DECEMBER 26, 2004 INDIAN OCEAN TSUNAMI
FIELD SURVEY (JAN. 21-31, 2005) AT NORTH OF SUMATRA ISLAND

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SUMMARY

This report is about the the field survey performed in between January 21-31, 2005 at North Coast of Sumatra Island at Medan, Meulaboh cities and Simeulue Island. In the report we presented the survey results about runup, arrival time and damages of tsunami. Additionally we also presented the prelinminary results simulation performed by Yalciner in comparison with the survey results of other tsunami survey teams at Sumatra, Thailand, Sri Lanka, India and Maldives.

1. INTRODUCTION

International Tsunami Survey Team consisted of Ahmet C. Yalciner (Turkey), Dogan Perincek (Turkey), Sukru Ersoy (Turkey), Gegar S. Presateya (Indonesia), Rahman Hidayat (Indonesia), Brian McAdoo (USA) have performed the field survey in between January 21-31, 2005 along coasts of Medan, Meulaboh cities, and Simeulue island which are located North of Sumatera with the invaluable survey support by UNESCO IOC and also invaluable logistic and administrative supports by Indonesian Government, Ministry of Fisheries and Marine Affairs, and Indonesian Army. The Russian survey team Victor Kaistrenko (leader) and Nadia, Yuri, Andrey Zaitsev, Nocholai Poloukhin has participated and contributed the survey in Simeulue island and Medan.

In theis report we presented our survey results on runup, arrival time and damages of tsunami at North of Sumatra. Additionally we also presented the prelinminary results of simulation performed by Yalciner in comparison with the survey results of other tsunami survey teams at Sumatra, Thailand, Sri Lanka, India and Maldives.

2. INDONESIA / NICOBAR / ANDAMAN / SUMATRA EARTHQUAKE ON DECEMBER 26, 2004

The devastating megathrust earthquake (Indonesia/Nicobar/Andaman/Sumatra Earthquake) of December 26, 2004, occured on Sunday, December 26, 2004 at 00:58:53 GMT (7:58:53 AM local time at epicenter) with Mw=9.0 NEIC Epicenter Latitude 3.32 North, Longitude 95.85 East (USGS) or 3.09N, 94.26E southwest Banda Aceh in Northern Sumatra (Borrero, 2005). The earhquake occurred on the interface of the India and Burma plates and was caused by the release of stresses that develop as the India plate subducts beneath the overriding Burma plate. The India plate begins its descent into the mantle at the Sunda trench, which lies to the west of the earthquake's epicenter. The trench is the surface expression of the plate interface between the Australia and India plates, situated to the southwest of the trench, and the Burma and Sunda plates, situated to the northeast (Taymaz,Tan, Yolsal, 2005). The fault plane solutions of the earthquake are shown in Figure 1.

