

TSUNAMI HEIGHT MEMORIAL POLES IN BANDA ACEH AND RECOMMENDATIONS FOR DISASTER PREVENTION

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ABSTRACT: Huge earthquake and tsunami on December 26th, 2004 caused more than 150 thousands casualties around Indian Ocean rim countries especially Banda Aceh city and Aceh Besar district in Sumatra, Indonesia. Japanese investigation group led by the first author found that the local people's awareness of tsunami was very low from the results of questionnaires. For disaster education of local people and students, construction of tsunami height memorial poles was proposed by the first author and supported by the local people and the embassy of Japan. Construction of the poles, distribution of the tsunami height and recommendations including education from the investigation team is introduced and discussed in this paper.

Key Words: Indian Ocean, tsunami and earthquake, Banda Aceh, Memorial poles, disaster prevention, education, recommendations

INTRODUCTION

Huge earthquake and tsunami on December 26th, 2004 has caused a great number of casualties around Indian Ocean rim countries especially in Banda Aceh city and Aceh Besar Sub-province, in Sumatra Island, Indonesia. Lessons from this huge disaster shall be learnt by locals and people all around the world.

In a quick response to the disaster, a Japanese group of researchers led by the first author departed to Banda Aceh and surrounding areas in attempt to study the lessons by the huge earthquake and tsunami. In this paper, the results of the questionnaires distributed in the tsunami affected area, construction of the tsunami height memorial poles, recommendations for disaster prevention including education are introduced.

IMPORTANT RESULT OF QUESTIONNAIRES

The questionnaires were distributed to the affected people. They consist of questions asking their

experience during and after the earthquake and tsunami. The main aim for collecting information in the questionnaire was to get a basis for planning a safer town under earthquake and tsunami disaster. Except the questionnaires, there were no recorded numerical data in the area. The most important result of the questionnaires is that even if people had started running away just after the big earthquake, the percentage of expected survivors would have been less than 100%, according to the respondents. Fig.1 shows the percentage of survivors ; the upper numbers show the actual percentage in the area and the lower number in the parenthesis show the estimated percentage assuming that local people had started running away just after the earthquake.

The practical implication is that education, socialization, escape routes, escape structures, warning system, wave resisting structures are among important factors for people to be safer against future earthquake and tsunami attacks.

