PAGEOPH, Vol. 144, Nos. 3/4 (1995) 0033-4553/95/040839-16$1.50 + 0.20/0

Field Survey of the East Java Earthquake and Tsunami of June 3, 1994

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Abstract —A field survey of the June 3, 1994 East Java earthquake tsunami was conducted within three weeks, and the distributions of the seismic intensities, tsunami heights, and human and house damages were surveyed. The seismic intensities on the south coasts of Java and Bali Islands were small for an earthquake with magnitude M 7.6. The earthquake caused no land damage. About 40 minutes after the main shock, a huge tsunami attacked the coasts, several villages in East Java Province were damaged severely, and 223 persons perished. At Pancer Village about 70 percent of the houses were swept away and 121 persons were killed by the tsunami. The relationship between tsunami heights and distances from the source shows that the Hatori's tsunami magnitude was $m = 3$, which seems to be larger for the earthquake magnitude. But we should not consider this an extraordinary event because it was pointed out by HATORI (1994) that the magnitudes of tsunamis in the Indonesia-Philippine region generally exceed 1–2 grade larger than those of other regions.

Key words: 1994 East Java Tsunami, aftershock area, large tsunami with weak shaking, house and human damage due to the tsunami, relationship between earthquake and tsunami magnitudes.

1. Introduction

A large earthquake of magnitude M_w 7.6 (M_S 7.2) occurred off the southeast coast of Java Island, Indonesia at 01h 17m local time on June 3, 1994 (at 18h 17m GMT on June 2). The epicenter was at 10.5°S, 113.0°E (by NEIC, USGS) about 240 km from the nearest coast. The shock was felt on east Java Island and on Bali Island. Only ten to twenty percent of the inhabitants of the villages on the nearest

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coasts were awakened by the ground shaking. No earthquake damage was reported on land. In contrast, about 50 minutes after the main shock, a sizable tsunami hit the coast, inflicting heavy damage on several coastal villages in the Banyuwangi and Jember regencies of East Java Province. A total of 223 persons lost their lives and 15 persons were missing, mainly on Java Island; at the village of Pancer, about 50 km southwest of Banyuwangi, 121 persons died and 70 percent of the houses were swept away.

We organized a team and surveyed the south coasts of Bali and Java Islands from June 19th to 24th. We conducted interviews at damaged villages, searched for traces of submergence of sea water, and measured heights of sea-water inundation with reference to sea-surface elevation at the time of the survey. Correction for the astronomical tide was applied later to obtain our estimates of tsunami heights referenced to mean sea level.

In this paper, we report the distributions of the seismic intensities, the distributions of tsunami heights, and human and building damages due to the tsunami. We will discuss the relationship between the hypocentral distance and tsunami height, and will estimate the tsunami magnitude.

2. *Survey Schedule*

We divided all members into three subteams. On June 20th, all subteams surveyed on the coast of Bali Island. On the morning of the 21st, all members entered Pancer, the village with the severest damage (Fig. 1). In the afternoon, those three subteams surveyed independently.

Sub-team A, Imamura's team, visited Rajekwesi Village, about 15 kilometers west of Pancer. The next day, June 22nd, they moved to Blitar City, about 300 kilometers west of Banyuwangi and conducted surveys on the coasts between Sempu Island and west to Perigi about 40 kilometers west of Blitar.

After finishing the survey of Pancer, subteam B, Matsutomi's team, moved to Lampon, about 10 kilometers east of Pancer. They surveyed the coasts towards the easternmost point of Java Island.

The third subteam, Tsuji's team, collected the statistical tables of damage, maps of distributions of swept-away houses at Pancer, Lampon and Rajekwesi at the local government office, and conducted field surveys at Bambangan, Ngliyep, and Popoh villages.

On our survey, students of the University of K. Petra, Surabaya, and two engineers from BPPT Jakarta assisted and joined our team.

3. *Aftershocks*

About 1,500 aftershocks were recorded within 4 days after the main shock by the seismic network of the Indonesian Meteorological and Geophysical Agency.