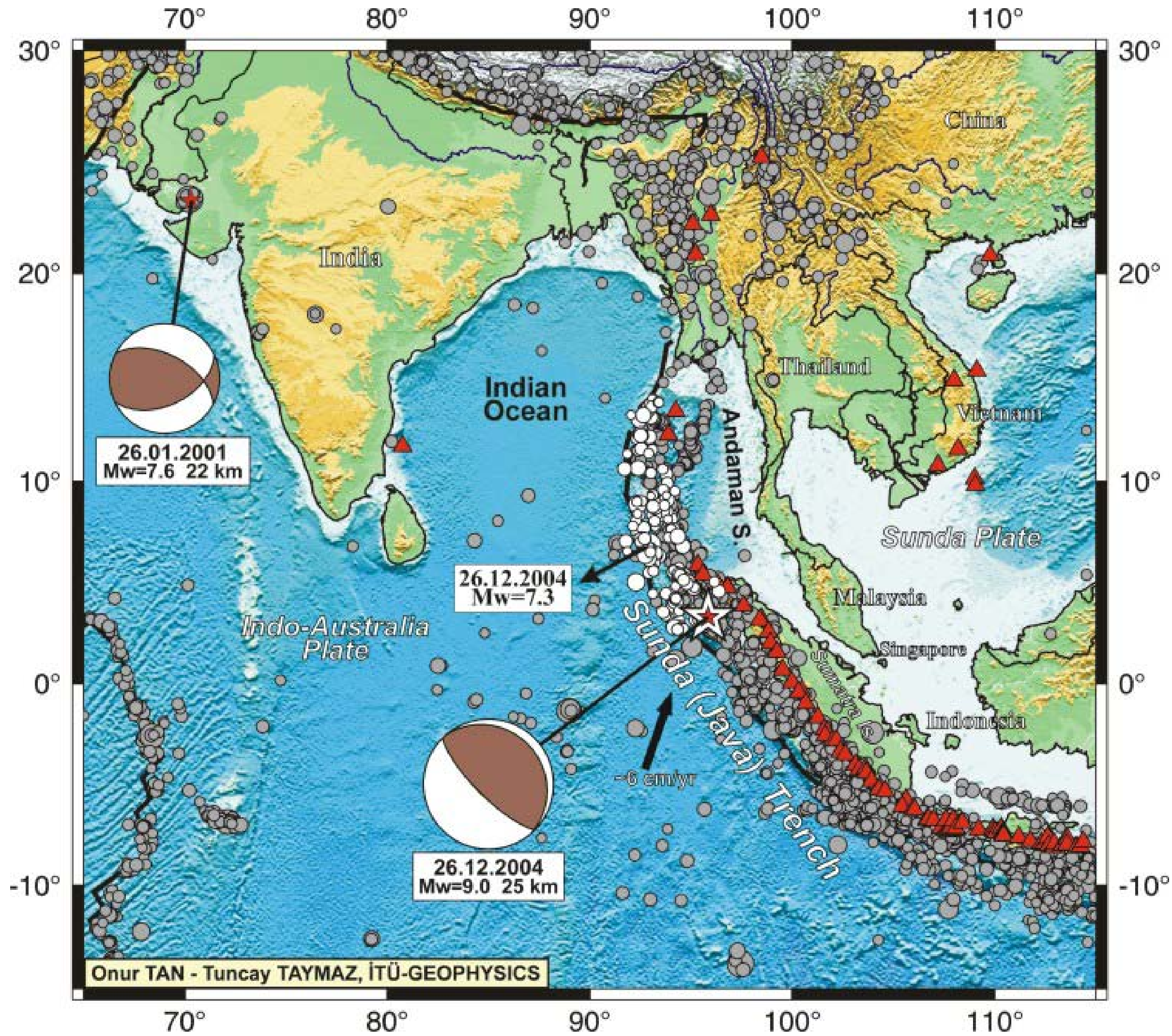

Figure 1. The fault plane solutions of December 26, 2004 Earthquake (Taymaz,Tan, Yolsal, 2005).

3. INDIAN OCEAN TSUNAMI ON DECEMBER 26, 2004

The earthquake has also triggered giant tsunami and the tsunami waves that propagated throughout the Indian Ocean and have caused extrme inundation and extensive damage, loss of property and life along the coasts of 12 surrounding counties in the Indian Ocean. The loss of lives has also been extended to the people from totally 27 countries from other parts of the world. The number of casualties and missing from the Countries Bordering Indian Ocean, (AFP, 2005) given in Table 1.

The tsunami waves have arrived North of Sumatra in half an hour. The waves have arrived Thailand and Sri Lanka, India and Maldives within hours and also arrived Somalia Africa some hours later. The number of casualties and missing people are listed in Table 1 (AFP, 2005). The total number of death toll in the list shows that this tsunami is the first one of the most destructive tsunamis experienced in human life from antiquity. Because of this exceptional character, it is clearly seen that, the shaking of North Sumatra Earthquake has not only triggered a tsunami and cause damages and loss of lives but also shaked the psychology, social life, scientific considerations, understanding of hazards and priorities of mitigation measures. This event will remain as the most important item in the agenda of assessment of natural hazards in the long run.

Table 1. The number of casualties and missing from the Countries Bordering Indian Ocean (AFP, 2005)

Country	Dead	Missing
Indonesia	125,598	94,574
Thailand	5,395	3,001
Sri Lanka	30,957	5,637
India	10,749	5,640
Myanmar	61	-
Maldives	82	26
Malaysia	68	-
Somalia:	298	-
Tanzania	10	-
Bangladesh	2	-
Kenya	1	-
TOTAL	173,221	108,878

Understanding of Indian Ocean Tsunami will provide us very valuable experience, knowledge and sense to develop better defense of humanity against natural hazards. In the following the tsunami survey performed by ITST (Turkish, Indonesian, Russian, USA) is described briefly and the results are presented.

4. TSUNAMI FIELD SURVEY AT NORTH OF SUMATRA ON JANUARY 21-31, 2005

International Tsunami Survey Team consisted of Ahmet C. Yalciner (Turkey), Dogan Perincek (Turkey), Sukru Ersoy (Turkey), Gegar S. Presateya (Indonesia), Rahman Hidayat (Indonesia), Brian McAdoo (USA) have performed the field survey in between January 21-31, 2005 along coasts of Medan, Meulaboh cities, and Simeulue island which are located North of Sumatera with the invaluable survey support by UNESCO IOC and also invaluable logistic and administrative supports by Indonesian Government, Ministry of Fisheries and Marine Affairs, and Indonesian Army. The Russian survey team Victor Kaistrenko (leader) and Nadia, Yuri, Andrey Zaitsev, Nocholai Poloukhin has participated and contributed the survey in Simeulue island and Medan.

The survey locations are tabulated in Table 3 and and shown on the Figure 6-7. The water level data in Table 2 are before tidal correction. For tidal correction the data is given in Tsuji, Namegaya and Ito, (2005).

Table 2: The list of measured parameters by the Turkish-Indonesian-USA Team during the field survey on Sumatra on January 21-29, 2005. (The water level data are before tidal correction)

No.	Survey point	Latitude	Longtitude	Survey Date	Max. Flow depth	Inund. Dist.	Arrival Time of Tsunami (min after the earthq.	Max. positive tsunami amplitude near the shore	Notes
1	Simeulue Ganting	02°32.935N	96°20.083E	Jan 22, 05	1.5 m	1.5km along creek	~ 30min	1.75m	bridge damaged
2	Simeulue Ganting	02°33.022N	96°19.797E	Jan 22, 05	2 m	2km along creek	~ 30min	3m	Boat dragged 250m away from shore
3		02^0 33.484N	$96^0$18.452 E	Jan 22, 05	2.5 m	2km	~ 30min	>4m	sea receeded upto 2km horizontally 10min. after earthq. and advanced 15min later
4	Simeulue Tsunami end point	02°34.517N	96°16.122E	Jan 23, 05	0.3 m	10m	~ 30min	<0.30m	IMPORTANT north of this point no significant wave action, sea water is very clear
5	Simeulue Tanjun Raya	02°33.892N	96°17.262E	Jan 23, 05			~ 30min	1.9m	
6	Simeulue Senebu village	02°33.430N	96°18.057E	Jan 23, 05	2 m	1.5 km	~ 30min	2m	2hr. after eq. sea receeded and advanced
7	Simeulue Near Senebu	02°20.630N	96°28.098E	Jan 23, 05	2 m	1ç5 km	~ 30min	2.5m	Sea receded first after 4hr from eq @ 12:00 o.clock
8	Simeulue Near Senebu village	02°23.156N	96°29.322E	Jan 23, 05	3 m	1.5 km	~ 30min		damaged walls, undamaged piers of mosque