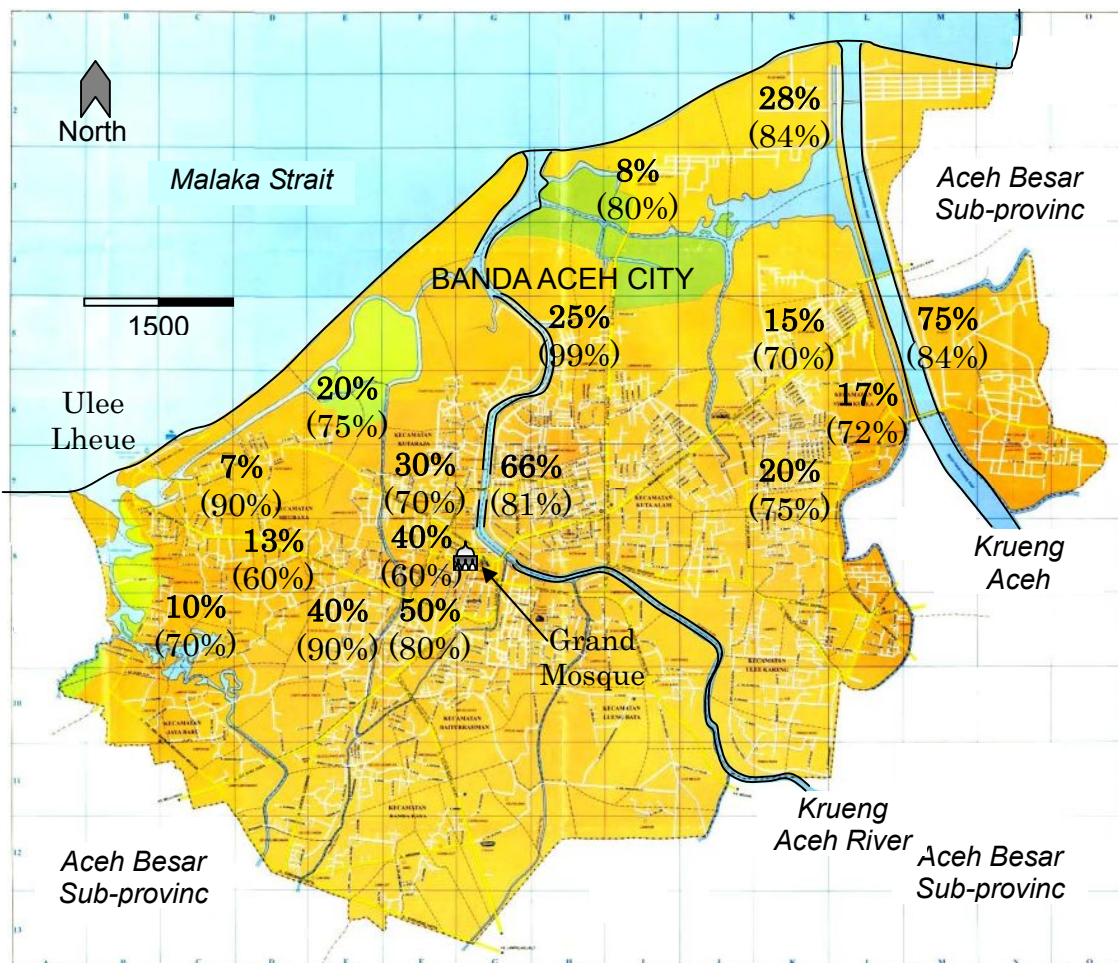


Fig.1 Actual and Estimated Percentage of Survivors in Banda Aceh (number in parenthesis shows percentage of survivors if people could have escaped immediately after earthquake)

IMPORTANCE OF TSUNAMI HEIGHT MEMORIAL POLES

Since tsunami is a rare event, the future generations may forget the disaster easily. People need encouraging and reminding words that would be written on lasting memorial structures. One of the ideas prompted by the first author to local people is to build poles with the height of tsunami run up

throughout the affected areas in the city.

The poles have many important purposes: (1) to encourage people to be prepared for the next one, (2) to keep the memory of tsunami attack, (3) to educate next generation the important lessons from the tsunami, (4) to mourn the passed away people and to restore and reconstruct Banda Aceh from the disaster, (5) to keep accurate data of tsunami height for future planning, (6) to be escaping sign with the tsunami height, (7) to encourage local people to live with hope and ease under tsunami risk, and (8) to be a symbol of Banda Aceh as the tsunami-attacked city.

CONSTRUCTION OF THE POLES

The idea of the construction of many poles in the city area was supported by local people and the Embassy of Japan in the Republic of Indonesia. The Embassy made available a grant up to US \$ 91,411 (US \$ Ninety one thousand, four hundred-eleven) by March 31, 2006. It contributes to the execution of the construction by the Yayasan Umi Abasiah. The project entitled “The Project for Supporting Education of Tsunami Disaster Prevention in Nanggroe Aceh Darussalam”.

The first author also provides technical assistance. The pole structure should be strong and yet reasonably economical and feasible in the material availability point of view. Hybrid structure consisting of masonry and reinforced concrete was finally adopted as the material. The first drawing for designing the poles is shown in Figure 2.

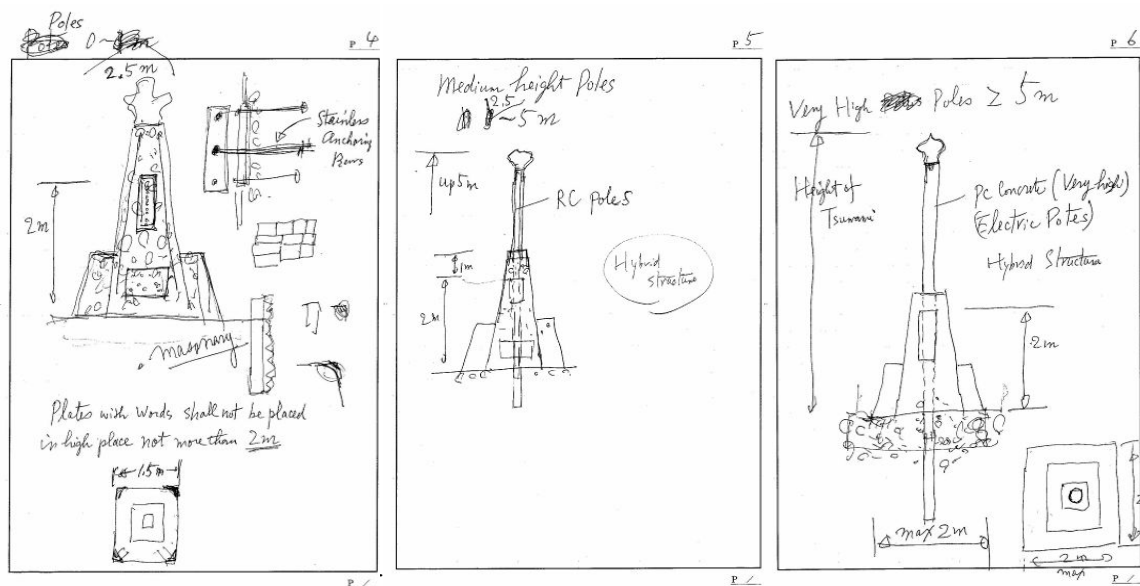


Fig.2 First Design of Structures of Low, Medium and High Poles

The proposed locations of the poles are as shown in Figure 3. The purpose is for providing evacuees with escaping sign with height, so that the evacuees escape toward the lower poles. Therefore the poles would be built along the evacuation routes. After considering the limitation of the land for construction, the realized location of the poles is as shown in Figure 4. The height of the poles is the inundation of tsunami water, when the tsunami wave was relatively flat/stop and around ten minutes later, the tsunami water returned back to the sea.

