International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.3 Issue No.7, pp : 991-993 1 July 2014

Correlation Between the Reported Earthquakes Damages from the Magnitude 6.5 Lake Tanganyika earthquake of October 2, 2000 and the Simulated PGA Shaking Maps

Asinta Manyele, Alfred Mwambela
Department of Electronics and Telecommunications, University of Dar es Salaam, Dar es Salaam, Tanzania
e-mail: asinta3@yahoo.com, nkomo98@yahoo.com

Abstract : ***October 2, 2000, magnitude 6.5 earthquake occurred along Lake Tanganyika, inducing several damages in Rukwa region communities. The study demonstrates that simulated earthquake peak ground acceleration (PGA) shaking maps for magnitude 6.5 earthquake correlates well with the reported damages and thus can be used for rapid earthquake impact assessments.***

Keywords— **Earthquake damages; PGA maps**

I. Introduction

The East African Rift (EAR) system with eastern and western branches that passes across Tanzania is a major source of earthquake ground shaking experienced across Tanzanian communities [1], [2]. In the past few years, earthquake ground shaking in South Western Tanzania (SWTZ) regions has resulted into loss of lives and damages to several houses [1], [2], [3], [4], [5].

Following the occurrence of large earthquakes, rapid identification of potential damaged areas is advantageous for deployment of emergency teams and provision of early warnings to public. Currently, ground shaking maps generated from instrumentally recorded data, eyewitness reports or predicted data, are used in earthquake damage assessments in several regions [7], [8].

The U.S. Geological Survey (USGS) operates USGS ShakeMaps system that generates earthquake ground shaking maps by combining instrumentally measured data and predicted from ground attenuation equations [7]. In Southern California, shaking maps generation methodology utilizes earthquake preliminary motions (P-waves) observed by few closer to the event stations for predictions of up-coming earthquake peak motion (S-wave) at target site [6]. The two methodologies provide accurate results when denser seismic networks are available, with accompanying knowledge of geological conditions across the region [6], [7].

The USGS DID YOU FEEL IT? (DYFI) system, collects eyewitness report from internet users who experience ground shaking as well as any damage reports to generate earthquake intensity maps as they are reported [9]. Provided that the internet remains functioning and people make the filling of the online questionnaire as the first priority to their safety , the methodology can provide damage assessment faster [9].

In this study, we propose the earthquake peak ground acceleration (PGA) simulation procedure for predicting earthquake expected PGA at target sites and mapping them as a methodology for faster assessment of earthquake impacts in a regions without sensor stations. In the prediction of PGA values, rapidly estimated earthquake source parameters from preliminary motion (P-waves) and region P-wave based PGA attenuation relationship are the only parameters required. The study demonstrates that, it is possible to rapidly predict the damage pattern of the earthquake by simulating the expected PGA values from rapidly estimated earthquake source parameters. We apply the numerical simulation techniques to the magnitude 6.5 earthquakes of 2000 along Lake Tanganyika to predict the peak ground shaking and expected damage distributions. A comparison of simulated PGA shaking maps to values generated from eyewitness reports by the USGS DYFI system is also performed.

II. Impacts Data for Oct 2 2000 Magnitude 6.5 Earthquake along Lake Tanganyika

As published by the USGS, the Oct 2 2000 earthquake along Lake Tanganyika resulted into injuries of six people, destroyed at least 7 houses and damaged 150 houses in Nkansi District, Rukwa Region [5]. From collected eyewitness reports, the USGS DYFI system published earthquake intensity ShakeMaps shown in Figure 1.

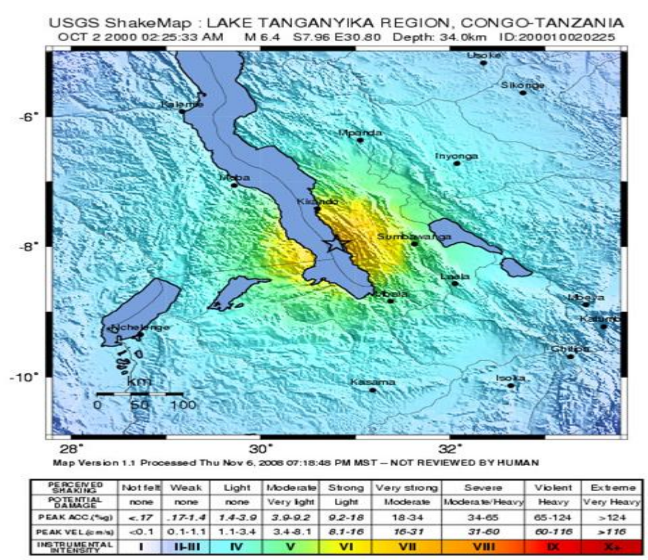


Figure1: USGS ShakeMap: Lake Tanganyika Region, Congo-Tanzania Oct 2 2000 magnitude 6.5 earthquake