9	Simeulue Labuhan Bakti	02°24.404N	96°29.000E	Jan 24, 05	3 m	1.5km	~ 30min	4m	hardest hit, southeast point of Simeulue
10	Simeulue Labuhan Bakti	02°24.459N	96°28.892E	Jan 24, 05	2 m	1.5km	~ 30min		
11	Simeulue Labuhan Bakti	02°24.265N	96°28.890E	Jan 24, 05	2 m	1.5km	~ 30min	2.5m	photo, inside government building , notes
12	Simeulue Labuhan Bakti	02°24.192N	96°28.854E	Jan 24, 05	2 m	1.5km	~ 30min		damaged cottage of old woman, photo
13	Simeulue near Labuhan Bakti	02°24.107N		Jan 24, 05	2 m	1.5km	~ 30min	2.5m	destroyed jetty, photo, subsidence proof
14	Simeulue Near Labuhan Bakti			Jan 24, 05		1.5km	~ 30min	2.5m	800m west of point 9
15	Simeulue Laubang	02°25.942N	96°15.626E	Jan 23, 05		500m	~ 30min	1.5m	
16	Simeulue Lantik or Tembah Barat	02°25.947N	96°15.624E	Jan 23, 05		500m	~ 30min	1.5m	
17	Simeulue Salur	02°26.528N	96°14.561E	Jan 23, 05		500m	~ 30min	1.5m	
18	Simeulue Busung	02°23.589N	96°20.204E	Jan 23, 05		500m	~ 30min	1.5m	
16	Meulaboh Suaktimah village	04°12.638N	96°03.884E	Jan 27, 05			~ 40min	>15m	village completely destroyed
17	Meulaboh Skoneda	04°12.552N	96°02.379E	Jan 2, 05			~ 40min	>15m	

18	Meulaboh Skoneda	04°12.501N	96°02.389E	Jan 27, 05		~5 km	~ 40min	>15m	shoreline
19	Meulaboh Kuala Buban Bay	04°12.455N	96°02.346E	Jan 27, 05		~5 km	~ 40min	>10m	
20	Meulaboh Kuala Tadu	03°57.930N	96°18.576E	Jan 28, 05		~5 km	~ 40min	>15m	
21	Meulaboh Port	04°07.740N	96°07.738E	Jan 28, 05		~5 km	~ 40min	>15m	harbour washed out and compltely destroyed
22	St 176, WPT17	04°12.525N	96°02.214E	Jan 27, 05			~ 40min	>15m	collapsed bridge at the north of Meulaboh near Palm oil Tank (near shoreline)
23	Meulaboh near Aronghan	04°18.504N	95°58.326E	Jan 27-28, 05		~5 km			inundation limit at land
24	Meulaboh Aronghan	04°17.797N	95°56.879E	Jan 27-28, 05		~5 km	~ 40min	15m	Shoreline near Aronghan
25	Meulaboh Aronghan	04°17.796N	95°56.831E	Jan 27-28, 05		~5 km	~ 40min	15m	Shoreline near Aronghan
26	Meulaboh near Aronghan	04°18.010N	95°59.235E	Jan 27-28, 05		~5 km		9m	inundation limit at land
27	Medan East Pentai Cermin			Jan. 21, 05		500m	~ 4 hr	1.7m	
28	Medan East Kuala Ruteri			Jan. 21, 05			~ 4 hr		
29	Medan East Belawan Port	03°47.059N	98°42.921E	Jan. 21, 05			~ 4 hr		
30	Medan East Ferry Port	03°47.235N	98°42.297E				~ 4 hr		