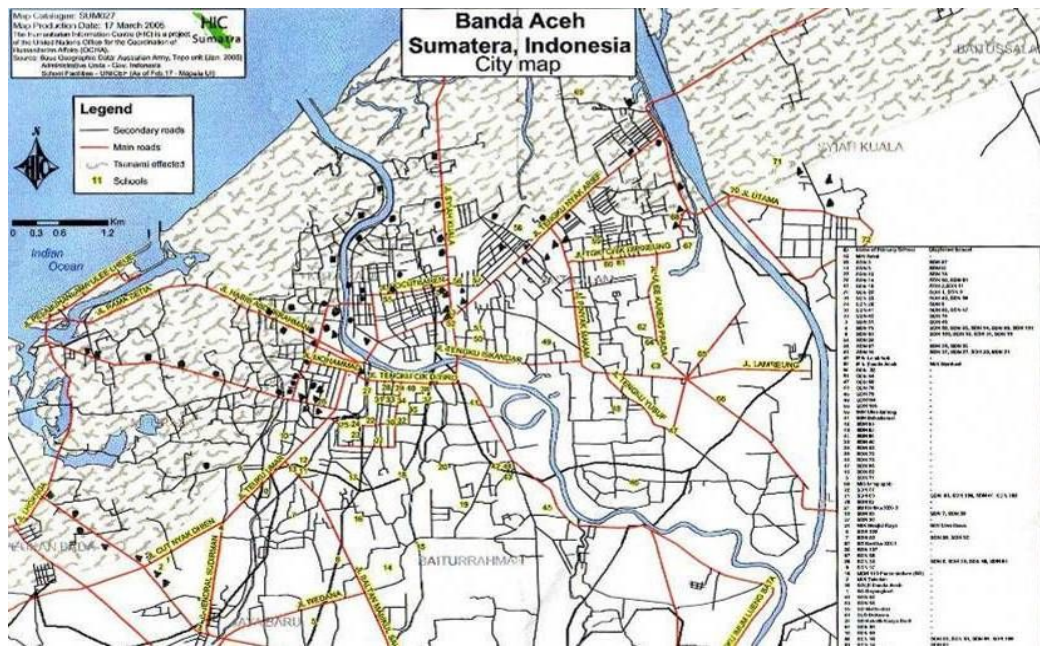


Figure 3. Tsunami Height Memorial Poles along the Evacuation Routes for Hazard Data Dissemination

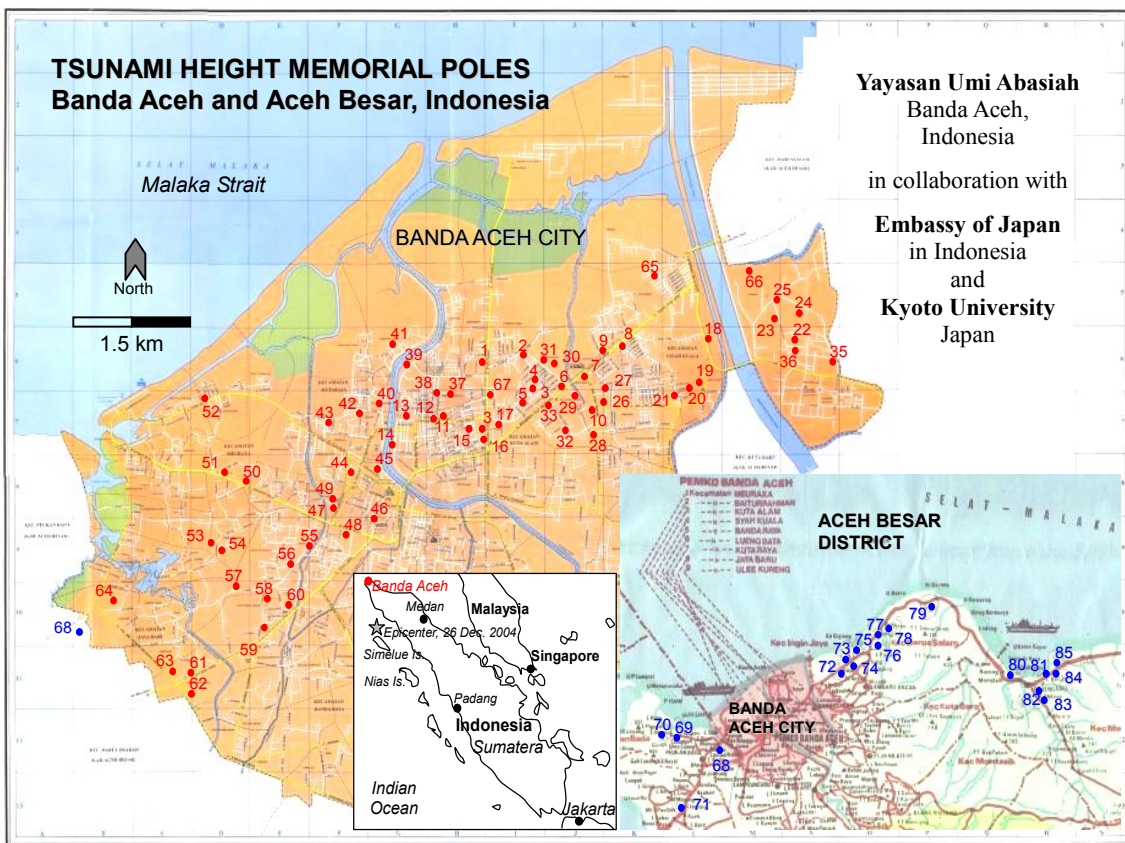


Figure 4. Location of actually built Tsunami Height Memorial Poles



Figure 5. The Firstly Built Tsunami Pole (February 2006)
 Pole No.: 01, Height: 3.15 m, Distance from Shore: 2.80 km, Location: Gampong Lamdingin, Kecamatan Kuta Alam, Banda Aceh. The placard in front of the pole shows the inundation height, distance from shore, time of tsunami arrival, time of earthquake, location name, words of wisdom, developer, and donor



