

The Characteristics of M8.7 Nias Earthquake of March 28, 2005 and Induced Tsunami and Structural Damages

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Abstract

A very large earthquake with a magnitude of 8.7 occurred nearby Nias Island of Indonesia on March 28, 2005. Although the magnitude of the earthquake was large, the scale of the induced tsunami was very small. This may be due to the particular sea topography and the small amplitude of the uplift of the seabed. Strong ground motions induced heavy casualties and damages to structures. Although the magnitude of this earthquake was much smaller than that of December 26, 2004, the induced strong ground motions were much higher. The earthquake induced widespread liquefaction and lateral spreading. This phenomenon was the primary cause of heavy damage to bridges and buildings in Nias Island.

1. INTRODUCTION

An earthquake with a magnitude of 8.7 occurred on March 28, 2005 nearby Nias Island soon after the North Sumatra Earthquake of December 26, 2004 (Figure 1). The epicenter location determined by HARVARD was

close to Nias Island, where the heaviest damage observed. The number of casualties is said to be more than 850. However, there are some discrepancies on the number of casualties between the Indonesian official records and UN records. Anyhow, the town of Gunung Sitoli on Nias Island was most severely hit by this earthquake. The casualties and injuries were mainly

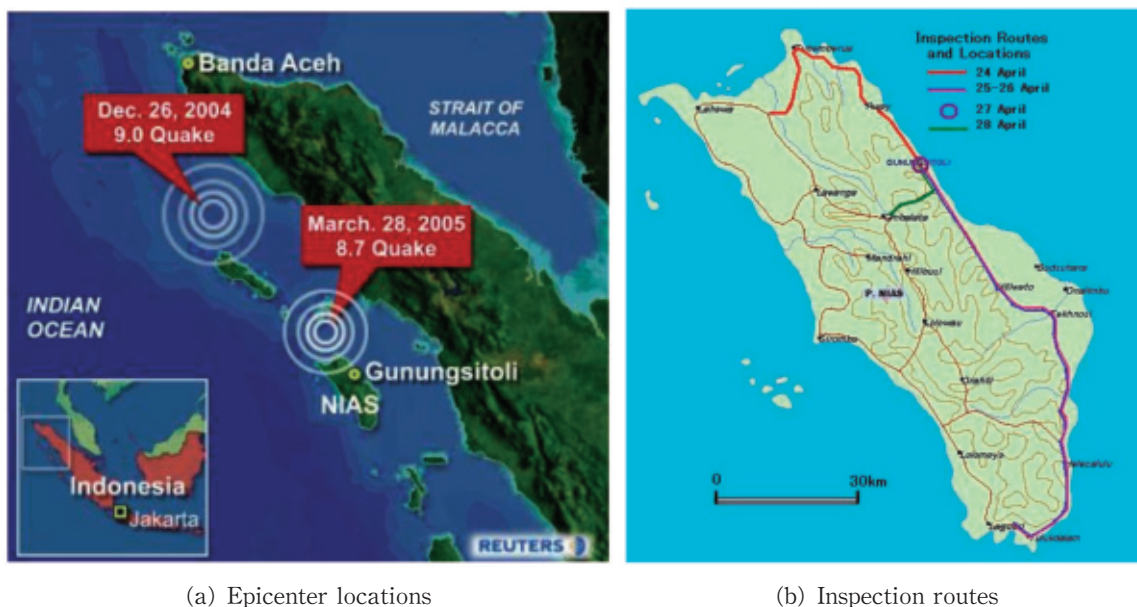


Figure 1 Epicenter of Nias earthquake and inspection routes

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caused by the collapse of RC buildings and brick and wooden houses. This earthquake is somewhat surprising as it occurred in the region, which was assumed to have been partly ruptured in 1861. The dominant faulting mechanism was inferred to be thrust-type and it was gently inclined towards NE. Compared with the strong ground motions induced by the Mw9.3 North Sumatra Earthquake, very strong ground motions were observed, which resulted in heavy damage in coastal cities and towns along the eastern shore of Nias Island. The strong ground motions also induced widespread ground liquefaction along the eastern shore of the island, which severely damaged buildings, bridges and roadways. The authors carried out site inspections soon after the earthquake on the behalf of Japan Society of Civil Engineers to provide expertise knowledge and suggestions to local engineers and authorities for the reconstruction and rehabilitation works. The technical inspections and recommendations are also the first work of *Engineers Without Borders (EWOB)*. This article describes the characteristics of M8.7 Nias Island earthquake and induced tsunami and structural damages.

2. THE CHARACTERISTICS OF THE EARTHQUAKE

The epicenters determined by USGS and HARVARD differed from each other. While USGS estimated the hypocenter just beneath Banyak Island, Harvard's epicenter was further SW and nearby Nias Island. Since the damage was much heavier in Nias Island and no damage was observed in Banyak Island, the estimation by HARVARD is likely to be very close to the actual epicenter. The initial estimation of the magnitude (Mw) of the earthquake by USGS was 8.1 and it was revised to 8.7. HARVARD estimated that the moment magnitude (Mw) of the earthquake as 8.6 (Table 1).

The faulting mechanism of the earthquake estimated by several institutes. HARVARD inferred the dominant faulting mechanism to be thrust-type, while USGS inferred the dominant faulting mechanism to be sinistral strike-slip (Figure 2). However, the fault plane is very gently inclined and its inclination ranges between 4 and 7°. Yagi of BRI (2005) inferred the slip propagation and he estimated relative slip at the hypocenter as about 10m.