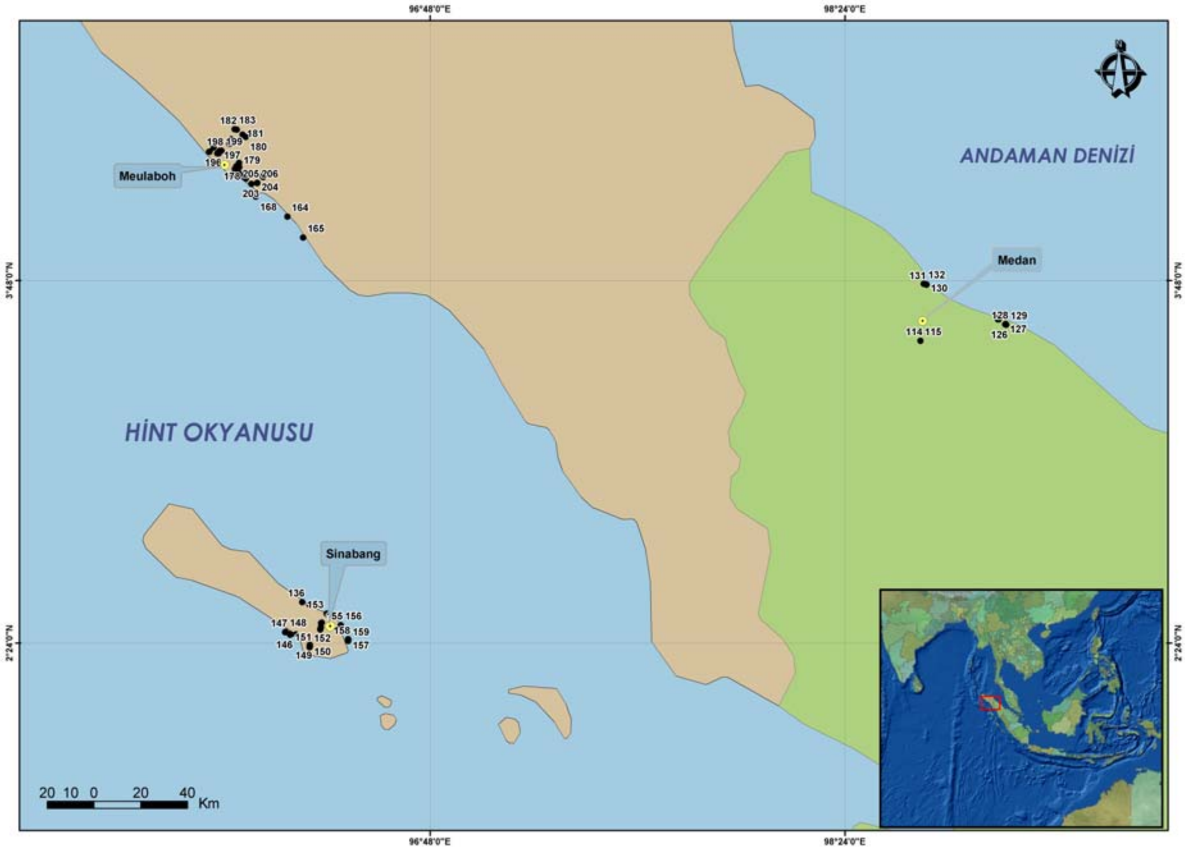

Figure 2. The survey locations on the Map of North Sumatra

Figure 3. The survey locations on the Map of North Sumatra

4.1. FIELD SURVEY NEAR MEDAN COAST

The field survey has been performed on January 21, 2005 at the coastal regions named Pantai Cermin and Kuala Ruteri near Medan. Tsunami waves have also been arrived in these localities after diffraction from the north part of Sumatra island. The survey near Medan coast provided us the data for understanding the transformation (shoaling, diffraction and refraction) characteristics of tsunami waves. According to our eyewitness interviews at two survey sites, it was determined that

i. The arrival time of tsunami waves was about 4 hours, and

ii. The maximum elevation of the water level near the coastline has exceeded 2-2.5m elevation (as measured from the traces on the walls of houses). The sediment deposited irregularly on land near the coastline depending on the land topography near the shore. The inundation distance was observed as about less than 1 km at survey points at east of Medan.

Figure 4. The Survey Location near East of Medan

4.2. FIELD SURVEY ALONG THE COAST OF SIMEULUE ISLAND

The survey has been performed on January 22-26, 2005 at the coastal regions named. Laubang, Lantik, Tembah Barat, Salur, Busung, Labuhan Bakti, Belawan Port, Ganting, Sinabang Port, Senebu, Tanjun Raya by ITST, and additionally near Alafan at North of Simeulue (by Russian team). Simeulue island provides very illustrative picture of understanding, awareness and mitigation of tsunami hazards. The previous experience of tsunami attack to west side of this island in 1907 have thaught the peolpe that the sea inundation (called “smong” in local language) may cause damages, loss of life and property near the coastlines. The people always were very sensitive about the sea motion after erathquakes since 1907 event. It was noted by the Governor of the Island (Buphati Dr. Darmili) that all people had escaped from the shoreline when they felt earthquake and 8 people died out of 78 000 inhabitant in the island. The hardest tsunami hit was reported at north of island near Alafan (maximum tsunami elevation was more than 10 m). The most damage was at Labuhan Bakti at south of island where the maximum tsunami elevation was more than 2.5 m. According to our eyewitness interviews at the survey sites near Simeulue, it was determined that

Sea receded in 10 minutes after the earthquake about 200-400 m and at about 30th minute after the eq. the first wave has arrived, and second one folowed it 50-60 minutes after the first one, and The maximum elevation of the water level near the coastline has exceeded 3 m elevation (as measured on the walls of houses.

Figure 5. The survey locations at Simeulue Island

4.3. FIELD SURVEY ALONG THE MEULABOH COAST

Tsunami has directly attacked towards north west coast of Sumatra Island from 25 km south of Meulaboh to north tip of the island Banda Aceh. The tsunami inundation started from the coastal location at 30 km south of Meulaboh city. The inundation distance is observed as about 5 km and almost the same along the south and north coast of Meulaboh city. The wave propagated much more distances towards inland along the rivers' beds.

