskesmas Pal 30 Village, Lais, North-Bengkulu

SMUN 1, Pal 30 Village, Lais, North-Bengkulu

Figure 12.: Walls tend to tear apart

Pondok Kelapa Village, Lais, North-Bengkulu

Pasar Palik Village, Lais, North-Bengkulu

Figure 13.: Failure at corners of openings

Pal 30 Village, Lais, North-Bengkulu

Lunang Silaut, Pesisir Selatan, West-Sumatra

Figure 13. (Cont'd): Failure at corners of openings

Pal 30 Village, Lais, North-Bengkulu

Pal 30 Village, Lais, North-Bengkulu

Figure 14.: Diagonal cracks in walls due to out of plane loading

Pondok Kelapa Village, Lais, North-Bengkulu

Pal 30 Village, Lais, North-Bengkulu

SMPN 1, Pal 30 Village, Lais, North-Bengkulu

SMPN 1, Pal 30 Village, Lais, North-Bengkulu

SDN 02, Pal 30 Village, Lais, North-Bengkulu

Figure 15.: Walls collapse due to out of plane loading

Pasar Palik Village, Lais, North-Bengkulu

Pal 30 Village, Lais, North-Bengkulu

SMPN 1, Pal 30 Village, Lais, North-Bengkulu

SMPN 1, Pal 30 Village, Lais, North-Bengkulu

Puskesmas Pal 30 Village, Lais, North-Bengkulu

Figure 16.: Poor reinforcement detailing and poor workmanship

SMUN 1, Pal 30 Village, Lais, North-Bengkulu

SMPN 1, Pal 30 Village, Lais, North-Bengkulu

Muko-Muko, North-Bengkulu

Puskesmas Pal 30 Village, Lais, North-Bengkulu

Muko-Muko, North-Bengkulu

Parking area of BPKKD Muko-Muko, North-Bengkulu

Figure 16. (Cont'd): Poor reinforcement detailing and poor workmanship


Lubuk Sanai Village, Muko-Muko, North-Bengkulu


Lubuk Sanai Village Lubuk Pinang Village

Muko-Muko, North-Bengkulu




Lubuk Pinang Village, Muko-Muko, North-Bengkulu

Figure 16. (Cont'd): Poor reinforcement detailing and poor workmanship

Front view

Side view

Muko-Muko, North-Bengkulu

Figure 17.: “First soft story” type of failure

Pondok Kelapa Village, Lais, North-Bengkulu

Pasar Palik Village, Lais, North-Bengkulu

Kota Agung Village, Lais, North-Bengkulu

Figure 18.: Totally collapsed buildings

Kota Agung Village, Lais, North-Bengkulu

Pal 30 Village, Lais, North-Bengkulu

Lubuk Sanai Village, Muko-Muko, North-Bengkulu

Lunang Silaut, Pesisir Selatan, West-Sumatra

Figure 18. (Cont'd): Totally collapsed buildings

A two story shop house building with a first soft story was damaged. The media and local people reported that the damage was by settlement of the ground, however, no evidence of settlement could be seen and the damage was because of the first soft story.

Front view

Side view

Figure 19.: Collapsed of "first soft story" building at Padang Jati Rd., Tanah Patah, Bengkulu

Figure 19. (Cont'd): Collapsed of "first soft story" building at Padang Jati Rd., Tanah Patah, Bengkulu

There were few timber houses consisting of a timber frame and also timber planks walls and usually use galvanized iron sheets as roof. This type of buildings will gradually be abandoned and replaced by the confined masonry as soon as the owner manages to secure the fund. Timber buildings in general are earthquake resistant and survived the September 12, 2007 and September 13, 2007 earthquakes. Some timber buildings were damaged or collapsed because of deterioration due to lack of maintenance.

Lempuing, Bengkulu

Pondok Kelapa Village, Lais, North-Bengkulu

Kota Agung Village, Lais, North-Bengkulu

Lubuk Pinang Village, Muko-Muko, North-Bengkulu

Figure 20.: Timber houses

Linngosari Baganti, Pesisir Selatan, West-Sumatra

Figure 21.: Timber house collapsed due to lack of maintenance

INFRASTRUCTURE

Although some non-engineered masonry buildings were damaged by the September 12, 20007 and September 13, 2007 earthquakes, almost all infrastructures are practically intact. Several cracks were observed particularly at Lais along the road from Bengkulu to Lais. However the cracks occurred in limited areas only. There was indication of potential landslides along the roads.