Table 1 Main characteristics of the earthquake inferred by various Institutes

Institute	M	Mw	LAT (N)	LON (E)	DEP (km)	NP1 strike/dip/rake	NP2 strike/dip/rake
USGS	8.7	8.7	2.09	97.016	21.0	251/4/29	132/88/93
HARVARD		8.6	1.64	96.980	24.9	329/7/109	130/83/88

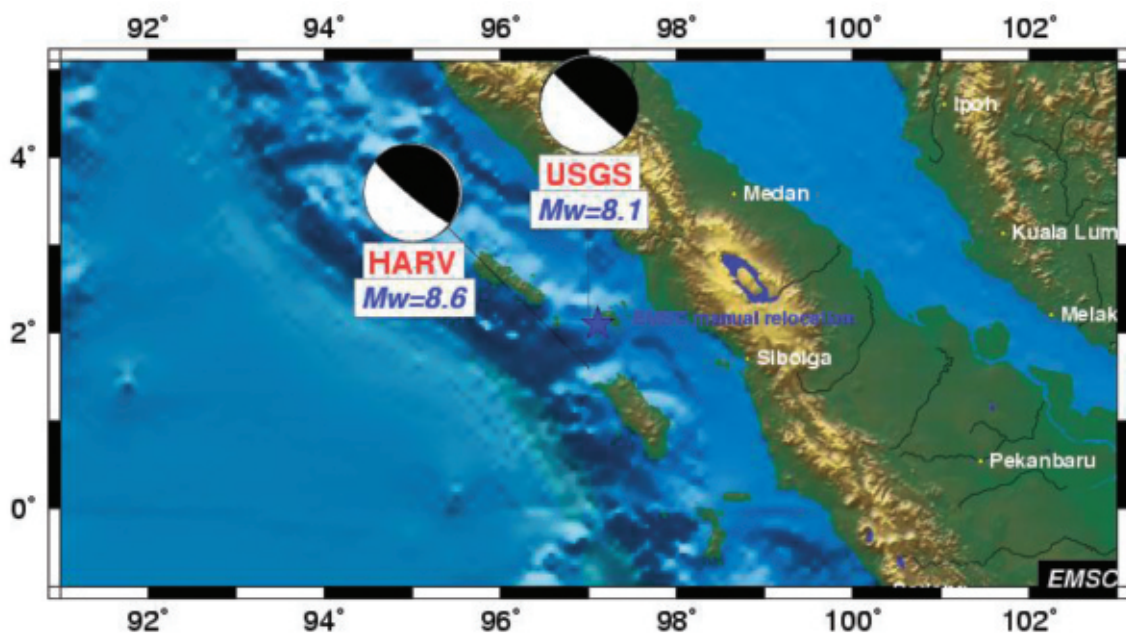


Figure 2 Faulting mechanisms inferred by USGS and HARVARD (EMSC)

Furthermore, he inferred that the propagation proceeded towards Nias Island. The estimation of Yagi (2005) for the vertical displacement is 2.4m on the ground surface while the vertical average displacement of the sea bed was estimated to be about 0.7m together with use of the fault inclination data of HARVARD and Aydan's empirical relations (Aydan 1997; Aydan et al. 2002) in this study (Table 2).

USGS released a map on the tectonics of the earthquake region as shown in Figure 3. The Indo-Australian plate obliquely subducts beneath Euro-Asian plate along the Sunda subduction zone. The earthquakes in this region are mainly due to thrust faulting with a slight dextral sense of slip. The earthquake occurred in the Sunda subduction zone and the rupture area consists two parts. One part remained as non-ruptured in the 2004 earthquake while the other part was ruptured in the 1861 earthquake with a magnitude of 8.5. Therefore, the

region was a seismic gap and this gap was broken soon after the 2004 event. If the regions ruptured in 1861 and 1833 are correctly depicted, it seems that there is an additional seismic gap in the vicinity of Batu Islands. However, this region experienced an earthquake with a magnitude of 7.7 in 1935. If any earthquake occurs to the south of this region, that seismic gap could be the potential area for a future earthquake nearby Sumatra Island.

3. TSUNAMI

Tsunami warnings were immediately issued by Pacific Tsunami Warning Center and Japan Meteorological Agency to the countries concerned following the earthquake. This quick response was highly appreciated all over the world after the sad experience of the 2004 event. Bureau of Meteorology of Australia as shown in

Table 2 Rupture and slip characteristics of the earthquake fault

Reference	Magnitude	Length (km)	Slip (m)	Area (km ²)
Yagi (BRI)	8.7	470	10.0	470×100
Aydan	8.3 (Ms)	583	5.83	583×40