It was determined that tsunami waves have exceeded the height of coconut trees along Meulaboh coasts, have inundated 5 kilometers towards land, and have totally destroyed the Port of Meulaboh and its surrounding area, and have also killed about 2/3 of the whole population in Meulaboh. It was also determined that the loss of life has reached 70 percent of the population in Tanom and Calang cities at the north of Meulaboh coasts

According to our eyewitness interviews at all survey sites near Meulaboh, it was clearly determined that
i. Sea receded in 10 minutes after the erathquake about 500 m and advanced with the amplitude of 1-1.5. At about 30 minute later, the second wave, but the first desctructive wave has arrived, and second destructive wave arived 50-60 minutes after the first one, and
ii. The maximum elevation of the water level near the coastline has exceeded 15m elevation (in comparison with the height of coconut trees) during either the first and second destructive waves. Totally 5 main coastal areas have been surveyed on land at south and north of Meulaboh. The inundation distance is clearly distinguished by the dried vegetation along the coastlines because of the salt water inundation.

The southern end of tsunami attack (where the inundation distance is short) at north west coast of Sumatra island has also been documented by a series of air photographs (southernmost survey point on the map shown in Figure 10). There was no safe access along the road to Calang because of damages on amost all the bridges in the inundation zone of tsunami. The increasing pattern of inundation distances and higher runup elevations will be measured when the field survey is extended to far north of Meulaboh to Tanom, Calang and Banda Aceh.cities when the bridges and road are repaired for transportation.

Figure 6. The survey locations near Meulaboh

5. DISCUSSION OF SURVEY RESULTS

5.1. Runup, Inundation, Arrival Time

The maximum positive amplitude of tsunami near the shoreline has been measured by following the information obtained from eyewitness interviews and/or field measurements of tsunami traces at Medan, Simeulue and Meulaboh. At all coastal locations where we have surveyed, the tsunami have much more inundated towards inland along the rivers.

The waves have arrived Medan 4 hours after the earhquake with an average positive amplitude of 1.5m.

The eyewitnesses have reported that sea receded about 500 m and advanced with an approximate amplitude of 1-1.5m ten minutes after the earthquake. Half an hour after that the second (but) destrcutive wvae has arrived. The third wave was also destructive and arrived 50-60 minutes after the previous (second) wave. We have observed that the extensive inundation of tsunami waves at north west coast of Sumatra Island started at a location about 30 km south of Meulaboh city. The maximum positive amplitude of tsunami waves have been observed by eyewitnesses as higher than 15m. near Meulaboh. The inundation distance is about 5 km.

The people living in Simeulue Island were very sensitive about the sea motion after the earthquake snce 1907 when a tsnami hit western coast of Island. Only 8 people died in the island out of 78000 population. The hardest hit was at north of Island. There was weak wave action at east side of island especially at North of Tanjun Raya.

In Figure 7, the distribution of Runup at several coastal locations near the coast of Indian Ocean is presented. The figure is drawn by compilation of results of several field surveys in the region published or publicized in Fritz H. and Synolakis C., (2005), Gusiakov S., (2005), Kawata Y. et. al., (2005), Shibayama et. al., (2005), Synolakis C., and Borrero J., (2005) Taymaz et. al., (2005), Tsuji Y. et. al., (2005), Yalciner et. al. , (2005), Yeh (2005),