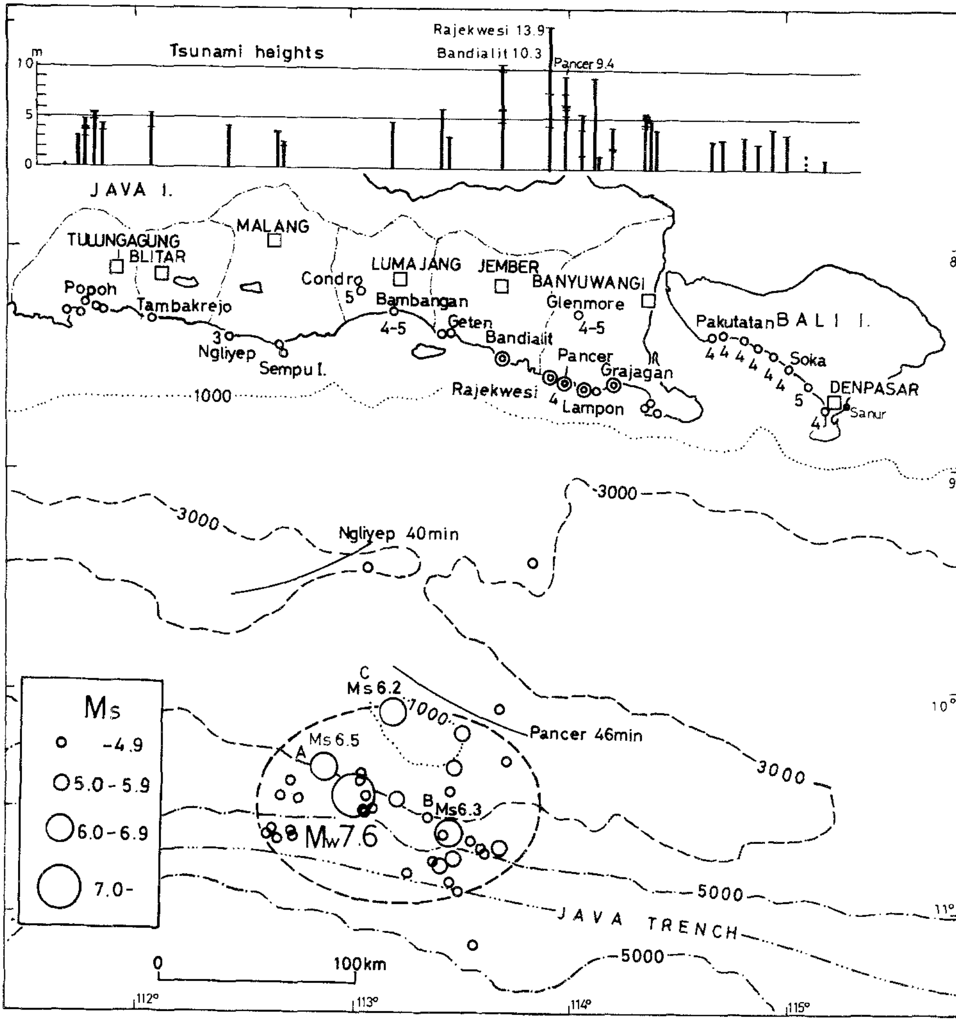

Figure 1

Distributions of tsunami heights, seismic intensity, and aftershocks of the 1994 East Java earthquake. Distribution of tsunami heights is denoted by solid bars in the upper graph. Small horizontal bars attached to each solid bar show the tsunami height at individual points where we measured at more than two points in the same village. Open circles on land illustrate the surveyed points, and attached numbers represent seismic intensity on the Modified Mercalli scale. Double circles show severely damaged villages due to the tsunami. Chain lines show regency boundaries, and squares show capitals of regencies. Circles in the sea area display the locations of the main shock and the aftershocks within 10 days after the main shock (by NEIC, USGS). Tsunami wavefronts estimated from the travel times to Pancer and Ngliyep are also shown. Sea bottom topography is expressed by contours and depth is shown in meter.

Figure 2 shows the daily change of the number of observed aftershocks. The daily number of aftershocks decreased rapidly five days after the main shock.

NEIC quick epicenter determination by USGS reported 34 aftershocks of the present event within ten days after the main shock (Fig. 1). The shape of the

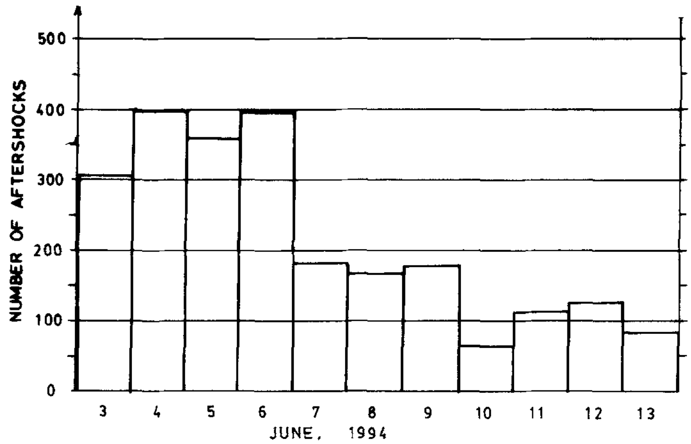

Figure 2
Daily change of aftershocks for the period from June 3 to June 13 observed by the Meteorological and Geophysical Agency, Indonesia.

aftershock area is an ellipse with the longer diameter 120 km in an east-west direction and the shorter diameter 100 km in a north-south direction. The aftershock area is located near the axis of the Java trench. The northern boundary of the area is about 200 km distant from the southeast coast of Java Island.

Three big aftershocks occurred; event A (M_s 6.5) is at 21h 07min GMT on June 3 (04h 07min on June 4 local time), B (M_s 6.3) is at 00h 58min on June 4 (07h 58min), and C (M_s 6.2) is at 01h 45min on June 5 (08h 45min). It is probable that smaller tsunamis were also generated by these three aftershocks.