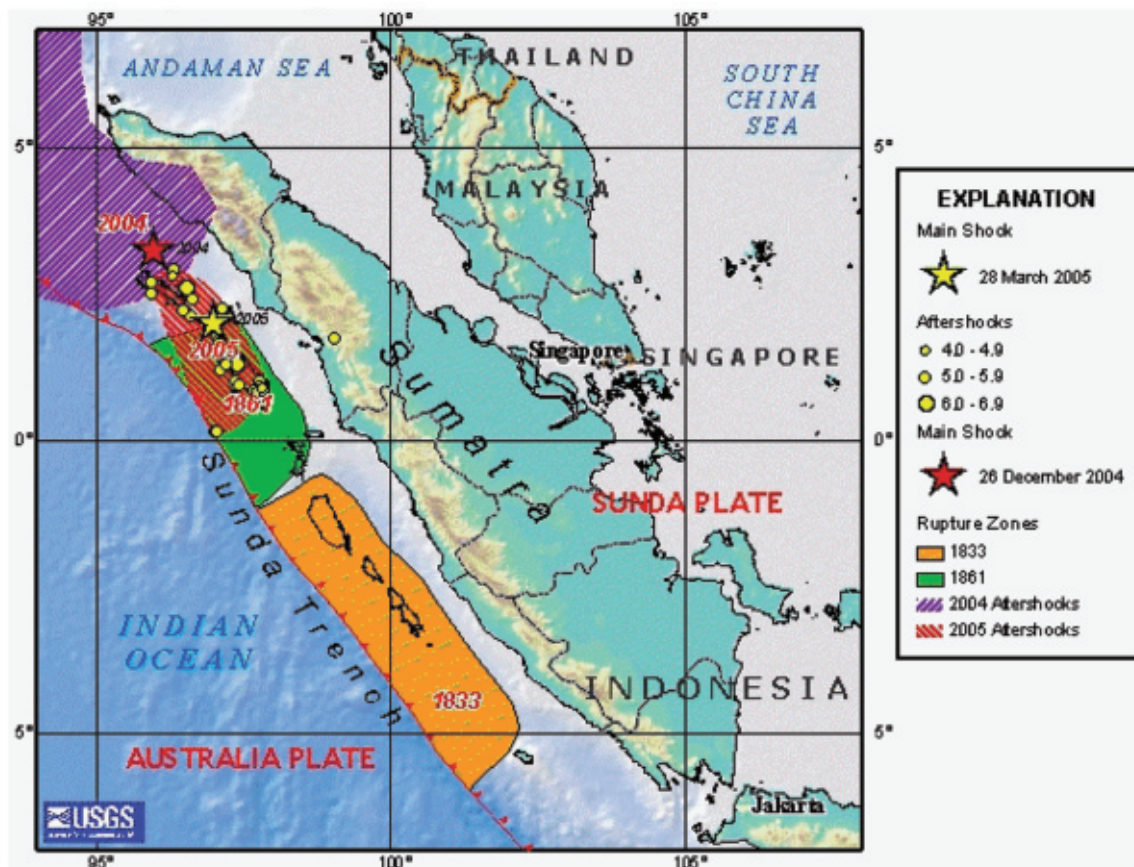


Figure 3 Tectonics of the earthquake region and ruptured zones by the previous earthquakes (USGS)

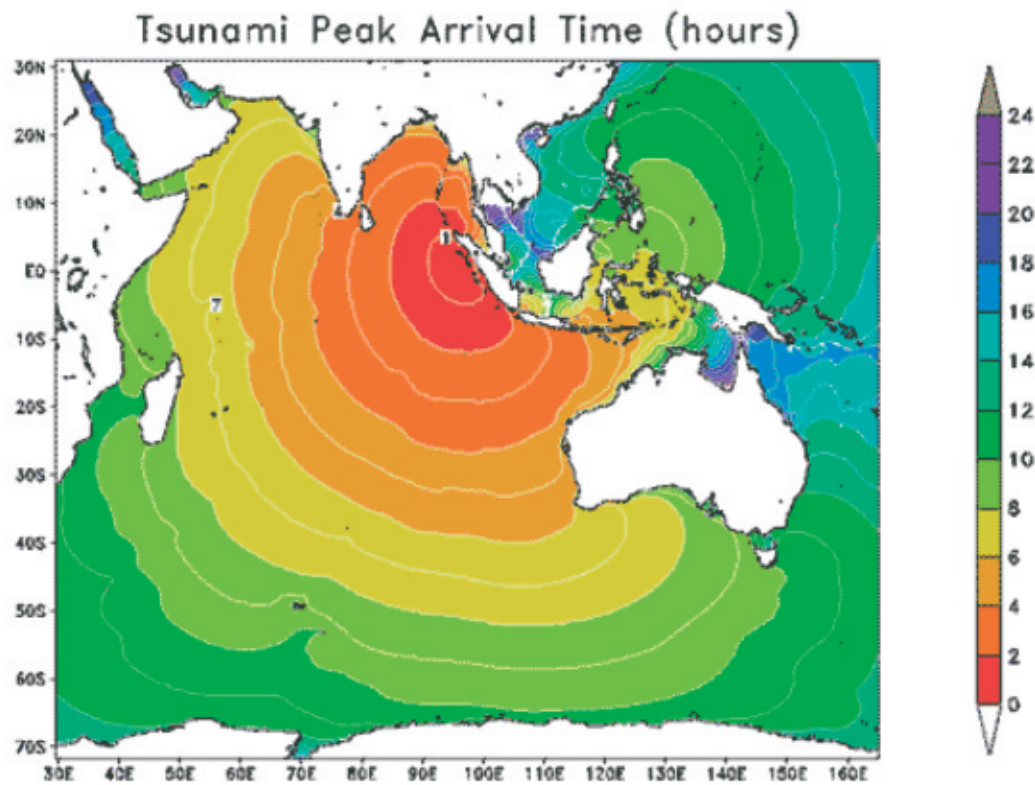


Figure 4 Travel time estimated by Bureau of Meteorology of Australia



Figure 5 Location of towns affected by the earthquake and induced tsunami

Figure 4 estimated the travel time and wave height of the tsunami induced by the 2005 event. The estimated wave height of the tsunami was more than 3m. However, the actual scale of the tsunami induced by this

earthquake was quite small. The areas hit by the tsunami are Simeulue Island, Singkil district on Sumatra Island, Nias and Banyak Islands (Figure 5). The observed wave height was 3-4 meters in Simeulue Island.