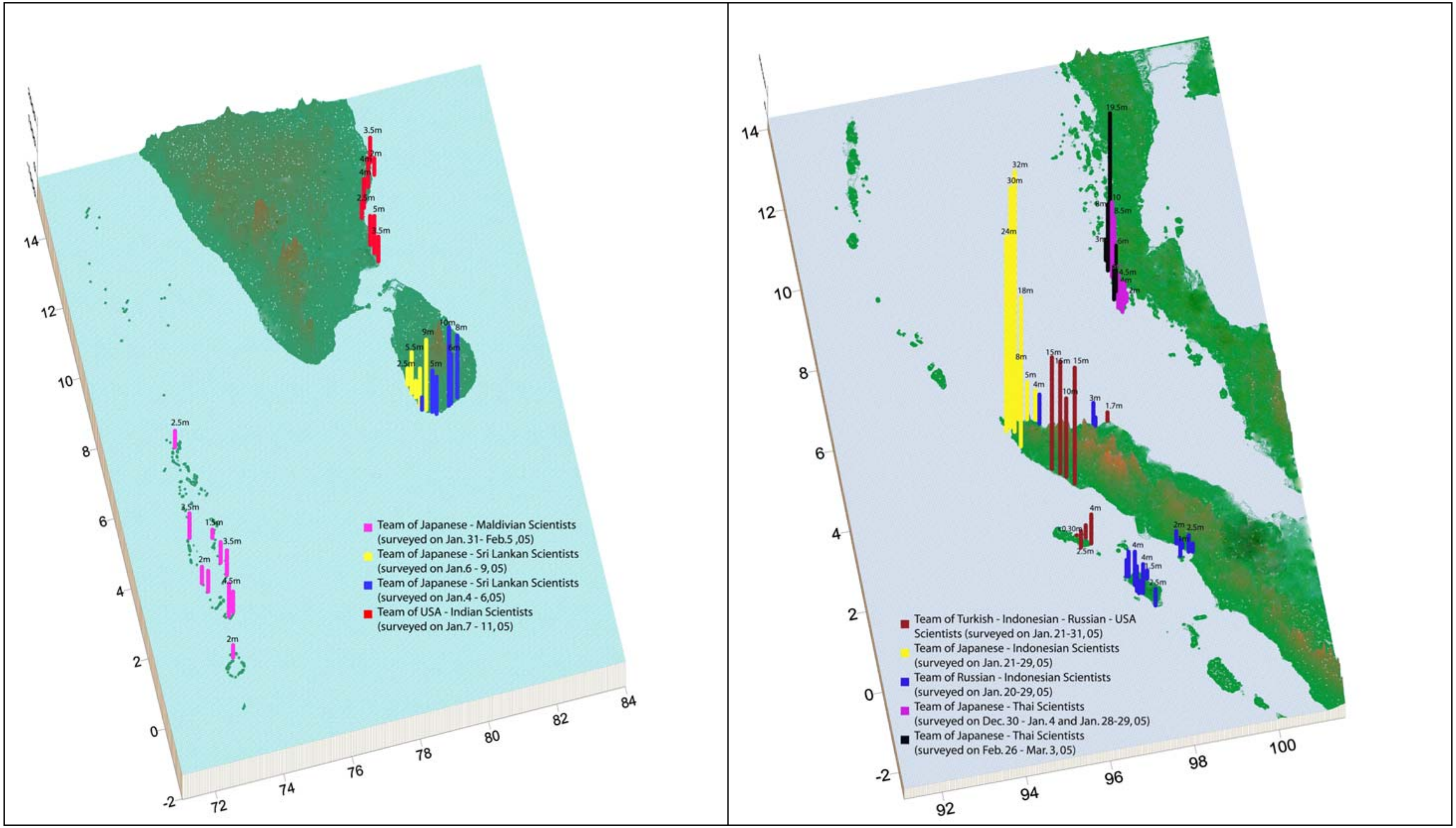

Figure 7. The Runup Distributions at North Sumatra Coats (Indonesia), Thailand, India, Sri Lanka, Maldives Measured by Indonesian, Japanese, Russian, Turkish and USA Scientists.

5.2. The Response of Structures Against Tsunami Attack

The structural response can be analysed for two types of structures

i. Wooden Stuctures
ii. Conrete Structures
iii. Infrastructures

5.2.1. Wooden Stuctures

The wooden structures has been constructed on a concrete ground base. It is clearly observed that tsunami has swept the wooden part of the structures and completely damaged them where the flow depth exceeded 2.5-3 m in the inundation region. The photographs in Figure 7 show the typical damages and damage levels of tsunami on wooden structures.

Figure 7: The typical damages and damage levels of tsunami on wooden structures.

5.2.2. Concrete Stuctures

The concrete structures have standed against tsunami waves. But their level of resistance and success for survival are fully dependent on i. the percent of open area (area of windows) on the walls of ground floor for tsunami transmission and also ii. The flow depth of tsunamis near the structure. The scour around the concrete sturctures are the common effect of flow velocities related to tsunami action. The photographs in Figure 8 show the typical damages and damage levels of tsunami on concrete structures.

Figure 8: The typical damages and damage levels of tsunami on concrete structures.

5.2.3. Infrastructures

Mainly the cities are located the shoreline in Sumatra. Most of the villages near the cities at north of Sumatra are located near the coastline (in the range of 1-2 km from the shoreliine). The main components of transportation between the cities and villages are land transportation on roads, bridges and partly betwen harbors as maritime transportation. This type of land use plans have resulted the effects of tsunami waves to be much more destructive and devastating on either accomodation structures or transportation infrastructures

Figure 9: The Typical Damages and Damage Levels of Tsunami on Infrastructures

6. MODELING

The generation, propagation and coastal amplification of tsunami waves are modeled using *TUNAMI N2* software. *TUNAMI N2* is authored by *Fumihiko Imamura* in Tohoku University Japan, and developed in Middle East Technical University by *Ahmet Cevdet Yalçıner,* and in the University of Southern California by *Costas Synolakis*. It is the outcome of UNESCO TIME Project. The model applications for this event have been done by *Ceren Özer, Hülya Karakuş, Gülizar Özyurt* and *Ilgar Şafak* at Middle East Technical University (METU), Ankara-Turkey and *Efim Pelinovsky* and *Andrey Zaitsev* from Institute of Applied Physics, Russian Academy of Sciences, Nizhny Novgorod, Russia

During the estimate stage of the initial wave Geophysicist Ugur Kuran, Seismologist Prof. Dr. *Tuncay Taymaz* and Prof. *Emile Okal* has contributed the model in determination of the tsunami source. We acknowledge Prof. *Efim Pelinovsky* for providing the bathymetric data. The simulation had been done by the model *TUNAMI-N2* which was authored by Prof. Fumihiko Imamura in Tohoku University Japan, and developed in Middle East Technical University-Ankara under support of TÜBİTAK and by collaboration with Prof. Costas Synolakis in University of Southern California, USA and licensed by Imamura-Yalciner-Synolakis.

The initial wave for simualtion has been computed by the fault data given in Table 3. The sea state at 5, 30, 60, 120, 180, 240, 300, 360, 420, 480, 600 minutes in Indian Ocean are presented in Figure 10. The computed maximum water surface elevations reached at each grid point and travel time curves during propagation of tsunami in Indian Ocean is also presented in Figure 11.