Figure 6. The Lowest Tsunami Pole
 Pole No.: 28, Height: 0.90 m, Distance from Shore: 4.30 km, Location: Dinas Pertanian dan Tanaman Pangan, Banda Aceh.



Figure 7. Tsunami Pole at a School, Pole No.: 15, Height: 1.52 m, Distance from Shore: 3.90 km, Location: SD Negeri 28, Kp. Keuramat, Banda



Figure 8. The Tallest Tsunami Pole
 Pole No.: 69, Height: 9.00 m (w), Distance from Shore: 0.50 km, Location: Masjid Lam Tengoh, Peukan Bada, Banda Aceh. The wave height was justified from witnesses, because there was no



Figure 9. Tsunami Pole at a School, Pole No.: 49, Height: 3.80 m, Distance from Shore: 3.10 km, Location: SDN 2, Punge Jurong, Banda Aceh



Figure 10. Tsunami Height Memorial Poles as part of Education Tools on Hazard Mitigation

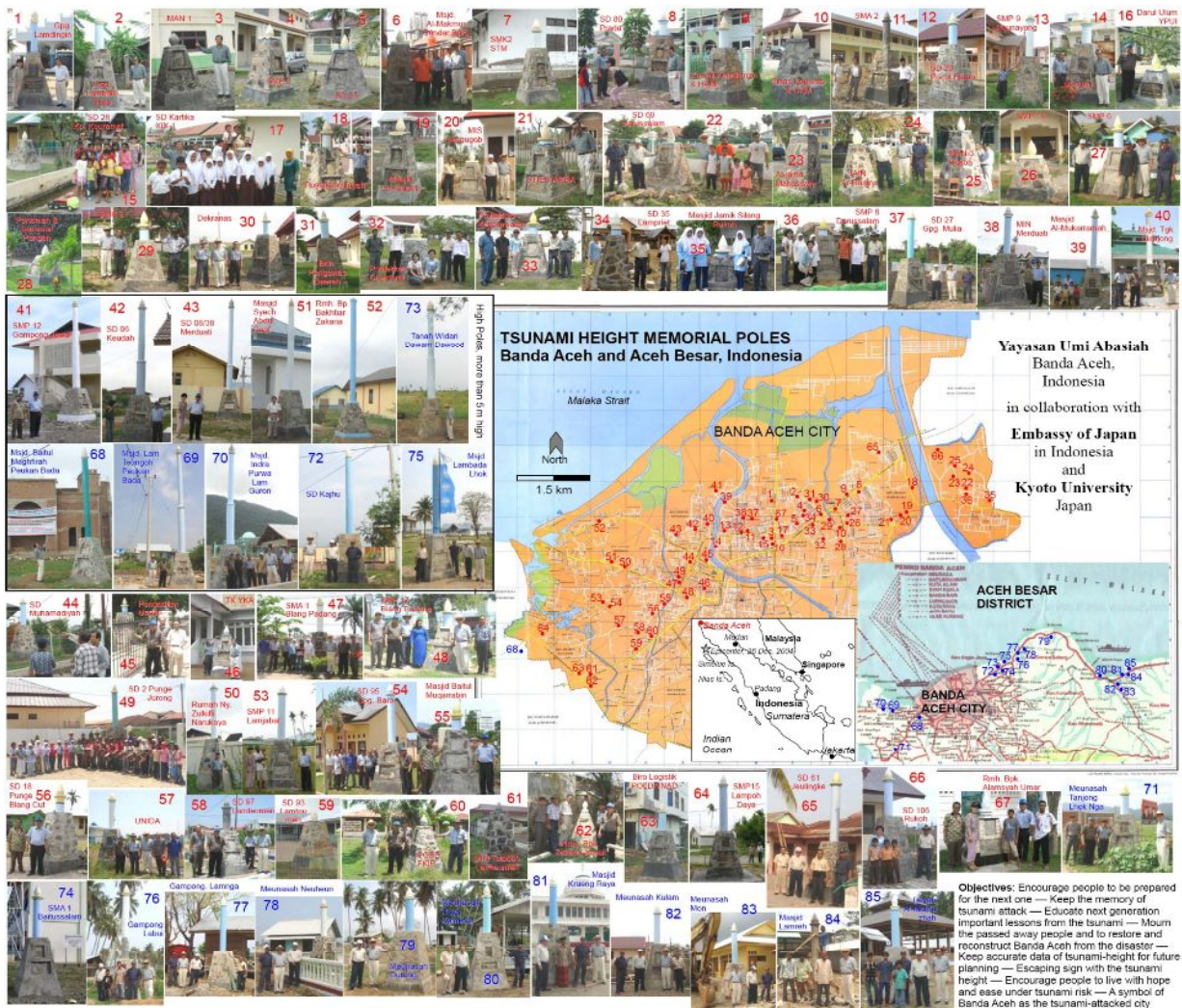


Fig.11 Photo of 85 Constructed Poles and the Site Location

In May 2007, all of the 85 poles were constructed throughout Banda Aceh city and surrounding areas. Some photos are shown in Figures 4 to 10 and the list of the poles is shown in Table 1.