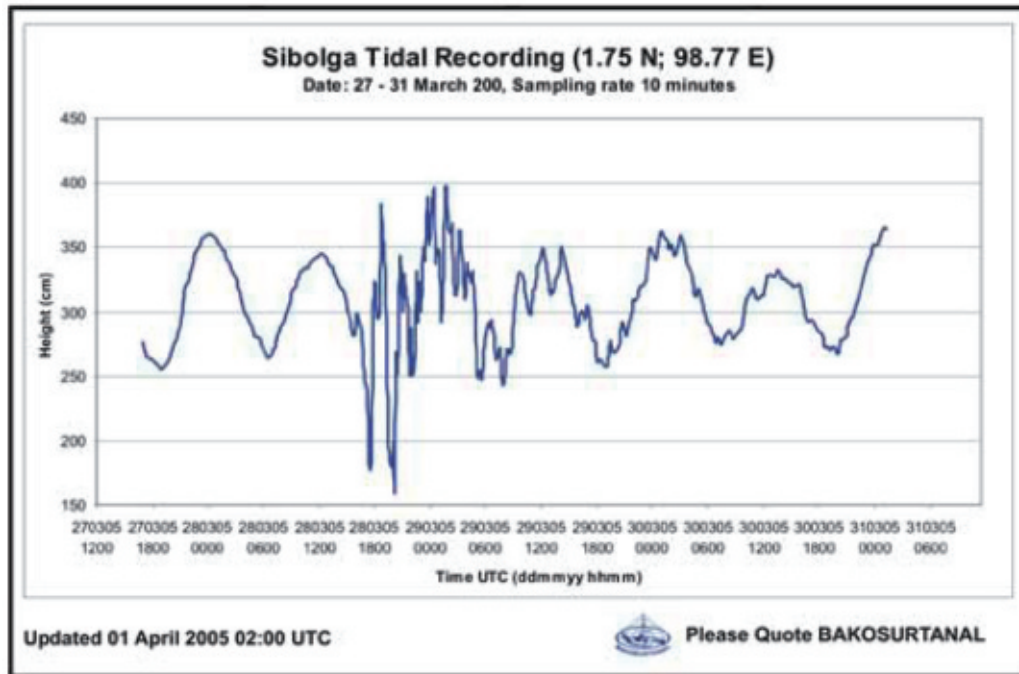


Figure 6 Tide gauge record at Sibolga station (from BAKOSURTANAL)



Figure 7 Traces of Tsunami in Banyak, Sumatra and Nias Islands

Indonesian Meteorological Agency has some tide gauges along the west coast of Sumatra Island. The highest wave was recorded at Sibolga tide gauge and it was more than 1m (Figure 6). The effects of tsunami were observed at Telukdalam and Thuemberua districts (Figure 7). The tsunami height could be about 4–5m in Thuemberua district while this value was less than 2m in Telukdalam district. A 2-metre wave struck the village of Sirombu on the west coast of Nias. Singkil residents have also reported that tsunami hit the coastal area and it was up to 4 meters high. Flooding up to a meter was also reported from as far north as Meulaboh.

According to the Pacific Tsunami Warning Center (PTWC) tide gauges in the Indian Ocean recorded minor wave activity in the Australian Cocos Island (10–23cm), the Maldives (15cm) and Sri Lanka (25–30cm). There were also reports of the recession of the sea from Chennai, Mamallapuram, Ramanathapuram district and Tuticorin district in Tamil Nadu and at Machilipatnam in Andhra Pradesh in India.

4. STRONG MOTIONS

There is unfortunately no acceleration record in any of Simeulue, Nias and Banyak Islands and the west

coast of Sumatra Island. Therefore, it is almost impossible to know the exact ground motions during this earthquake. The only way is to infer the strong motions from the collapsed or heavily damaged structures such as reinforced concrete buildings, masonry or wooden houses and walls. The authors inferred the MKS intensity as IX from the observations of the collapsed buildings. Furthermore, the maximum ground accelerations should be ranging between 300 and 900 gals depending upon ground conditions using the approach proposed by Aydan (2002) (Figure 8).

USGS also conducted a hearing survey on the seismic intensity felt by the people in the earthquake region and neighboring countries. The seismic intensity was also assigned as IX on MKS intensity scale in Gunung Sitoli in Nias Island.

5. STRUCTURAL DAMAGES

5.1 Buildings

The reinforced concrete structures are framed structures with integrated or non-integrated in-fill walls. The reinforcing bars are generally smooth and infill walls are built with red-burned solid clay bricks using mortar. The floor height in the region ranges between 3

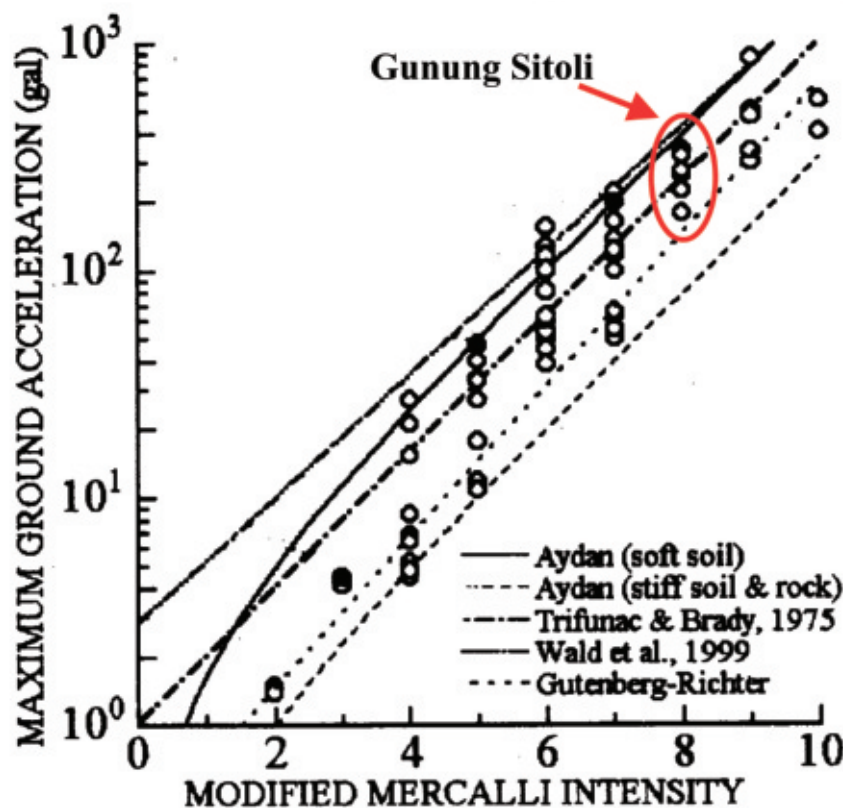


Figure 8 Inferred maximum ground acceleration (A_{max})

