

**NUMERICAL MODELING OF TSUNAMIS FOR EARLY
WARNING AND EVACUATION**

MASTER OF ENGINEERING

**E.R.S.UDAYAKUMARA
(B.Sc. ENG.)**



University of Moratuwa, Sri Lanka.
LIBRARY
UNIVERSITY OF MORATUWA, SRI LANKA
Electronic Theses & Dissertations
MORATUWA
www.lib.mrt.ac.lk

**UNIVERSITY OF MORATUWA
SRI LANKA**

SEPTEMBER, 2008

LA/15001/25/09

Numerical Modeling of Tsunamis for Early Warning and Evacuation

By

E.R.S.UDAYAKUMARA
B.Sc. Engineering, AMIE(Sri Lanka)

This thesis was submitted to the Department of Civil Engineering of the University of Moratuwa in partial fulfillment of the requirements for the Degree of Masters of Engineering in Environmental Water Resources Engineering and Management



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

Supervised by
Dr.S.P.Samarawickrama

624 "08"
504+627(043)

University of Moratuwa



92947

TH

Department of Civil Engineering
Faculty of Engineering
University of Moratuwa
Sri Lanka

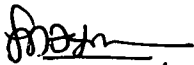
September, 2008



92947

Declaration

The work included in the thesis in part or whole has not been submitted for any other academic qualification at any institution.



.....
E.R.S.Udayakumara

UOM Verified Signature

Dr. S.P.Samarawickrama
Supervisor

ABSTRACT

Its creation was prompted by the 2004 Indian Ocean earthquake and resulting tsunami, which left some 230,000 people dead or missing. Many analysts claimed that the disaster would have been mitigated if there had been an effective warning system in place, citing the well-established Hawaii-based Pacific Tsunami Warning Center, which operates in the Pacific Ocean. People in some areas would have had more than adequate time to seek safety if they were aware of the impending catastrophe. The only way to effectively mitigate the impact of a tsunami is through an early warning system. Other methods such as tsunami walls only work for a percentage of waves, but a warning system is effective for all waves originating outside a minimum distance from the coastline.

Based on the above information, great attention was paid towards the Indian Ocean Tsunami Warning System. But the still Indian Tsunami Warning System has only two deep water buoys to detect the tsunami waves and two number of buoys are not enough to issue accurate warning at all. Due to this reasons, in most of the occasions tsunami warnings had been issued for Indian Ocean countries including Sri Lanka, mainly based on the magnitude of the earthquake which causes the tsunami. This is a blind issue of warning such as the Sri Lankan experience in 2007 September tsunami. Therefore in order to issue a warning accurately and with confidence, there must be a properly developed tsunami warning system.

In this project, I'm going to develop such system for Sri Lanka considering the earthquake on Sunda fault, which lies in the Indonesian region. This fault is considered as a most critical fault for Sri Lanka. The selected region of the fault has divided in to several segments which act as tsunami sources. Tsunami modeling software "WinITDB" is used to model the tsunami under each earthquake case. After running the model for several magnitudes of earthquake for each source, wave heights and reaching time was measured at selected Six coastal points around the country. A database was created using the observed data for the analysis purpose.

ACKNOWLEDGEMENT

Completing this research project would not have been an easy task for me without the support of a lot of individuals whom I am not in a position to thank individually.

Dr. S.P.Samarawickrama was my supervisor who moulded the research study, corrected all my writings, discussed and made a substantial contribution to complete this research in time. I owe to him a big thank you, and also I should thank to Dr.N.P.D.Gamage and Mr.Ratnasooriya for their excellent guidance as project coordinators.

I should thank Mr.S.K.H.Perera and Mr.S.K.Wijetunga the Additional General Managers of National Water Supply and Drainage Board, for showing me the importance of this research project and also for greatly influencing me to carryout the study.

I am grateful to the Vice Chancellor, Dean of the faculty of Engineering and Head of the Department of Civil Engineering for the permission granted for study.

My sincere thanks goes to the panel of Senior Lecturers and Professors who enlighting me on the new developments of Environmental Water Resources Engineering and Management.

And also I should thank to Mr. P.K.C.De Silva, Mr. R.B.C.D.Manawasekara and Miss.A.V.A.U.Karunathilaka for giving me their valuable support to complete this research successfully.