The tsunami height memorial poles are also education tools for hazard preparedness. One example is by showing the students the record of the data mentioned in the poles and why they were built as shown in Fig.10. Fig.11 shows the photo of all of the poles and their locations. The enlarged copies of this photo were distributed to the people at all the sites for understanding of the tsunami height distribution.

RELATION BETWEEN TSUNAMI HEIGHT AND DISTANCE FROM THE COAST

Together with the construction of the poles, three dimensional coordinates (horizontal location and height of the ground from the sea level) were measured by portable GPS system. Construction sites in Banda Aceh city and Aceh Bessar sub-province are plotted in Fig.12 a(a) and (b), respectively. The distance from the nearest coast is calculated from the measured coordinates. The tsunami height and the distance from the coast are listed in Table 1 in the Appendix.



Figure 12 (a). Distribution of Poles in Banda Aceh City (based on GPS Positioning)

In Fig.13 (a), the tsunami height from the ground level against the distance from the coast is plotted, in which relatively good correlation among them is found.

Meanwhile, both the height of the ground from the sea level and the tsunami height from the

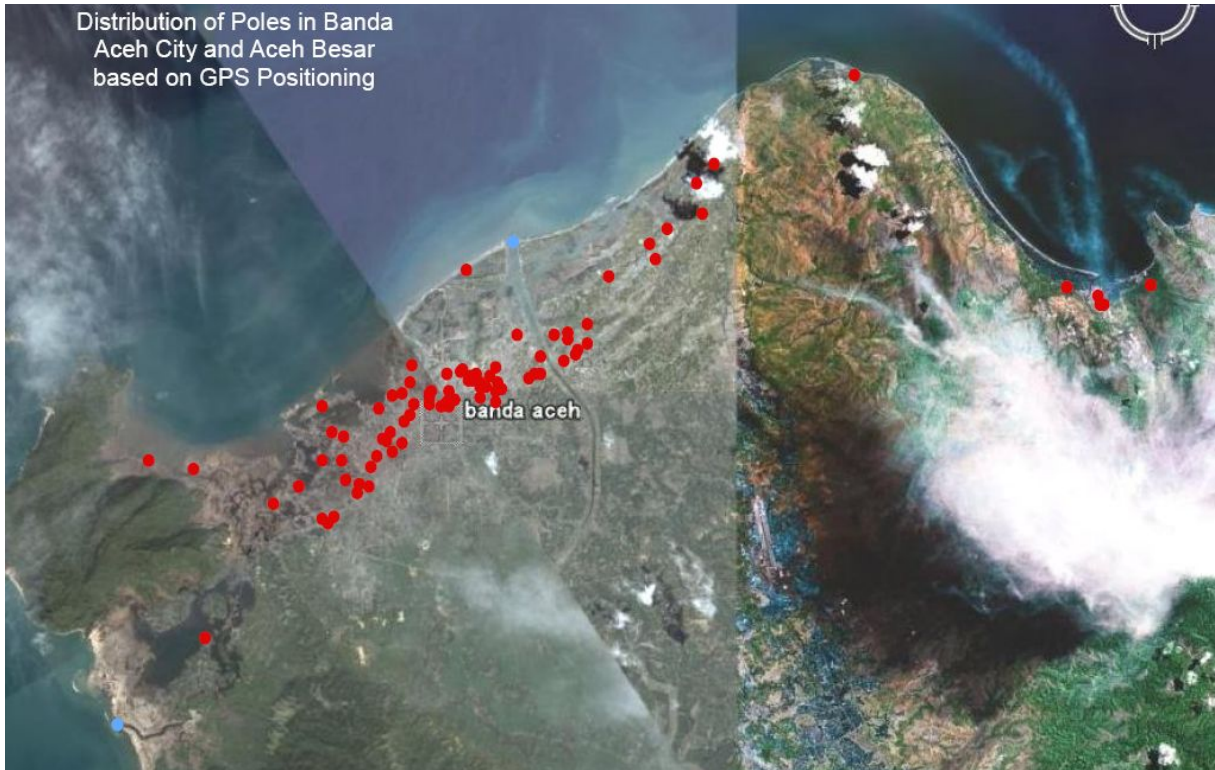


Figure 12 (b). Distribution of Poles in Banda Aceh City and Aceh Besar Sub-province (based on GPS Positioning)