to 4m. The inspections of the reinforced concrete buildings indicated that they are mainly failed in the pancake mode. RC buildings are generally found in cities and towns such as Gunung Sitoli, Telukdalam and Tetelesi. The concrete buildings having 2 or more stories were either collapsed or heavily damaged. The concrete buildings in Simeulue Island were also heavily damaged or collapsed. The collapse of Sinabang hospital in Simeulue Island, which was a reinforced concrete building, killed 3 people. The collapsed or heavily damaged RC buildings were all located in lowland areas nearby shores and riverbanks.

There are many churches in Nias Island built as RC framed structures. The towers and main compounds of churches were collapsed or heavily damaged and the causes of damage or collapses of churches were exactly the same as those for RC buildings. In addition, the complete or partial landslides and movements of slopes caused the heavy damage to churches situated on hills.

The main causes of the collapse or heavy damage of the structures in this earthquake can be broadly classified as follows:

- a. Soil liquefaction and lack of the soil bearing capacity in the coastal areas and nearby river banks
- b. Fragile structural walls and lack of lateral stiffness,
- c. Poor concrete quality and workmanship,
- d. Plastic hinge development at the beam-column joints,
- e. Lack of shear reinforcement and confinement,
- f. Soft story,
- g. Pounding and torsion and
- h. Ground motion characteristics (i.e. multiple shocks, long duration etc.).

The causes (a) and (b) should be generally regarded as site effects and local ground conditions, which affected residential apartment buildings in the region. Although it is not known exactly, the 15-20 percent of damaged buildings in the Gunung Sitoli either settled up to 1m or tilted and toppled due to ground liquefaction and associated lateral spreading (Figure 9). Due to high level of underground water table and liquefaction of the ground, buildings without raft foundations and continuous tie beams could not resist to ground failures unless they are built on piles extending into the non-liquefiable layers. Compared to those of December 26 2004 earthquake, so many buildings were affected due to the liquefaction in this earthquake.

The reclaimed area in the coastal region of Gunung Sitoli was strongly affected by the quake. Along the shore of Gunung Sitoli, settlement and lateral spreading of ground occurred. As a result, many buildings in a zone for a distance of about 800m from the shore were partially settled and dilapidated (Figures 9). At Fofold along the northern shore of Nias Island, even single story buildings were heavily damaged. The ground was wavy and sand volcanoes could be observed around the area. Although the trace of sand boiling could not be seen on ground at Telukdalam, many RC buildings along the shore were collapsed or damaged. Similar events were also observed along riverbanks.

Fragile structural walls and lack of lateral stiffness were another reasons for the collapse or heavy damage although some grooves on the column were constructed in order to increase the integrity of the frame with walls. Although the walls were made of solid red burned clay bricks, they were quite slender (300/10-300/15). These walls were easily come down in the out-of-plane failure mode.

The poor construction quality and structural design problems should be cited as one of the causes of heavy damage to buildings. The spacing of stirrups was too large and they were too thin for (a) shear resistance and (b) confinement of concrete. Spacing is generally 200 mm or larger for a column even at the column ends and their diameter is 8mm. Furthermore the hoops of stirrups are bent 90-degree instead of required 135-degree bent by the modern seismic design codes. As a result the stirrups become loose following the spalling of concrete cover. The spacing of stirrups at member ends for instance in for a shear wall is more than, 200mm, which is too large for preventing diagonal shear crack formation). Although seismic codes require cross ties to confine the concrete, they were non-existent in almost all collapsed RC buildings. Beam-column joints were not designed to transfer shear force and no lateral reinforcement was placed in these joints. Figure 10 clearly shows one of the causes of the heavy damage to RC buildings and illustrates the plastic hinge occurrence at the joint. The ductility provided by the members and the connections was apparently not sufficient to resist such high-level reversed cyclic earthquake loadings and imposed large deformations.

Buildings at the corners of streets collapsed as a result of pounding by the adjacent buildings This is probably one of the important problems in most of cities and towns in Nias Island. Many buildings had shops at their



Figure 9 Effects of liquefaction and lateral spreading on RC buildings



Figure 10 Typical poorly constructed column-beam joints

ground floor. Since there are generally no shear-walls to take up the load during earthquakes, the total load is transferred onto the columns. The super structure acts a top-heavy structure on the columns and in-fill walls, which are in poor contact with columns and beams, has no effect against the earthquake loading and they fail subsequently as seen in Figure 11.

The use of non-clean Coral Sea sand caused the poor adhesion of concrete and the corrosion of steel bars, which subsequently reduced the resistance of columns and beams against lateral loads. This is a quite serious problem for buildings constructed in town and villages

along the shores of Nias Island. The collapses and heavy damage of RC buildings in Telukdalam town, which is about 150km from the epicenter, may be associated with soft ground condition in addition to the problems mentioned above. It seems that the ground shaking may be amplified in soft ground, as it is the common case for shaking in coastal areas due to earthquakes in inter-plate subduction zones.

Wooden houses may be divided into modern and traditional types. Many wooden houses are elevated from ground. Although wooden houses generally performed well during earthquake, the damage or collapse of the



Figure 11 Failure of buildings due to soft floor effect



Figure 12 Damage to wooden houses and schools

wooden houses was mainly caused by the dilapidation of super structure as a result of differential settlement and lateral spreading of liquefied ground and landslides (Figure 12).