International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.3 Issue No.7, pp : 991-993 1 July 2014

From the U.N Office for Coordination of Humanitarian Affairs (OCHA) report, the worst hit areas by the Oct 2 2000 earthquake along Lake Tanganyika was the Nkansi district in Rukwa Region where one death and several injuries was reported [3], [4]. In Isale, Kipili, Kirando, Namanyere, Ntatumbila and Wampembe, in Nkansi district, several houses were reported to be completely destroyed and while over 150 houses sustained cracks[3], [4]. In the village of Kate in the district, 7 houses and one dispensary with the capacity of 10 beds and 12 rooms were demolished [3], [4]. No water services were available for the Kate village and there was the disruption of communications [3], [4].

III. Methodology

The goal is to produce PGA predictions and its spatial distribution paying special attention to maximum values that will indicate the potential damaged zones. Our predictions are based on the event magnitude and epicenter location information released rapidly following the observation of earthquake initial P-wave motions.

A. Determining PGA at Target sites

Knowing earthquake magnitude and its epicentre location, first uniformly spaced grid of phantom stations are created across the affected region with spacing for each grid point kept constant at 0.1º by 0.1 º. Utilizing the estimated event geographical location, the epicentral distance between each grid point and event location are estimated using Equation

$$R = 111.19\sqrt{cos(LatG) * (LonG - LonE)^2 + (LatG - LatE)^2}$$
(1)

Where R is distance between grid point and event epicentre in kilometer, LatG and LonG are latitude and longitude coordinate of grid point, and LatE and LonE are latitude and longitude coordinate of event.

Then, the peak ground acceleration (PGA) value at each target is predicted using an empirical attenuation relation based on base rock shown in Equation (2).

$$PGA = 1.42 \exp (1.43M) R-1.2 (0.719 \ln (\tau)) \quad (2)$$

Where M is the earthquake estimated magnitude, R is the distance from the event epicenter to the grid point center and τ is the P-wave observation time window selected as 4 seconds. The reason for the selection of time window of 4 seconds is due to several researches in EEW systems that suggests the use of at least three seconds of P- wave data for arriving at reasonable estimations of earthquake parameters (Lawrence et al., 2011; Satriano et al., 2011; Cochran et al., 2009; Lawrence et al., 2009; Wald et al., 2006; Allen, 2004).

B. Earthquake PGA Mapping

The computed earthquake PGA values at each target are used as input to the C-shell mapping script containing ordered Generic Mapping Tool (GMT) commands that transform the gridded PGA datasets into PGA visual display (shaking maps) colour coded according to hazard level of predicted PGA value at each target site. The PGA shaking maps are useful in determining which sub-regions to notify of incoming significant ground motion.

For easy plotting of predicted PGA values, colour code is used according to the following categorization: red- yellow represented severe shaking, green represented strong shaking and light blue to blue represented the decreasing weak shaking. The red – to orange represents the ground shaking level above 0.5g. This is the area predicted to have severe ground shaking, and most damages are expected here. Green region represents the areas predicted with ground shaking levels below 0.5g but above 0.1g. Strong ground shaking is expected in this region, but not necessarily with damages. The blue region represents the areas predicted with ground shaking levels below 0.1g, representing a weak ground shaking region where no damage is expected. By looking on colour coded PGA shaking maps, areas requiring immediate emergency response are expected to be easily identified by colours for faster rescue operation planning.

IV. Results and Discussion

A. *Comparisons of Simulated PGA values and Eyewitness reports*

There is correlation between PGA values to the experienced damages, but not always absolute agreement since experiences and damage can be affected by many other factors, including the quality of earthquake engineering, type soil cover, as well as construction practices. Table 1 compares the eyewitness reports and simulated PGA values for magnitude 6.5 earthquake along Lake Tanganyika.