Table 3: The fault data used to compute the tsunami source for simulation

Epicenter Eastern Coordinate	93.13^{o} N
Epicenter Northern Coordinate	03.70^{o} E
Fault Length	443km.
Fault WİdtH	170km.
Stirke Angle	329^{o}
Dip Angle	8^{o}
Slip Angle	110^{o}
Displacement	30
Focal Depth	25km
Maximum +ve Amplitude at Tsunami Source	+ 10.7m
Maximum -ve Amplitude at Tsunami Source	- 6.6m

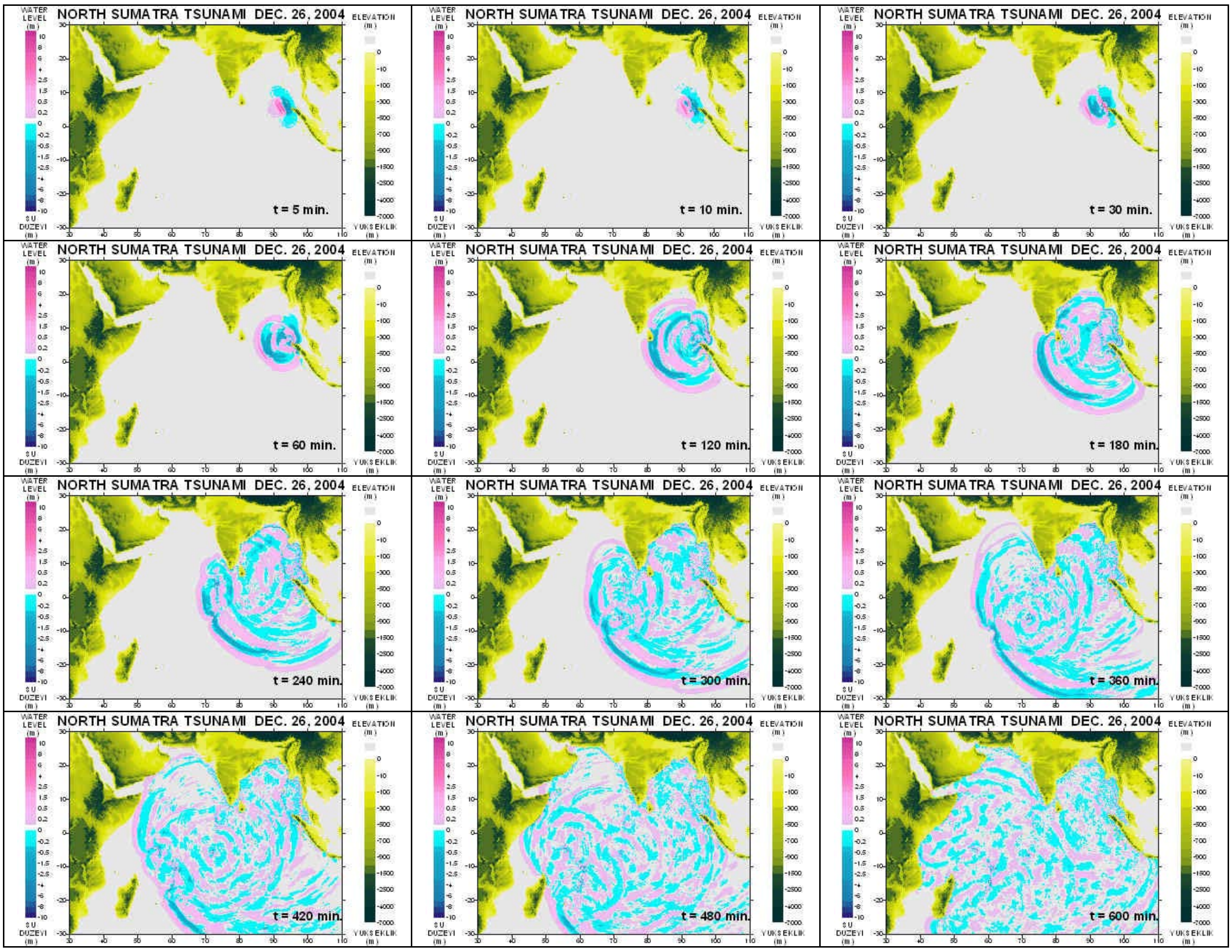

Figure 10. The sea state at 5, 30, 60, 120, 180, 240, 300, 360, 420, 480, 600 minutes in Indian Ocean