Traditional houses are built with good material and good workmanship, and the damage to this type houses is almost nil except those induced by partial landslide and permanent movement of slopes. The superstructure utilizes good quality cylindrical wooden beams together with truss-type construction method. The villages having traditional houses are all located on hills, where ground motions may be amplified due to topographical effect. When the houses were very close slope crest, some ground cracks with a separation of 100mm and 60 mm settlement caused the dilation of super-structure (Figure 12). Since these buildings accommodate some relative displacement, the damage was generally non-noticeable in the super-structure.

5.2 Damage to Roadways and Bridges

Roadways are generally narrow (less than 5m) and the asphalt surfacing of roadways is generally in poor condition having many potholes. Besides the poor condition of the asphalt surfacing of roadways, the damage was caused by landslides, lateral spreading of liquefied ground, embankment failure (Figure 13). The cracks on the roadway pavement were either longitudinal or perpendicular or both to the road alignment. Longitudinal cracking was generally associated with lateral dilation of roadway embankment. Perpendicular cracking to the road alignment was generally observed nearby bridge abutments due to lateral spreading of ground. However, such cracking was also observed in areas, which are non-affected either by landslides or lateral spreading. Although the reason is still unknown, a possible explanation may be related to the fracture propagation during faulting.

Bridges in Nias Island may be broadly classified as a) Truss bridges, b) RC bridges, c) RC Box Culvert



Figure 13 Damage to roadways

Bridges, d) Wooden paved steel framed bridges, and e) Wooden bridges. Long span bridges are either truss bridges or RC bridges with or without box culverts. The bridges are designed as simple-supported structures. The bearing supports of many bridges do not have shear-keys or stoppers against both horizontal and vertical movements. The heavily damaged non-accessible large bridges within the surveyed area are Muzoi Bridge between Gunung Sitoli and Lahewa route and Gawo Bridge between Gunung Sitoli and Telukdalam nearby Tetelesi. These bridges consist of truss super-structures and RC box culverts. Muzoi Bridge were tilted and settled due to bearing capacity and lateral spreading problems associated with liquefaction of ground (Figure 14). The engineers of Department of Public Works pointed out that piers have piles reaching rock formation. It seems that the piles were designed against vertical loads and horizontal loads were not considered. The ground is laterally moved towards the river, which can be clearly inferred from the tilted electric poles next to the bridge and the lateral movement of the ground was more than 4m on both sides.

The second pier of Gawo Bridge was tilted and slid towards the upstream side of the river and the box-culvert to this pier was also tilted and slid together with the pier (Figure 15). The upper deck of the truss section of the bridge is horizontally shifted about 1.3m. The piers were constructed without using pile foundations. The site investigation indicated that there is a mudstone-like layer and overlaying soil layers consist of sand,

gravel and sandy-silt from bottom to top (Figure 16(a)). These layers are tilted towards upstream side with an inclination of 5–10 degrees. Furthermore, the river flow is directed towards the pier and box-culvert. Although the construction details of the pier and box culvert are not known, it seems that the toe erosion (scouring) of the pier and box culvert together with liquefaction of inclined sandy layer and horizontal shaking may be the major causes of the damage to Gawo bridge.

The lateral spreading of liquefied ground damaged RC bridges in Gunung Sitoli town. The bridge foundations have some piles and some of these piles were broken at the top (Figure 17). Many truss bridges along Gunung-Sitoli and Telukdalam route were damaged by permanent movement of abutments as a result of lateral spreading of liquefied ground. The ground consists of mudstone-like layer, sand layer and clayey-silty soil and top organic soil (Figure 16(b)). Sandy layer is generally found at the water level of river and it is expected to be full saturated. During earthquake shaking, it seems that this sandy layer is liquefied and caused the lateral spreading of ground. The lateral spreading of ground was particularly amplified on the convex side of the riverbank as the ground can freely move towards the river. These movements caused high lateral forces on the abutments, which caused the sliding and tilting of piers or fractured the piles of the abutments of truss bridges. Similar situations are also observed on RC bridges.