Kota Agung Village, Lais, North-Bengkulu

Kota Agung Village, Lais, North-Bengkulu Pal 30 Village, Lais, North-Bengkulu

Figure 22.: Cracks along roads from Bengkulu to Padang

Pal 30 Village, Lais, North-Bengkulu

Roads along Lais to Ketahun

Roads along Lais to Batik-Nau

Roads along Lais to Batik-Nau

Figure 22. (Cont'd): Cracks along roads from Bengkulu to Padang

There was a slight disturbance in electrical power supply. Some of the electric poles were damaged. One bridge was slightly damage along the road at Pal 30 Village, Lais, North-Bengkulu. Telecommunication towers, railways and port were practically not affected by the earthquake.


From Lais to Ketahun

Figure 23.: Electric poles damage




Figure 24.: One bridge was damaged at Pal 30 Village, Lais, North-Bengkulu

Figure 25.: Minor damage at bridge in Padang, West-Sumatra

Figure 26.: Port at Teluk Bayur, Padang, West-Sumatra

FIRE AFTER THE EARTHQUAKE

Right after the earthquake, the top part of Plasa Andalas, a market in Padang caught fire due to the overturning of a gas stove. However the fire could be contained and extinguished and did not spread to other buildings. The fire originated from an overturned gas stove of a restaurant located at the top part of Plasa Andalas.

Figure 27.: The top part of Plasa Andalas, a market in Padang, caught fire right after the earthquake

FACTS WORTH MENTIONING – MEDIA COVERAGE

Right after any earthquake in Indonesia, the media started interviewing "experts" in tsunami, earthquake engineering and geologists. Many of the experts interviewed most of the time are researchers who has not yet visited nor interested to learn from the actual condition in those earthquake stricken areas. Needless to say, all "experts" that were interviewed considered their field of expertise as the most important and therefore, the media is filled with all sorts of opinions which are confusing the common people.

a. Based on the media coverage, almost everybody, including the government was lead to believe that a big magnitude earthquake is equivalent to disaster. While in reality, magnitude is not directly related to damage and disaster. However, such news became a very effective mean for exaggerating the severity of damage, by presenting mark up figures of the number of buildings and / or infrastructure damage and / or collapsed number of casualties etc. for the purpose to collect more funds for the "reconstruction".

b. Right after the first earthquake struck, tsunami experts started modeling the tsunami and publish their findings that in Padang a tsunami wave of 2 m did occur and that based on the same modeling, a tsunami wave of 4 m will occur in Bengkulu. This is confusing and not in accordance with the facts on the ground and in spite of the fact that the early warning equipments installed along the coast of West Sumatra were not triggered and did not issue tsunami warnings. It was also surprising that the early warning system was not functioning at the time when the September 12, 2007 earthquake occurred and that the warning issued by BMG through mass media was not based on the expensive tsunami early warning system that was installed soon after the Aceh tsunami of December 26, 2004.

c. Geologists were giving statements that the three big earthquakes of September 12, 2007 and September 13, 2007 were "foreshocks" that will be followed by a M9 earthquake in the near future. This did cause panic, particularly because such news was spread through sms. If such theory is correct, maybe the current methods used in PSHA and adopted worldwide to create a seismic map (including Indonesia) should be revised.

d. Seismologist at the BMG (Badan Meteorologi dan Geofisika) always unnecessarily release to the media the hundreds of aftershocks recorded after any earthquake, irrespective of the magnitude and without explaining that in general aftershocks are smaller than the main shock and that if a building is intact after the main shock, it is hardly unlikely that the aftershock will cause collapse. Such announcement always created panic among the common people and is exaggerated by government officers by unnecessarily advising people to sleep in tents outside their houses. A list wills all the aftershocks are useful for experts and not for the common people.

e. The actual real problem is the damaged or collapsed of non-engineered construction during the September 2007 earthquakes and almost nobody is highlighting the need to make all non-engineered construction earthquake resistant. This shall be made as the main target of the government, to create awareness for the need to build earthquake resistant, non-engineered construction.

f. What is really needed is to create awareness that Indonesia is an earthquake prone country and that all construction shall be made earthquake resistant. Statements from "experts" as mentioned earlier will no doubt create "scare-ness" instead of awareness and unless this is done, history will be repeated in future earthquakes.

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