Table 1: Simulated PGA values and Corresponding Eyewitness report

Reporters distance (km)	Reported Situation	Simulated PGA	Warning type
123.03	Building shaking in Rukwa	0.42	strong
387.74	Shake felt in Tabora	0.11	strong
313.40	Felt in Chunya, frightening	0.13	strong
354.06	Felt in Rungwe, frightening	0.12	strong
187.36	Felt in Mpanda, caused panic, but no significant damage	0.25	strong
57.14	Houses collapse in Isale	1.06	severe
60.47	Houses collapse in Kipili	0.99	severe
67.30	Houses collapse in Namanyere	0.86	severe
53.84	Dispensary collapse in Kate Village, and 7 houses. Cuts water services and	1.24	severe

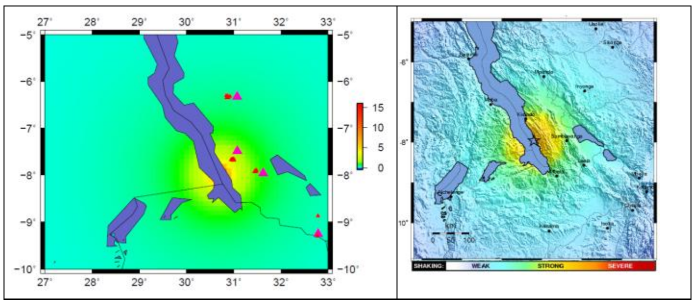
International Journal of Scientific Engineering and Technology (ISSN : 2277-1581)
Volume No.3 Issue No.7, pp : 991-993 1 July 2014

	communications		
100.50	Beds shaking in Sumbawanga, but no damage	0.56	severe

From Table 1, the earthquake was felt up to a distance of about 400 km, but most damages occurred within a distance of about 100 km from the epicenter position.

A. Simulated PGA Shaking maps and USGS ShakeMaps

The comparisons of the simulated PGA shaking maps from this study and USGS ShakeMaps was done to compare the observed situation as reported by observes at the sites and the predicted case (see Figure 2).



.

Figure 2: October 2, 2000 Magnitude 6.5 earthquake along Lake Tanganyika Predicted and Intensity ShakeMaps

From Figure 2, areas shaded red to yellow colours, experienced severe shaking and are comparable from the USGS ShakeMaps and the PGA shaking maps from this study. Areas experiencing strong and weak ground shaking are also comparable.

V. Conclusion

For the purpose of identifying areas falling in earthquake potential damaged zones, PGA shaking maps that can be generated after automatic estimation of earthquake source parameters, correlates well with experienced earthquake damages. That is, predictive PGA shaking maps is adequate for initiating earthquake early warnings and emergency responses.

Acknowledgement

The study was funded by Dar es Salaam Institute of Technology under the assistance of World Bank. The authors would like to thank Electronics and Telecommunication department staffs at the College of Information and Communication Technology, University of Dar es Salaam for their assistance during the study.

References

i. Mavonga, T., 2007. An estimate of the attenuation relationship for the strong ground motion in the Kivu Province, Western Rift Valley of Africa, Phys. Earth.Planet.Interiors, Vol. 162, pp 13- 21.

ii. Mavonga, T.G., Durrheim, R.J., 2009. Probabilistic seismic hazard assessment for Democratic Republic of Congo and surrounding areas, Western Rift Valley of Africa, Special AfricaArray issue of South African Journal of Geology, Volume 112, Number 3-4, pp. 329-342

iii. UN Office for the Coordination of Humanitarian Affairs (OCHA) OCHA Situation report No. 1 2005/12/05.

iv. UN Office for the Coordination of Humanitarian Affairs (OCHA) 2000, 2005, 2009. OCHA Internet Website at http://www.reliefweb.int

v. USGS web site 2000, 2005, 2009 www.earthquakes.usgs.gov/

vi. Allen R.M (2007) The ElarmS earthquake early warning methodology and application across California.In: Gasparini P et al (ed) Earthquake early warning systems. Springer, Berlin, pp 21–43. doi:10.1007/978-3-540-72241-0

vii. Wald, D. J., V. Quitoriano, L. Dengler, and J. W. Dewey (1999). Utilization of the Internet for Rapid Community Intensity Maps, Seism. Res. Letters, 70, 680-697.

viii. Macheyeki A. S. ,Delvaux D,, Batist M. De ,Mruma A. (2008). Fault kinematics and tectonic stress in the seismically active Manyara–Dodoma Rift segment in Central Tanzania – Implications for the East African Rift. Journal of African Earth Sciences 51 (2008) 163–188*

ix. D. Wald et al., "USGS Did You Feel It? Internet-Based Macroseismic Intensity Maps," Annals of Geophysics 54, no. 6 (2011):688–707