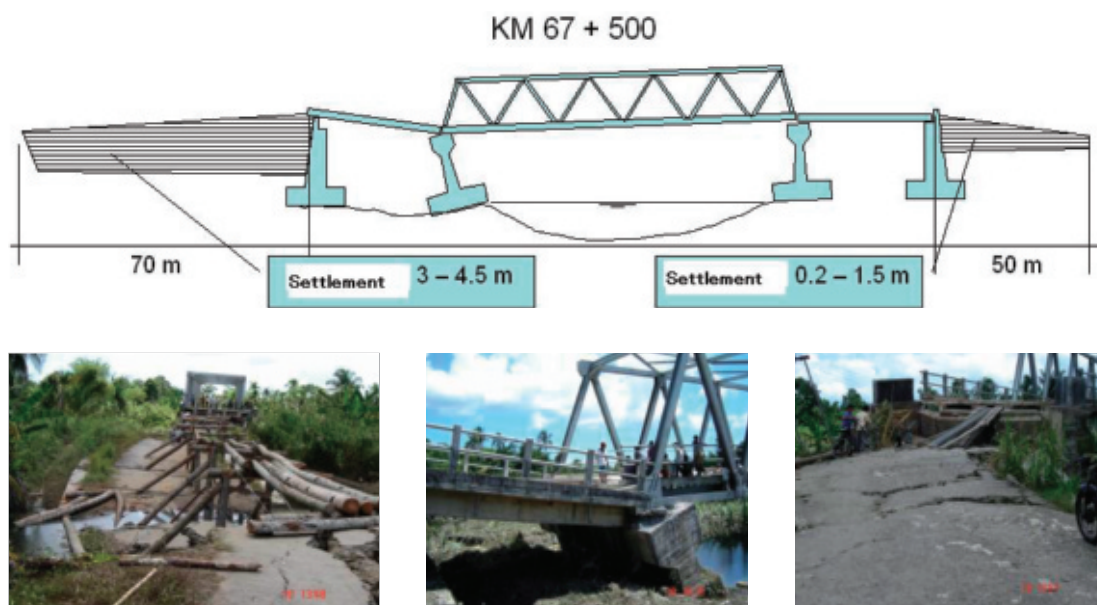


Figure 14 A sketch of Muzoi River Bridge and some views of its present state



Figure 15 Gawo Bridge nearby Tetelesi

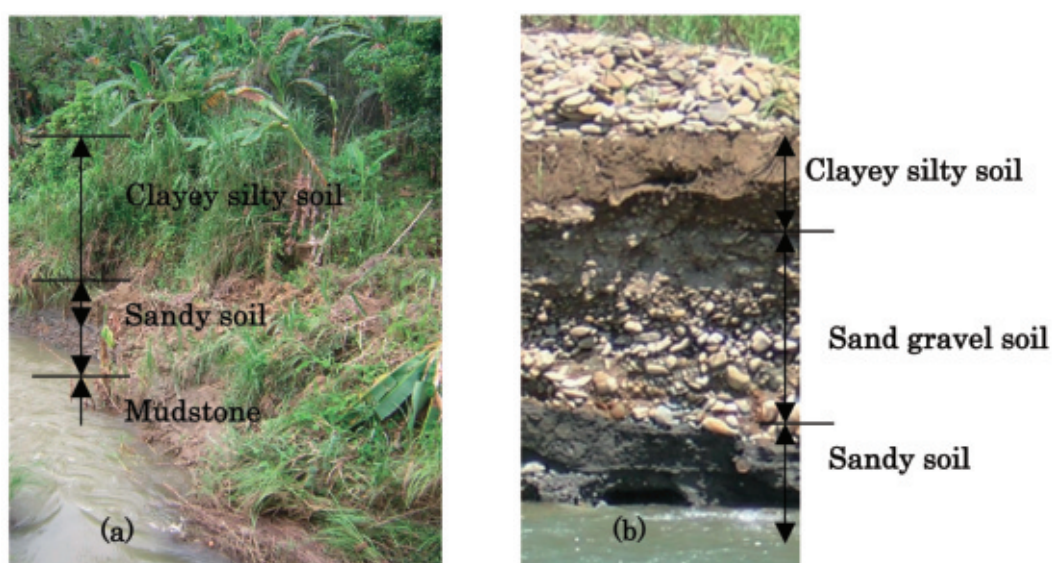


Figure 16 Typical soil conditions at the abutments of bridges

Box culvert bridges generally performed well during the earthquake except locations where scouring or ground settlement occurred (Figure 18).

The approach embankments of bridges are generally damaged and settled due to lateral spreading of ground and failure of wing-embankment walls. The settlements were generally greater than 30cm in many locations (Figure 19). The backfill materials of approach embankments consist of gravelly soil and it is expected that the potential of settlement or liquefaction is low.

The damaged bridges generally need to be re-constructed and it should be next to existing piers with necessary geotechnical investigation of ground and its characteristics. The present truss decks can be used in the new-constructions with some replacement of damaged elements and bolts and bearings together with appropriate stopper against horizontal and vertical relative movements.



Figure 17 Some examples of damage to RC bridges



Figure 18 Non-damaged RC box culvert



Figure 19 Settlement of approach embankments of bridges

5.3 Damage to Port Facilities and Coasts

There is some damage to port facilities in Nias Island due to ground shaking rather than tsunami (Figure 20). The lateral spreading of liquefied ground damaged the new wharf of Gunung Sitoli port. As a result, the pile

heads fractured and settled. Furthermore, there was a relative movement of 15cm between the sections of the wharf. In Telukdalam new port, a part of wharf sank into the sea and some pile heads were fractured by collision of wharf segments.



(a) Damage at Gunung Sutoli port



(b) Sank part of the wharf at Telukdalam new port

Figure 20 Damage to ports in Nias Island

6. LIQUEFACTION AND LATERAL SPREADING

As expected from the magnitude of this earthquake, the liquefaction of sandy ground is very likely. Seashore and riverbanks were generally consisted of sandy ground. The traces of ground liquefactions were observed in various locations along the inspected routes. Figures 9 and 21 show some examples of ground liquefaction. The all possible forms of ground movements and the effects of ground liquefaction were observed such as sand boils, lateral ground movements, settlement. The damage induced in Gunung Sitoli is widespread along the coastal area and reclaimed ground and in other coastal towns. The lateral spreading of ground nearby bridge abutments was almost entirely associated with liquefaction of sandy soil layer as shown in Figure 16. However, the geotechnical investigations of ground are lacking in Nias Island and it would be desirable to carry out such investigations for areas particularly affected by ground liquefaction are necessary.

7. CONCLUSIONS

The conclusions drawn from the investigations in Nias Island following the March 28, 2005 earthquake may be summarized as follows:

- Very strong ground motions were induced M8.7 Nias earthquake of March 28, 2005 as compared with those induced by the Mw9.3 North Sumatra Earthquake of December 26, 2004. This may imply that the ground

motions do not necessarily become larger even though the magnitude of the earthquake becomes larger. This observation requires further studies on this aspect of the earthquakes.

- The strong motions also induced widespread ground liquefaction along the eastern shore of the island, which severely damaged buildings, bridges and roadways.