We also obtained eyewitness accounts of aftershocks at a few points. At Soka on Bali Island, 35 kilometers northwest of Denpasar, the inhabitants said that they felt an aftershock during the afternoon of the next day, and later another tsunami occurred. They testified that the height of the inundation limit of sea water was nearly the same as that of the main shock tsunami. We measured the height of both tsunamis as 3.7 meters above the mean sea level. We cannot identify the corresponding event in the table announced by NEIC.

On the coast of Bambangan (8°17′21.6″S, 113°06′30.3″E), 20 kilometers south of Lumajang City, we interviewed witnesses who related that at 7 o'clock on the morning of June 5th, two days after the main shock, another tsunami arrived. We measured the tsunami inundation heights for both the main and the aftershocks, on the basis of eyewitness accounts of the inhabitants, as 4.6 and 3.0 meters above the mean sea level, respectively. This aftershock tsunami was suggested to be generated by the abovementioned aftershock C.

4. *Distribution of Seismic Intensity*

As the native languages of the south coasts of the provinces of Bali and East Java are Javanese and Standard Indonesian, we interviewed the inhabitants with the assistance of Indonesian translators. We prepared the questionnaire sheets in the Indonesian language, asking the condition of the tsunami and the grade of seismic intensity on the Modified Mercalli scale. We asked Indonesian co-workers to judge the seismic intensity through natural conversation with the inhabitants in their native language.

As the main shock occurred at midnight, most people were asleep. About ten to twenty percent of the population at Pancer Village awoke, while the rest continued sleeping without noticing the shock. Seismic intensity is estimated as 4 on the Modified Mercalli scale there.

We estimated seismic intensity from interviews at 14 points (Fig. 1). It was clarified that seismic intensity did not exceed 5 at any point. There was no earthquake damage.

Through our interviews with the inhabitants we also noticed that most people on the coasts did not receive correct knowledge of tsunamis in order to be prepared for a tsunami attack after feeling a strong earthquake on the coast. But for the present case, even if they had the knowledge, we could not expect that people on the coast would take precautions against the tsunami, because they felt such a weak shaking which they experience several times every year.

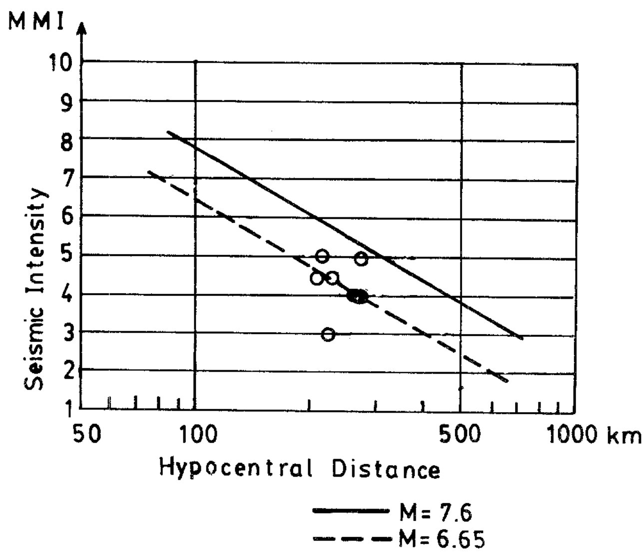

Figure 3
Relationship between the hypocentral distance and the seismic intensity. The solid line shows the relation given by the formula (1) for the case $M = 7.6$ and the dashed line is for $M = 6.65$.

The relationship between the seismic intensity and the hypocentral distance is formulated by ESTEVA *et al.* (1965) as follows

$$I = 8.16 + 1.45\,M - 2.46 \ln r \qquad (1)$$

where r(km) is the hypocentral distance, M is magnitude, and I is seismic intensity on the Modified Mercalli scale. For the present case we plotted the seismic intensities against the hypocentral distances as displayed in Figure 3. The solid line shows the expected intensity given by formula (1) for $M = 7.6$. The seismic intensity felt by the inhabitants at each point is evidently smaller than that expected by equation (1).

The formulae of the attenuation of Modified Mercalli intensity, with respect to the hypocentral distance, were also proposed by BRAZEE (1976) and ANDERSON (1978), mainly for earthquakes in the U.S.A. SATO (1948, 1955) and KAYANO (1990) also obtained empirical formulae from Japanese data for the relationship between seismic intensity and distance. These works illustrate that, strictly speaking, the attenuation of seismic intensity with respect to the distance varies in different localities and cannot be expressed by a universal formula. We suggest here that the present event was felt weaker in magnitude by the inhabitants.

5. *Distribution of the Tsunami Heights*

We found clear traces of tsunami submergence at many places on the coastal areas facing the source. We could easily distinguish the traces of inundation of sea water on walls of houses and on surface barks of trees in severely damaged villages (double circles in Fig. 1). We could measure the tsunami height using those traces. On the coasts far from the source, we measured the tsunami height mainly on the basis of eyewitness accounts of the inhabitants.