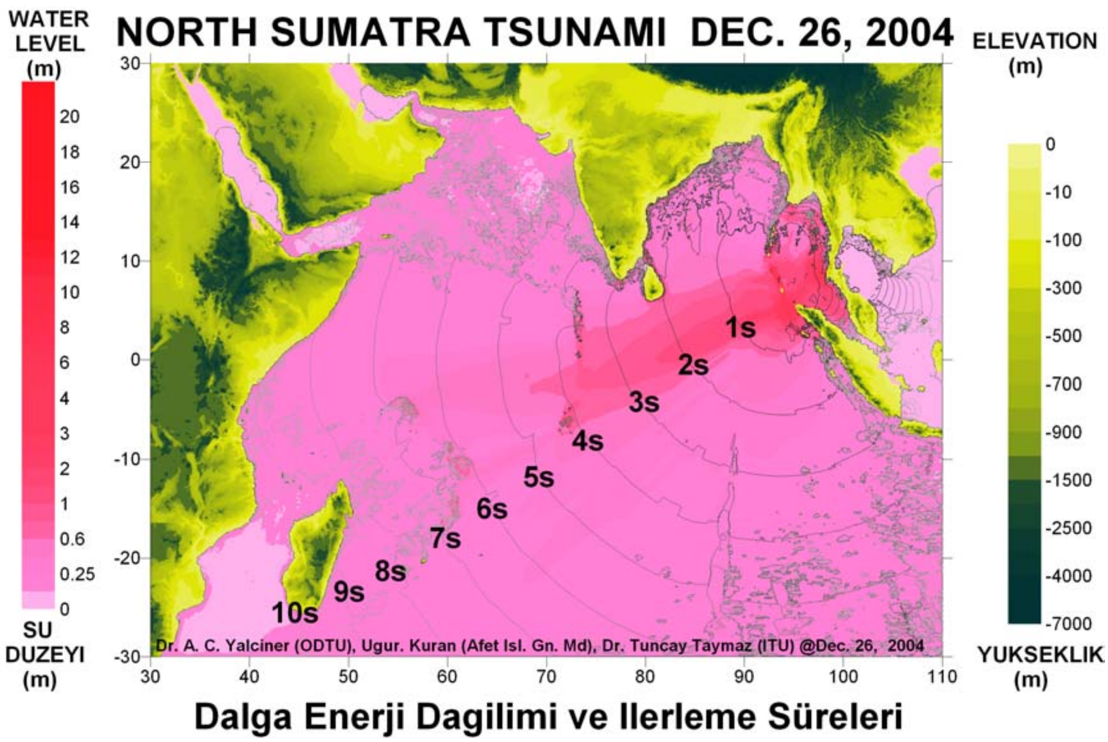

Figure 11. The Computed Maximum Water Surface Elevations Reached at Each Grid Point and Travel Time Curves During Propagation of Tsunami in Indian Ocean .

6. CONCLUSION

The Indian Ocean Tsunami is the most destructive tsunami experienced by humanity since antiquity. The nuımber of death tolls is around 300 000.

The earthquake triggered this tsunami has also shaked the psychology, social life, scientific considerations, understanding of hazards and priorities of mitigation measures, and political priorities. This event will remain as the most important item in the agenda of assessment of natural hazards in the long run. All aspects of tsunamis have been observed, recorded and documented in this event.

In this report the general characteristics of North Sumatra Earthquake and Indian Ocean Tsunami is presented. The distribution of positive amplitude of tsunami waves near Medan, Meulabh and Simeulue ısland are presented (Figure 7) together with inundation data (Table 1). The structural response against tsunami waves are also discussed for wooden and concrete structures, and coastal infrastructures. The significant scour around concrete structures, generally partial damage on concrete structures, full damage on wooden structures are basic data obtained during observations. The performance of on coastal infrastructures after tsunami attack has also been documented. The results presented in this report are not complete. The additional photographs from this survey report are also available from yalciner@metu.edu.tr .

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8. REFERENCES

AFP, (2005), Death toll in Asian Tsunami Disaster
http://story.news.yahoo.com/news?tmpl=story2&u=/afp/20050305/wl_asia_afp/asiaquaketoll

Borrero, J. (2005), "Learning from Earthquakes, The Great Sumatra Earthquake and Indian Ocean Tsunami December 26, 2005, Field Survey on Northern Sumatra", Report#1 EERI, Special Earthquake Report, March 2005

Fritz H. And Synolakis C., (2005), http://www.gtsav.gatech.edu/cee/groups/tsunami/index.html

Gusiakov S., (2005) http://tsun.sscc.ru/tsulab/20041226.htm

Harada and Hiraishi et. al., (2005), 2004 Sumatran open sea earthquake tidal wave Phuket (Thai) field work" http://www.drs.dpri.kyoto-u.ac.jp/sumatra/thailand/phuket_survey.html

Kawata Y. et. al., (2005), “The December 26, 2004 Sumatra Earthquake Tsunami, Tsunami Field Survey around Galle, Sri Lanka” http://www.drs.dpri.kyoto-u.ac.jp/sumatra/srilanka/galle_survey_e.html

Shibayama T. Et. al., (2005), “The December 26, 2004 Sumatra Earthquake Tsunami, Tsunami Field Survey around Southern Part of Sri Lanka”, http://www.drs.dpri.kyoto-u.ac.jp/sumatra/SriLanka_survey_result/srilanka_survey_ynu_e.html

Synolakis C., and Borrero J., (2005) http://www.usc.edu/dept/tsunamis/2005/index.html

Taymaz, T., Tan O., Yolsal S., (2005), Sumatra Earthqake (Mw~9.0) of Deceber 26, 2004, Source Rupture Processes and Slip Distribution Modelling, Preliminary Rupture Model http://www.geop.itu.edu.tr/~taymaz/sumatra/

Tsuji Y., Namegaya Y. and Ito J., (2005), “Astronomical Tide Levels along the Coasts of the Indian Ocean”, http://www.eri.u-tokyo.ac.jp/namegaya/sumatera/tide/index.htm

Tsuji Y. et. al., (2005), “Distribution of the Tsunami Heights of the 2004 Sumatera Tsunami in Banda Aceh measured by the Tsunami Survey Team (The Head: Dr. Tsuji)”, http://www.eri.u-tokyo.ac.jp/namegaya/sumatera/surveylog/eindex.htm

Yalciner et. al. http://tsun.sscc.ru/tsulab/20041226.htm

Yeh K.. (2005), “Learning from Earthquakes, The Great Sumatra Earthquake and Indian Ocean Tsunami December 26, 2005 Tsunami Survey along the Southeast Indian Coast.”, Report#2 EERI, Special Earthquake Report, March 2005