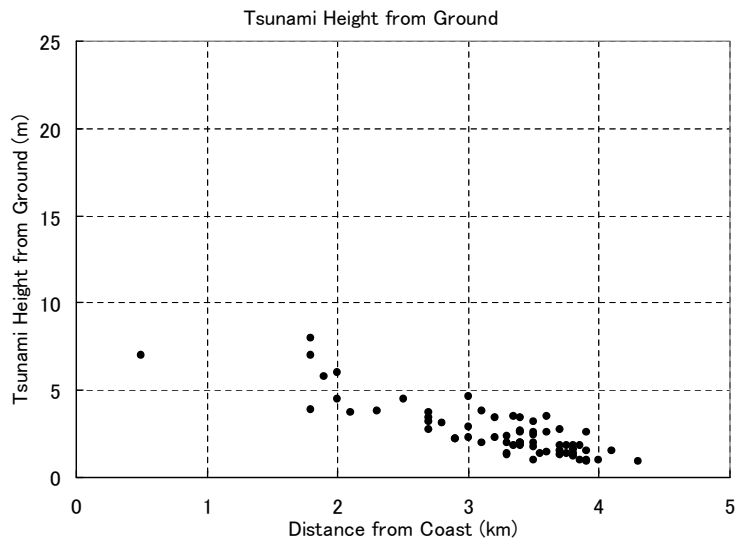


Figure 13 (a). Tsunami Height (from Ground Level) in Banda Aceh City

ground against the distance are plotted in Fig.13 (b). The bottom of the allow bar shows the ground height from the sea level and the length of the allow bar shows the tsunami height from the ground. Hence, the top of the allow shows the tsunami height from the sea level, which shows high values when the sites are high and low values when the sites are low.

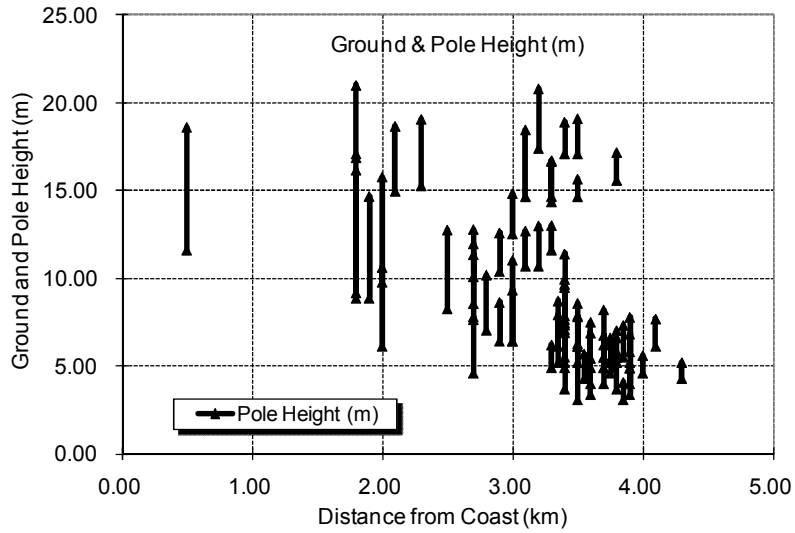


Figure 13 (b). Tsunami Height (from Sea Level) in Banda Aceh City

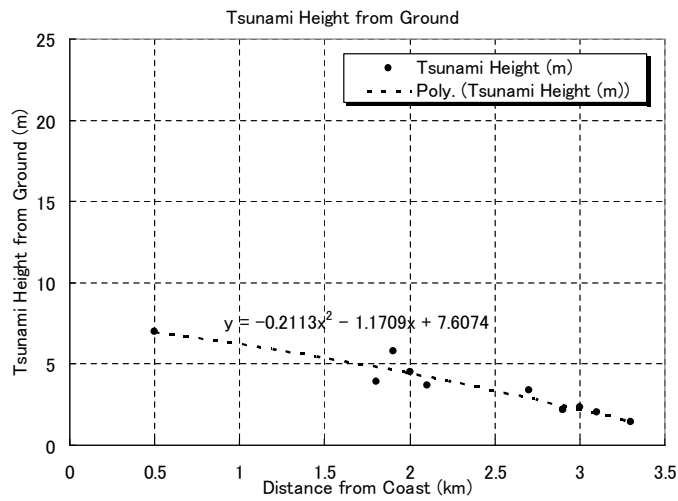


Figure 14 (a). Tsunami Height (from Ground Level) in Banda Aceh City (at Meuraxa Ward only)

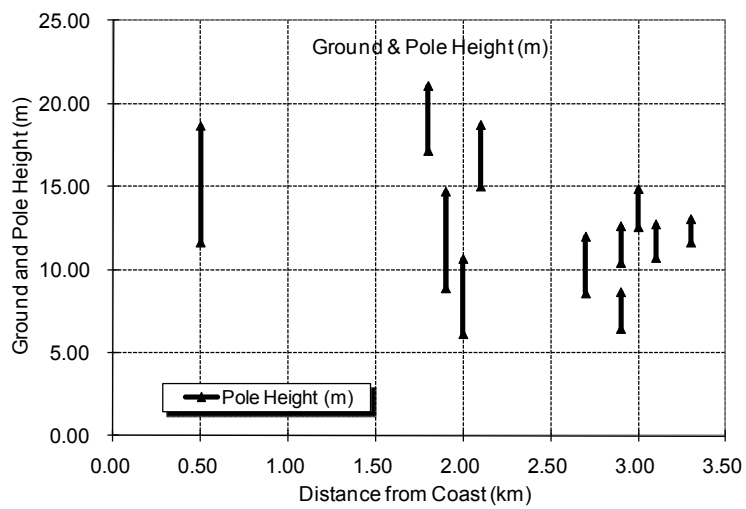


Figure 14 (b). Tsunami Height (from Sea Level) in Banda Aceh City (at Meuraxa Ward only)