The south coasts of Java and Bali Islands are attacked by high swells from the subantarctic zone repeatedly every day, and the sea surface is disturbed usually. Thus, it is difficult to detect the sea-surface abnormality due to the tsunami with absolute height less than two meters.

A tide gauge station is located at Cilacap in Central Java, some 600 km west of the source, but we could not obtain information of the record there prior to this writing.

As we could not use bench marks on land, we measured the inundation height above mean-sea level at the time of the survey, and the astronomical tide component was compensated afterwards by the tide tables of Banyuwangi, Cilacap and Sanur Ports, which were computed on the data basis of 7 tidal elements (M2, S2, O1, K1, P1, N2, and K2) supplied by the Japan Ocean Data Center of the Hydrography Department, Maritime Safety Agency. Cilacap Port is on the south coast of Central Java about 600 kilometers west of Banyuwangi, and Sanur is on the

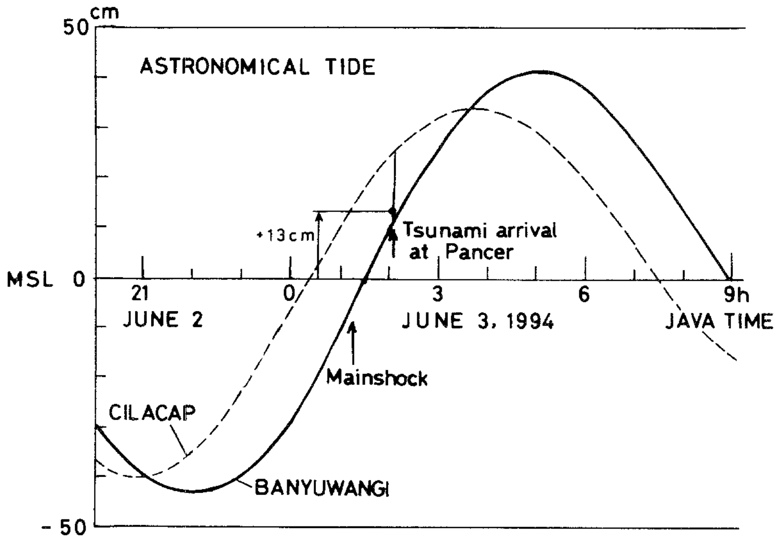

Figure 4
Computed astronomical tides at Banyuwangi and Cilacap ports for the day of the 1994 East Java earthquake tsunami.

southeast coast of Bali Island (Fig. 1). After observing that the tidal phase at Banyuwangi lags behind Cilacap by 60–90 minutes and that the amplitude of the former is 10–20 percent larger than that of the latter, we estimated the tidal level at survey time by interpolation for each point on Java. The same interpolation was made for points on Bali by using tidal data of Banyuwangi and Sanur. Hereafter we will denote tsunami height as the tide corrected value.

The astronomical tide change at the time of tsunami arrival is shown in Figure 4. Tsunami arrival time at Pancer was testified by the inhabitants at 02h 03min, that is 46 minutes after the main shock. At that time, astronomical tide was +13 cm above mean sea level and was in the rising phase.

The distribution of the inundation heights of the tsunami is displayed in the upper bar graph of Figure 1. We generally measured at more than two points in the severely damaged villages. Small horizontal bars attached with a fat vertical bar depict inundation height at an individually measured point in such a village. The highest inundation of 13.9 meters was measured at the east entrance road of the residential area of Rajekwesi village.

The length of the coast where tsunami height exceeded 4 meters is about 300 kilometers.

6. *Tsunami Arrival Time*

We obtained information of the tsunami arrival time in four villages. A person in Pancer Village continuously watched time and noticed the tsunami arrival at

02h 3m, that is 46 minutes after the main shock. We also obtained an eyewitness account of the tsunami arrival time at Ngliyep Village which the wave attacked shortly before 2 o'clock, from which we can estimate that tsunami arrival time was about 40 minutes.

Additionally, we obtained eyewitness accounts of the tsunami arrival time as 15–20 minutes, both at Bambangan and Popoh Villages. These were not checked by a clock, thus, we cannot expect accuracy from those witnesses.

We drew refraction diagrams inversely from Pancer and Ngliyep up to 46 and 40 minutes, respectively (Fig. 1). We can expect that the final progressive lines should touch the tsunami source region. The line from Pancer runs close to the boundary of the aftershock area. We can judge that the tsunami source area of the present event coincides with the aftershock area generally.

7. *Damage due to the Tsunami*

Most human and house damage was sustained in the territory of East Java Province. Table 1 lays out the statistics of damage by regions. The damage in the Banyuwangi Regency constitutes a large majority of the total damage. Killed and lost lives due to the tsunami totaled 223 and 15, respectively. The statistics of damage caused in the villages is reported by the rescue headquarters at Pancer in Table 2. The district office also announced the population and the total number of houses of the damaged three villages (Rajekwesi, Pancer, and Lampon), and we could calculate the mortality and the ratio of collapsed houses to the total (Table 3).