The recommendations for rehabilitation and re-construction of roadways, bridges and buildings in Nias Island are as follow

- The present roadways are too narrow and they should be widened and improved for smooth flow of traffic
- Almost all bridges should be re-constructed.
- The truss decks of bridges can be used with some replacement of damaged parts
- Truss bridges are much more preferable for the region
- Ground investigations must be done to have fundamental data on ground characteristics for the structural design of piers and abutments.
- Pile design should be re-considered and their length should be sufficiently long and to be able to resist to lateral flow force of liquefied ground.
- Reconstructed abutments should have wing walls to prevent collapse of approach road to bridge.
- Present RC buildings do not satisfy the basic requirements of modern seismic design codes for buildings
- The steel bars of reinforcement and stir-ups are too thin to resist lateral forces
- The column beam connections are not properly done and the modern seismic design codes must be strictly implemented with the consideration of country condi-



Figure 21 Some examples of sandboils in Gunung Sitoli and coastal areas

tions.

- The level of workmanship must be improved by education.
- The size of columns should be increased with sufficient reinforcement and the use of shear walls should be encouraged instead of brick walls. If shear-walls could not be utilized due to economic situations, it is desirable to built wall first and then cast concrete column and concrete base slab since the present column-beam connections are very poor.
- The story number in structural design must be obeyed during the implementation as the actual story number is higher than the original story number
- Box-like (mat) foundations should be used for buildings in liquefiable area if piles could not be used
- Seismic characteristics of ground must be measured in towns and villages by provincial authorities
- Tie-beams must be used in the foundation design of buildings

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要 旨

2005年3月28日マグニチュード8.7のニース地震の特徴と地震に伴う 津波および構造物の被害

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3月28日マグニチュード8.7の地震が2004年の南側の領域で発生した。地震を起こした断層の長さは約500km、幅100km、滑り量は約10mにも及ぶ巨大地震であるが、2004年の地震に比べれば規模が小さい。ニース島は、南北約150km、東西50km、人口約70万人の島である。震源が島の北東に位置し、破壊領域が島の下に伝達したことにより大きな被害が発生した。国連の調べでは、死者847人、負傷者6279人を数える。地震の地震発生機構は逆断層型であり、その断層の傾斜は約4-7°であった。2005年の地震破壊時間は約150秒であり、推定破壊伝達速度が約3.3km/sであった。ニース島の被害調査は図-1に示すように島の東岸を中心に実施した。主な都市や被害地点を図中に示す。西岸は地震被害の影響もあり道路状況が悪く調査できなかった。

ニース島の橋梁のうち橋長が長いものは、トラス橋、RC橋、RCボックスカルバート橋とそれらの組み合わせである。大きな被害を受け交通が遮断されている橋梁としては、北部のムゾイ橋梁、東海岸のサウォ橋梁がある。ムゾイ橋の橋脚は液状化により傾斜、沈下した。橋台取り付け部の地盤は河心方向に4m程度移動し、3~4mの沈下が見られた。サウォ橋梁では、橋台とそれに続くボックスカルバートが上流側に傾斜し、トラスは水平方向に1.3m移動した。ボックスカルバートの基部が川の流れて直接洗掘されたことと、周辺で確認された砂層の液状化が被害の原因と推定される。

このほか、Gunung SitoliとTeluk Dalamの間の多くのトラス橋やRC橋の橋台が河心方向への移動、傾斜の被害を受けた。水位付近に砂層が確認される場合が多く、液状化に伴う地盤の流動が影響していると考えられる。橋台背後の盛土も30cm以上沈下している場合が多い。

道路は地震により、盛土の崩壊、斜面崩壊、液状化による地盤の側方流動の影響などにより亀裂や大きいところでは1m以上の沈下などの被害が数多く発生した。地震以前から、アスファルト舗装の状態が良くない箇所が多く、各所にくぼみが生じている状態であり、良好な輸送路の確保には舗装の更新が必要と考えられる。Gunung Sitoliでは、液状化による被害が確認された地域で、栈橋の杭頭部で亀裂が生じ、沈下や側方への変形が見られた。島の南端のTeluk Dalamでは、栈橋の一部が水中に没する被害が生じた。

都市部や比較的大きな町では、2階かそれ以上の階数のRC建物が存在し、その多くがパンケーキモードの崩壊や大きな被害を受けた。RC構造物の多くはフレーム構造で、壁はレンガかブロックである。被害を受けたRC構造物の多くは、建物重量が大きい割には柱が細いこと、また鉄筋量が少ないこと、帯鉄筋が細く間隔が大きいこと、帯鉄筋の定着、柱梁接合部の鉄筋の定着、耐震壁がないことなどから、大きな地震力が作用したことでパンケーキ状の崩壊が厳しい被害に至ったと考えられる。死者の多くは、これらの建物の下敷きとなったものである。また、壁の面外方向への倒壊も多い。多くの教会も被害を受けたが、壁の倒壊が非常に多かった。Gunung Sitoliでは液状化による沈下と地盤の流動で海岸沿いや河川沿いの多くの建物が被害を受けた。べた基礎でないことや基礎が地中梁で結合されていないことで、建物が沈下し、柱が変形し、1階の床が浮き上がるという被害が確認された。

海岸線沿いや河川沿いには砂質地盤が存在し、多くの地点で液状化が確認され、噴砂、地盤の流動、沈下といった被害が発生した。Gunung Sitoliでは、海岸に近い地域や埋立地の広い範囲で地盤の流動が確認された。また、橋台が河心方向へ移動する被害には、砂地盤の液状化に起因する地盤の流動が関係している場合が多く確認された。しかし、ニース島では地盤調査データの蓄積がほとんどなく、都市部の再開発や橋梁などの重要構造物の建設に関する基礎構造の設計には、地盤調査の実施が重要な課題と考えられる。

津波の被害は、島の北端部のTuhemberua（ツエンベルア）周辺と島の南端部のSorake（ソラケ）ビーチで確認された。津波の高さは住民の話では、それぞれ4~5m、6~7m程度であり、周辺の民家や2階建て程度のRC構造物が倒壊などの被害を受けている。西岸では、さらに影響が大きいとの情報もあり、正確な情報の蓄積が必要である。