Similar plots are shown in Fig. (a) and (b), limiting the sites only for relatively flat region ;Meuraxa Ward shown in Fig.12 (a) and (b), in which better correlation of tsunami height and distance is found.

Tsunami height seems attenuating smoothly with distance even though the land height is going up or down. This suggests that the Tsunami is like the strong stream which runs up the hill easily, and attenuates only with the distance.

RECOMMENDATIOS

Besides the construction of the Tsunami Height Memorial Poles, the investigation team proposed following recommendations to Indonesian people and Local Governments.

- 1) Installation of early warning system for tsunami attack
- 2) Construction of tsunami evacuation buildings or structures
- 3) Construction of the tsunami research center for collection of the data, analysis and counter measures
- 4) Construction of experimental tsunami simulation water channel
- 5) Construction of tsunami museum
- 6) Educational system for scientific study of earthquake and tsunami mechanics
- 7) Systematic education of disaster reduction

Most of the recommendations except the water channel have actively been carried out in Indonesia with worldwide technical and financial cooperation.

CONCLUDING REMARKS

The Japanese group of researchers led by the first author made field survey on earthquake and tsunami damage in Banda Aceh and surrounding area using the questionnaires with cooperation of local researchers. In this paper, not only results of the survey but also construction of the memorial poles, analysis of tsunami height distribution and recommendations to local people and governments are introduced and discussed. Each topic can be summarized as follows.

- (1) One of the important results of the questionnaires on the tsunami disaster is that even if local people at the coast had started to escape immediately after the earthquake motion, some percentage of the people could not have been saved because of no escape places near by.
- (2) The tsunami height memorial poles were built at 85 places in the Banda Aceh and surrounding areas not only to keep the data of the tsunami, but also to be important material for education of disaster mitigation. The poles are expected to last long for present and next generations.
- (3) With the analysis of the tsunami height of each site and the GPS data of the ground height from the sea level, and the distance from the coast it is found that the tsunami height attenuates smoothly with the distance from the coast, nevertheless local land height is going up or down.
- (4) Depending on the results of the survey, many recommendations on early warning system, education, disaster mitigation programs, construction of research center, museum etc are recommended. Most of them have been actively implemented by local governments and cooperation from overseas countries.