About seventy percent of the houses in Pancer were swept away by the tsunami. The rescue headquarters also made public the detailed maps of distributions of damaged houses in residential areas of those three villages (Figures 5a,b,c).

Table 1

Statistics of human and house damage by regencies in East Java Province, after the rescue headquarter at Pancer, up to June 20

	Human Damage				House Collapsed			
			Injury					Damaged
Regency	Killed	Missing	Heavy	Slight	Totally	Partially	Slightly	Ships
Tulungagung	2	—	20	—	62	59	—	84
Blitar	2	—	—	—	—	3	—	153
Malang	1	—	—	2	31	7	4	168
Jember	12	—	4	7	36	33	11	119
Banyuwangi	206	15	21	—	591	66	235	380
Total	223	15	45	9	720	168	250	904

Table 2

Statistics of human and house damage by villages in Banyuwangi Regency. After the table of the rescue headquarter at Pancer (number of injuries does not agree with Table 1)

Village	Human Damage Killed	Missing	Injury Heavy	Injury Middle	Injury Slight	House Collapsed	Population	Number of Houses	Reported Tsunami Height (m)
Lampon	39	1	4	29	30	112	645	171	12
Pancer	121	—	27	60	439	704	3,081	996	12
Rajekwesi	33	14	1	6	73	71	1,205	301	8
Purwosari	—	—	—	—	—	unknown	1,324	301	8
Grajagan	13	—	—	—	—	unknown	unknown	unknown	—
Kutorejo	—	—	—	—	3	unknown	2,688	647	8
Total	206	15	32	95	542	887	—	—	—

Table 3

Ratio of human and house damage to total population and number of houses by villages
*"House collapsed" contains both totally and partially collapsed houses

Village	Killed + Missing A	Population B	Mortality A/B	House Collapsed* C	Number of Houses D	Ratio of Collapsed, C/D	Tsunami Height m
Lampon	40	645	6.2%	112	171	65.5%	5.4
Pancer	121	3,081	3.9	704	996	70.7	5.7–9.4
Rajekwesi	47	1,205	3.9	71	301	23.6	5.0–7.5

A) Rajekwesi

Figure 5a shows the schematic map of the residential area of Rajekwesi Village. We measured tsunami height at 7.5 m at point A, where a new vertical surface of sand step appeared on the seaside slope of coastal sand dunes due to the erosion of inundated sea water.

B) Pancer

Figure 5b shows the map of the residential area of Pancer, which is situated on a sand dune of a river mouth, and faces the open ocean. A row of palm trees is arranged in front of the village, and seems to valid for reducing the energy of the tsunami to some extent. The river runs behind the residential area. Because sea water also rose along the river, the inhabitants had difficulty finding the escape route to higher places. In Figure 5b we notice that houses were also washed away in some areas facing the river.