E.R.S.Udayakumara

September 2008

TABLE OF CONTENTS

	Page No.
Introduction	01
Scope	02
1.0 Tsunamis	03
1.1 How tsunamis are created	04
1.2 Sub – Sea Earthquake	06
1.3 Underwater volcanic eruption	11
1.4 Influence to Sri Lanka	11
1.5 Tsunami warning system	13
1.5.1 International warning systems (IWS)	13
1.5.1.1 Pacific Ocean	13
1.5.1.2 Indian Ocean (ICG/IOTWS)	14
1.5.1.3 North Eastern Atlantic, the Mediterranean and connected Seas (ICG/NEAMTWS)	15
1.5.2 Regional warning systems	15
1.5.3 Conveying the warning	15
1.5.4 Shortcomings	16
1.5.5 Development of tsunami warning system	16
1.6 Available Numerical Models	17
2.0 Introduction to Software	19
2.1 Extension of the WinITDB graphic shell to the global coverage	20
2.2 Methodology	21
2.3 Selection of the region	22
2.4 Selection of the source parameters	23
2.5 Gauge stations	24
3.0 Model results	26
3.1 Near shore transformation	27
3.1.1 Green’s formula	28
3.1.2 Data handling	29
3.2 Data analysis	32
3.2.1 Tsunami wave heights	32
3.2.2 Tsunami wave travel time	35
3.3 Results	37
Conclusion	39
References	40

LIST OF FIGURES

Page No.

Figure 1.1	Characteristics of Tsunami waves.....	04
Figure 1.2	Creation of tsunami.....	04
Figure 1.3	Layout of major tectonic plates.....	07
Figure 1.4	Main types of plate boundaries.....	08
Figure 1.5	Underwater – volcano.....	11
Figure 1.6	2004 tsunami affected areas.....	11
Figure 1.7	Two major plate boundaries closer to Sri Lanka.....	12
Figure 1.8	Japanese TV warning of tsunamis, September 2004.....	15
Figure 1.9	Basic stages of development of Tsunami Warning System.....	16
Figure 2.1	Example of the screen output provided by the WinITDB graphic shell (Version 5.15) – Calculation of the tsunami travel time chart for the December 26, 2004 Sumatra tsunami.....	19
Figure 2.2	Example of the screen output provided by the WinITDB graphic shell (Version 5.15) – start up map with the global coverage and the global tsunami catalog overlaid. The “Area Select” pull down menu shows the list of available regional maps.....	21
Figure 2.3	Most effective area for Sri Lanka.....	22
Figure 2.4	Division of segments.....	22
Figure 2.5	Define the source parameters.....	23
Figure 2.6	Gauge stations.....	25
Figure 3.1	Results produced by the software.....	26
Figure 3.2	(Sectional view)–Wave height is increased rapidly when it reaches the near shore..	28
Figure 3.3	(Plan view) – Affect of the bay width.....	28
Figure 3.4	Wave heights at Pottuvil with the movement of tsunami source along the fault (Initial wave height of 5m at the source is considered for all cases).....	32
Figure 3.5	Wave heights at each gauge station with the movement of tsunami source along the fault (Initial wave height of 5m at the source is considered for all cases).....	33
Figure 3.6	Wave heights at Pottuvil with the change of earthquake magnitude.....	34
Figure 3.7	Wave travel time with the movement of earthquake source along the fault (Initial wave height of 5m at the source is considered for all cases).....	36
Figure 3.8	Locations of sources along the fault.....	37

LIST OF TABLES

	Page No.
Table 1.1	Maximum wave heights to Sri Lanka under recent tsunamis..... 12
Table 1.2	Characteristics of ComMIT, AVI-NAMI and WinITDB..... 17
Table 2.1	List of segments and its properties.....24
Table 2.2	List of gauge stations located around Sri Lanka.....25
Table 3.1	Prepared database with wave heights & reaching time..... 30
Table 3.2	Maximum wave heights & Minimum wave travel time for each station..... 37



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk



LIST OF ABBREVIATIONS

IWS	-	International warning systems
PTWC	-	Pacific Tsunami Warning Center
WC/ATWC	-	West Coast/Alaska Tsunami Warning Center
ICG/NEAMTWS	-	Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North Eastern Atlantic, the Mediterranean and connected Seas
MSL	-	Mean Sea Level
WinITDB	-	Integrated Tsunami Data Base
WinITRIS	-	Integrated Tsunami Research and Information System
N	-	North
S	-	South
E	-	East
W	-	West
Km/s	-	Kilometers per second
Km/h	-	Kilometers per hour
Km	-	Kilometers
m	-	meters
ft	-	feet
mph	-	miles per hour



University of Moratuwa, Sri Lanka.
Electronic Theses & Dissertations
www.lib.mrt.ac.lk