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APPENDIX

Table 1. List of 85 Tsunami Height Memorial Poles in Banda Aceh and Aceh Besar

1. 3.15 m 2.80 km GPG. LAMADINGIN KEC. KUTA ALAM	23. 1.75 m 3.50 km ASRAMA MAHASISWA UNSYIAH, DARUSSALAM	45. 2.30 m 3.20 km Kantor Pengadilan Negeri Banda Aceh	67. 1.30 m 3.30 km RUMAH BP. ALAMSYAH UMAR JALAN SYIAH KUALA
2. 2.90 m 3.00 km GPG. LAMBARO SKEP KEC. KUTA ALAM	24. 1.45 m 3.60 km Kantor Rektorat lain Ar-Raniry, Darussalam	46. 2.00 m 3.50 km Taman Kanak-Kanak YKA Taman Sari	68. 5.70 m 1.50 km MASJID BAITUL MAGHFIRAH PEUKAN BADA
3. 1.40 m 3.75 km MAN 1	25. 2.00 m 3.40 km MAN 3, RUKOH	47. 3.40 m 3.20 km SMA NEGERI 1 BLANG PADANG	69. 9.00 m (w) 0.50 km MASJID LAM TENGOH PEUKAN BADA
4. 1.95 m 3.40 km SMP NEGERI 2	26. 1.00 m 4.00 km SMP NEGERI 18	48. 1.80 m 3.40 km SMPN 17 BLANG PADANG	70. 7.00 m 0.40 km MASJID INDRA PURWA LAMGURON
5. 1.39 m 3.55 km SD NEGERI 25	27. 1.80 m 3.85 km SMP NEGERI 6	49. 3.80 m 3.10 km SDN 2 PUNGE JURONG	71. 2.50 m 2.50 km MEUNASAH TANJONG KEC.LHOKNGA
6. 1.84 m 3.70 km Masjid Agung Al Makmur Bandar Baru	28. 0.90 m 4.30 km DINAS PERTANIAN TANAMAN PANGAN	50. 4.50 m 2.00 km Rumah Ny. Zulkifli Narukaya Blang Oi	72. 5.50 m 2.50 km SDN KAJHU KEC.BAITUSSALAM
7. 2.60 m 3.60 km SMK NEGERI 2/STM NEGERI	29. 1.60 m 3.80 km SMK NEGERI 3	51. 5.80 m 1.90 km MASJID SYECH ABDUL RAUF BLANG OI	73. 7.00 m 2.20 km TANAH WIDARI DAWAM DAWOOD SP, COT PAYA
8. 2.60 m 3.40 km SD NEGERI 80, PRADA	30. 2.45 m 3.50 km Kantor Dekranas Taman Ratu Safiatuddin	52. 7.00 m 0.50 km Rumah Bp. Bachtiar Zakaria Deah Baro	74. 3.50 m 2.70 km SMAN-1 BAITUSSALAM
9. 2.60 m 3.50 km KANWIL KEHAKIMAN DAN HAM	31. 2.65 m 3.40 km KANTOR BAWASDA	53. 3.90 m 1.80 km SMPN 11 LAMJABAT	75. 5.10 m 1.50 km MASJID LAMBADA LHOK BAITUSSALAM
10. 1.55 m 4.10 km DINAS KOPERASI DAN UKM	32. 1.00 m 3.85 km Direktorat Politeknik Kesehatan	54. 3.70 m 2.10 km SDN 95 GAMPONG BARO	76. 4.60 m 2.00 km GAMPONG LABUI BAITUSSALAM
11. 3.20 m 3.50 km SMA NEGERI 2	33. 1.80 m 3.75 km Politekkes NAD Jurusan Keperawatan	55. 2.20 m 2.90 km Masjid Baitul Muqarrabin Punge Blang Cut	77. 4.00 m 1.50 km GAMPONG LAMNGA JALAN KRUENG RAYA
12. 2.70 m 3.70 km SD NEGERI 20, POCUT BAREN	34. 2.00 m 3.40 km SD 35 LAMPRIET	56. 2.20 m 2.90 km SDN 18 PUNGE BLANG CUT	78. 3.40 m 1.30 km MEUNASAH NEUHEUN MASJID RAYA
13. 3.50 m 3.60 km SMP NEGERI 9, PEUNAYONG	35. 1.80 m 3.35 km MASJID JAMIK SILANG RUKOH	57. 3.40 m 2.70 km Universitas Iskandarmuda Surien	79. 2.20 m 0.40 km MEUNASAH DURONG MASJID RAYA
14. 2.57 m 3.90 km KANTOR BKPMD	36. 1.20 m 3.80 km SMP NEGERI 8 DARUSSALAM	58. 2.30 m 3.00 km SDN 97 LAMTEUMEN TIMUR	80. 3.30 m 1.00 km MEUNASAH PAYA KAMENG MASJID RAYA
15. 1.52 m 3.90 km SD NEGERI 28, KP. KEURAMAT	37. 3.40 m 3.40 km SDN 27 GAMPONG MULIA	59. 2.00 m 3.10 km SDN 93 LAMTEUMEN TIMUR	81. 3.40 m 0.50 km MASJID KRUENG RAYA
16. 0.89 m 3.90 km DARUL ULUM, YPUI	38. 3.50 m 3.35 km MIN Merduati Jalan Malahayati, GP.MULIA	60. 1.40 m 3.30 km PGSD FKIP UNSYIAH GOHENG	82. 3.20 m 0.80 km GAMPONG MEUNASAH KULAM
17. 1.52 m 3.70 km SD KARTIKA XIX-I, LAMPRIET	39. 4.60 m 3.00 km MASJID AL MUKARRAMAH GP. MULIA	61. 2.00 m 3.30 km MIN TELADAN LAMTEUMEN	83. 3.20 m 0.80 km GAMPONG MEUNASAH MON
18. 1.91 m 3.40 km Badan Perpustakaan Wilayah	40. 4.50 m 2.50 km Masjid Tgk. Dianjong PEULANGGAHAN	62. 1.00 m 3.50 km RUMAH ZAKARIA ISMAIL LAMTEUMEN	84. 2.50 m 0.30 km MASJID LAMREH KRUENG RAYA
19. 1.80 m 3.80 km MASJID LAMGUGOB	41. 7.00 m 1.80 km SMPN 12 GAMPONG JAWA	63. 2.35 m 3.30 km BIRO LOGISTIK POLDA NAD LAMTEUMEN	85. 3.10 m 0.50 km PASANTREN/DAYAH AL MAHFUZHAH KRUENG

			RAYA
20. 1.40 m 3.80 km MIS LAMGUGOB	42. 6.00 m 2.00 km SDN 6 KEUDAH	64. 3.80 m 2.30 km SMPN 15 LAMPOH DAYA	Notes: - Data in [m] is height and data in [km] is distance from shore - Poles 43 & 69 show wave height. Others show inundation height - red in Banda Aceh, blue in Aceh Besar
21. 1.00 m 3.90 km STIES/AMBA	43. 8.00 m (w) 1.80 km SDN 8/38 MERDUATI	65. 3.70 m 2.70 km SDN 61 JEULINGKE	
22. 1.30 m 3.70 km SD NEGERI 69, DARUSSALAM	44. 2.70 m 2.70 km SD MUHAMMADIYAH LAMPASEH	66. 3.20 m 2.70 km SDN 106 RUKOH	

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