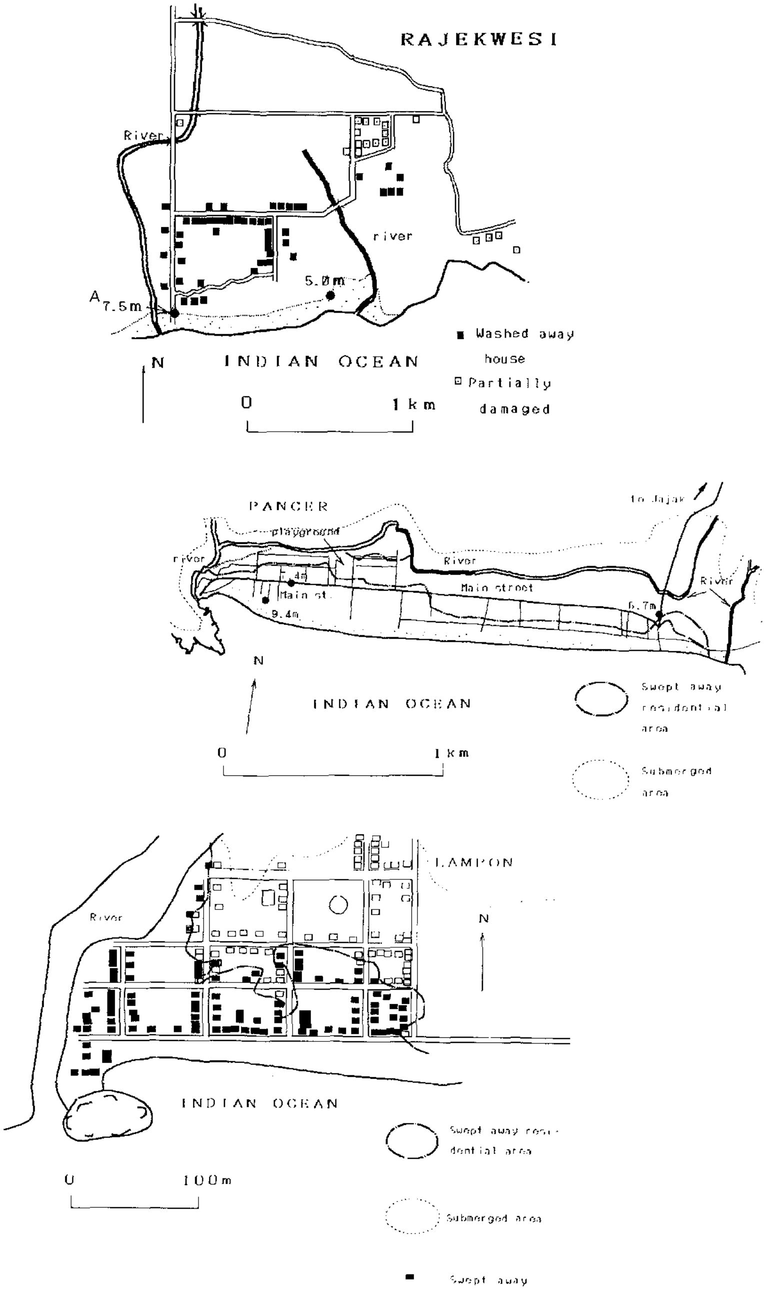

Figure 5a,b,c
Detailed maps of distributions of house damage of residential area of Rajekwesi, Pancer, and Lampon, respectively.

The surface height of the residential area is about 5 m, and the tsunami height was 9.4 m at the seaside part and 7.4 m at the main street in the central part. Thus, the water covered the surface with the thickness of 2–4 m. HATORI (1984) pointed out that when the thickness of inundating water exceeds 2 meters, wooden houses can be washed away. The main part of the residential area of Pancer seems to meet this condition. Actually, we saw nothing but foundations of houses on both sides of the main street of Pancer.

We observed that shore sand was carried into the residential area and formed a thin surface sediment layer. The shore bank was strongly eroded and the vertical surface of sand step with a height of 2–3 meters newly appeared.

The mortality of Pancer was only 3.9% in contrast to the ratio of collapsed houses which is about 70%. Considering that the time of tsunami arrival was midnight, and that tsunami height at the coast reached 9 meters or more, we should recognize that the mortality was fairly small in spite of the severe conditions.

C) Lampon

The residential area of the village of Lampon is also located on a sand dune at the mouth of a river (Fig. 5c). Sea water invaded the village, both from the ocean coast side and the river side. People living near the river mouth had difficulty escaping the tsunami due to its arrival from both sides. In the residential area near the mouth of a river, not only houses were swept away, but the ground itself was seriously eroded and even the foundations were lost. Only a few trees had been planted in front of the village, so sea water rushed into the residential area without impediment. The mortality of Lampon was 6.2 percent, and it seems to be influenced by the fact that there was a poor arrangement of trees in front of the residential area.

The height of the tsunami was measured as 5.4 m in the residential area, but we also measured the tsunami with a height of 9.1 m at a point on the seaside sand bank about 1 km east of the entrance to the village, where a new surface step with heights of 4–5 meters on the front side of the sand dune was formed by the erosion due to the tsunami.

8. Tsunami Magnitude

HATORI (1986) extended the definition of the tsunami magnitude m of Imamura-Iida's scale, which is defined with an interval of 0.5. He proposed two methods of estimating the tsunami magnitude. One is by using data of the averaged inundation heights H (unit; meter) and the epicentral distances D (km). He obtained an empirical formula

$$m = 2.7 \log H + 2.7 \log D - C. \qquad (2)$$

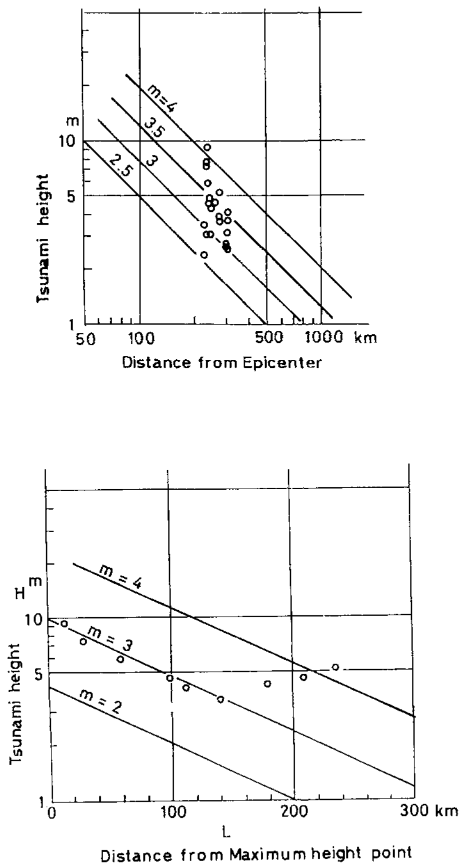

Figure 6(a,b)
(*Upper*) Attenuation of tsunami heights with epicentral distance for different tsunami magnitudes given by formula (2). Open circles show the measured data for the present event. (*Lower*) Relationship between tsunami heights H (unit: meter) and the distance L (unit: kilometer) from the location of the maximum height measured along the coast.

where C is constant and he assigned a value of 4.3. He confirmed that this formula provides good agreement with that defined by the amplitude of tide gauge records for many cases of small tsunamis. He also noted that for large tsunamis ($m > 1.5$), this formula produces about 0.5 larger value than that defined by tide gauge records. For the present case, tsunami magnitude evidently exceeds 1.5, therefore we selected the constant C as 4.8 instead of 4.3. In Figure 6a, we plotted the inundation height to the epicentral distance for each village (white circle). In cases of inundation heights measured at more than two points in the same village, we averaged them. Solid lines show tsunami magnitude defined by formula (2) with $C = 4.8$. Tsunami magnitude m of the present case can be estimated as 3 or 3.5.

The second method of estimating tsunami magnitude by Hatori is using the attenuation curve of inundation height H (in m) with the distance L (in km) from the location of the maximum height point. The empirical relationship between H and L with respect to m is expressed as,

$$m = 0.008\,L + 2.7 \log H + 0.31. \tag{3}$$

Solid lines in Figure 6b show the relationship of (3), and white circles are plotted values of inundation heights H to L for the present event, from which we can estimate the tsunami magnitude of the present case as $m = 3$.

We should notice that the distance from the source region is not considered for the estimation of the m value in the second method.

Even though the definition of the m value by Hatori contains ambiguity, we can summarize that the m value for the present case is about 3, estimated by both methods.

WATANABE (1984) obtained a relationship between earthquake (M) and tsunami (m) magnitudes by using Japanese tsunami data in the modern ages. He obtained the relationship,

$$m = 2.30\,M - 16.2 \tag{4}$$

by using the data of 60 events with removing four tsunami earthquake cases (dashed line in Fig. 7). KOYAMA and KOSUGA (1985) also proposed an empirical

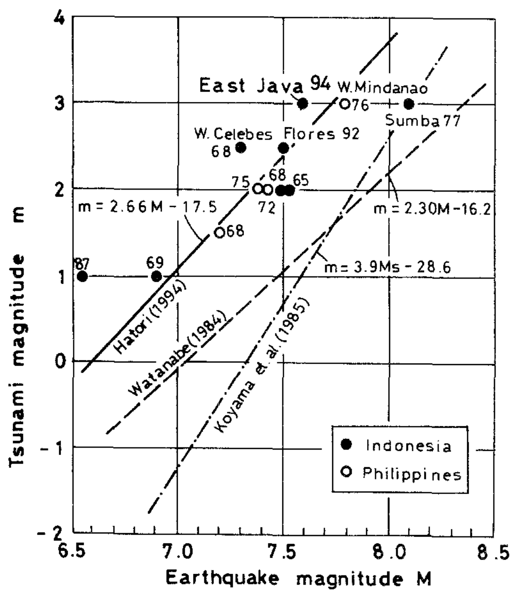

Figure 7

Relationship between the earthquake and tsunami magnitudes. Solid line shows the regressive line of Indonesia-Philippines Region by HATORI (1994). Dashed line shows the regressive line in the Japanese Islands by WATANABE (1984), and chain line shows that by KOYAMA and KOSUGA (1985) from 16 of the largest events in the world.

formula from 16 of the world's biggest events in addition to Japanese data,

$$m = 3.9\,M_s - 28.6, \tag{5}$$

which is expressed by the chain line in Figure 7.

Recently, HATORI (1994) pointed out that the magnitudes of the tsunamis in the sea regions of Indonesia and the Philippines exceed by one to two grades larger than those generated by the earthquakes of the same magnitude of the other regions, and gave the regression formula for those regions as

$$m = 2.66\,M - 17.5. \tag{6}$$

In Figure 7, the solid line shows the relationship (6). Circles represent tsunamis generated in the Philippine-Indonesia region and attached numbers designate years of occurrences. The plotted circle for the present event is also situated close to the line.

9. Discussion

The main shock was felt weaker on Java and Bali in contrast to its large magnitude 7.6. People could not imagine the attack of such a huge tsunami soon after the main shock, even if they comprehended tsunamis. Generally, earthquakes are frequently felt in the territory of Java and Bali Islands, and nobody considered that the present earthquake felt at midnight was an extraordinary one. The situation resembles that of the 1896 Meiji Sanriku Earthquake-Tsunami in Japan. Nobody was prepared for the gigantic tsunami, with height of 15 to 20 m which hit coastal villages thirty minutes after the earthquake and killed about 22,000 persons.

Our future task will be to clarify why the Indonesia-Philippine region has such characteristics that tsunamis one or two grades larger are generated by earthquakes of the same magnitude in comparison to other regions.

Acknowledgment

The authors wish to express their thanks to the staffs of the Meteorological and Geophysical Agency, Indonesia for their support of our field survey and for supplying us with the aftershock data.

We also thank Mr. Subandono, Mr. Presetya from BPPT, Mr. Z. L. Dupe from the Institute of Technology of Bandung, Ms. Maria Usman from the University of Southern California, and students from the University of K. Petra, Surabaya, for their assistance in the field survey. We also thank the Japan Ocean Data Center of the Hydrographic Department, Marine Safety Agency for offering data of tidal coefficients of Banyuwangi, Sanur, and Cilacap Ports. Dr. T. Hatori contributed useful suggestions in the estimation of tsunami magnitude.

Appendix

Table of the results of the measurement of tsunami heights

Place Name		Location				Height
Regency	Place	Lat.	S	Long	E	Abv. MSL (m)
	Kuta	8°	42.57′	115°	09.94″	1.0
	Tanah lot	8	37.19	115	05.15	<2.0
	Soka	8	31.59	114	59.59	3.7
Bali I.	Antor	8	31.65	114	59.72	4.1
	Surabratan	8	28.48	114	55.82	2.6
	Penggraguan	8	27.80	114	54.46	3.2
	Pakutatan	8	26.02	114	49.41	2.8
	Rambutsuiwi	8	24.30	114	46.03	2.7
	Trianĝĝul Asih*	8	39.41	114	21.64	4.9
	Trianĝĝul Asih*	8	39.42	114	21.64	3.6
	G-Land, Plenĝkunĝ	8	41.69	114	22.56	4.0
	Tg. Purwa 1	8	43.82	114	21.06	4.2
	Tg. Purwa 2	8	43.93	114	20.93	5.1
	Tg. Purwa 3	8	43.85	114	20.85	5.5
	Tg. Purwa 4	8	44.75	114	21.35	4.4
	Tg. Purwa 5	8	44.37	114	20.56	5.6
	Tg. Purwa 6	8	43.98	114	20.76	5.3
	Grajagan	8	35.78	114	13.40	2.5
	Grajagan West 1	8	36.0	114	13.5	2.3
	Grajagan West 2	8	36.49	114	13.60	4.1
Banyuwangi	Purwoasri	8	36.91	114	06.83	1.3
	Lampon East	8	36.0	114	05.8	9.3
	Lampon	8	36.93	114	05.19	5.4
	Lampon	8	36.93	114	05.19	1.3
	Lampon	8	36.93	114	05.19	3.8
	Pancer Center	8	35.35	114	00.26	6.7
	Pancer	8	35.4	114	00.3	7.5
	Pancer	8	35.4	114	00.3	9.4
	Pancer	8	35.35	114	00.28	6.7
	Pancer	8	35.16	114	00.47	5.7
	Pancer	8	35.36	114	00.50	6.3
	Rajekwesi	8	33.39	113	56.11	13.9
	Rajekwesi	8	33.40	113	56.11	4.2
	Rajekwesi	8	33.51	113	56.62	7.5
	Rajekwesi	8	33.32	113	56.69	5.0
	Bandialit	8	28.90	113	42.66	9.9
	Bandialit W	8	28.94	113	42.68	11.2
Jember	Bandialit E1	8	28.93	113	42.78	6.0
	Bandialit E2	8	28.97	113	42.75	5.9
	Bandialit E3	8	29.11	113	42.94	4.6
	Besini-Ngarpuĝer	8	22.82	113	27.93	5.9
	Geten	8	23.17	113	24.49	3.1
Lumajang	Bambangan	8	17.36	113	06.51	4.6

*Trianĝĝul Asih is in Kendalrejo Village

Appendix (Contd)

Place Name		Location				Height
		Lat.		Long		Abv. MSL
Regency	Place		S		E	(m)
	Sendanbru	8°	25.00′	112°	42.62′	3.6
	Sendanbru	8	25.81	112	41.08	3.4
Malang	Sendanbru	8	26.00	112	40.92	3.6
	Sempu Is.	8	25.76	112	41.53	2.7
	Sempu Is.	8	26.00	112	41.43	2.1
	Ngliyep	8	21.	112	21.2	4.3
	Tambakrejo	8	18.	112	05.	5.4
	Tambakrejo	8	18.	112	05.	3.7
	Sine Gulf	8	16.	111	53.	4.2
	Sine Gulf	8	16.	111	53.	3.5
	Gerangan	8	15.43	111	50.38	4.6
	Gerangan	8	15.41	111	50.43	5.4
Tulungagung	Gerangan	8	15.42	111	50.39	5.5
	Brumburn	8	15.70	111	50.02	4.8
	Brumburn	8	15.71	111	50.02	3.7
	Brumburn	8	15.72	111	50.04	3.8
	Popoh	8	15.58	111	48.43	2.9
	Popoh Port	8	15.78	111	48.26	3.9
	Sidem	8	15.34	111	48.00	3.1
	Prigi	8	17.23	111	43.43	

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(Received September 29, 1994, revised April 12, 1995, accepted April 18, 1995)