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NED UNIVERSITY OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF EARTHQUAKE ENGINEERING

Cowasjee Earthquake Study Centre NED NEWSLETTER

Nepal suffers Devastating Earthquake

Figure 1: Devastating Nepal earthquake.

A powerful 7.8 magnitude earthquake shook Nepal on Saturday, 25th April 2015, near its capital, Katmandu (**Figure 1**). Killing more than 4,000 people and, (**Figure 2**) flattening large sections of the city's historic center. The earthquake and also set off avalanches around Mount Everest, where at least 17 climbers have died. Nearly 34 deaths occurred in northern India. Tremors were felt as far away as New Delhi (in India) and Dhaka (in Bangladesh).

The epicenter of the earthquake was about 50 miles northwest of Katmandu, as the result of thrust faulting on or near the main frontal thrust between the subducting Indian plate and the overriding Eurasian plate to the north, according to the U.S. Geological Survey, which revised the magnitude of the quake down to 7.8 from an earlier estimate of 7.9. It was followed by a large, 6.6-magnitude aftershock and other smaller temblors.

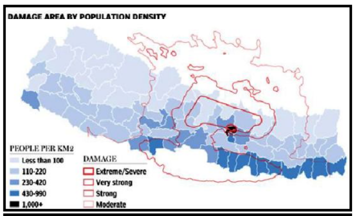

Figure 2: Damage area by population.

The country also saw a number of its iconic UNESCO World Heritage sites and most popular tourist attractions (some dating more than 1,700 years) reduced to piles of rubble including the 19th century 100-foot Dharahara Tower. Many people were killed due to the callapse of this nine-story tower and the well known tiered temples at Patan Durbar Square made of fired brick and timber. (The information for this article was collected from www.reuters.com)

South Asia Earthquake Network (SHAKE)

The total population of the countries in South Asia residing on the Indian Plate and its collision zone with Asia is approximately of 20 – 25% of the world's population. Due to continuous movement of the Indian plate towards the Eurasian plate, these countries have been experiencing both interplate and intraplate earthquakes for thousands of years.

The interplate boundary of the Indian and Eurasian plate is 3000 miles long and is shared by Pakistan, India, Nepal, Bhutan and Bangladesh. As the Indian plate moves beneath the Eurasian plate, the stress is frequently releases damaging earthquakes. And in the last decade i.e. post Bhuj and Kashmir earthquakes, which caused 0.1 million deaths approximately and huge monetary losses in India and Pakistan, and the recent Sikkim earthquake caused deaths in India, Nepal, Bhutan and Bangladesh. While research efforts in these countries have been concentrated on various fields related to earthquakes. However, the amount of research does not match the gravity of the risk. Moreover, the research has been conducted by these countries in isolation and there is a lack of integration, lack of knowledge, coupled with the lack of strict implementation of seismic design codes and bye-laws, economic constraints and awareness renders a huge population at risk.

In this context, a workshop on Quantification of Seismic Hazards in the Indo/Asian Collision Zone was organized by Dr. Abdulkrim Aoudia of The Abdus Salam International Centre for Theoretical Physics (ICTP) and co-sponsored by International Union of Geodesy and Geophysics (IUGG), National Science Foundation (NSF), UNAVCO, UNESCO, IAEA and Tribhuvan University. Thirty eight delegates from Pakistan, India, Nepal, Bangladesh, Italy, China and USA participated in this workshop. The team from NED University presented the idea of establishing ***SOUTH ASIA EARTHQUAKE NETWORK (SHAKE).*** The proposal was appreciated by the participants and a scientific advisory committee was formed to plan its establishment and framework.

As a result, the SHAKE network was established in 2014 with the long-term agenda to encourage a regional structured approach to earthquake forecasting, vulnerability and risk assessment of the infrastructure, seismic risk mitigation, and monetary losses and casualty reduction in Pakistan, India, Nepal, Bhutan, Sri Lanka and Bangladesh. The aim of SHAKE network is to contribute to the seismic risk reduction in South Asia through

1) Characterize seismic hazards uniformly and to the highest standards
2) Rigorously validate earthquake and shaking probabilities using local, regional and global data
3) Communicate seismic risk clearly, accurately, and transparently to all users
4) Integrate local expertise in a regional and global context
5) Monitor and update changing infrastructure and vulnerability
6) Build seismic risk management capacity in the whole region
7) Enable dialogue with decision-makers

(Continued on page 4)

EDITORIAL

This issue of CESNED Newsletter in hand presents some of the achievements by CESNED and the details of on-going works by the faculty members in the Department of Earthquake Engineering. All these activities are focused towards improving awareness of this particular hazard and creating resilient society in Pakistan through a partnership between the Department of Earthquake Engineering and national and international communities.

CESNED is and shall keep on striving hard for its cause and hope that the NEWSLETTER would receive your personal attention and patronage. — Editor

Inside this Issue:

CESNED

Development of Probabilistic Flood Risk Assessment of Karachi

Pakistan is a hazard-prone country with significent number of people living in high-risk areas. Floods are undoubtedly the most frequent type of natural disasters, particularly for coastal cities and in peripheral areas of sprawling cities. The toolbox of flood risk management measures has never been as comprehensive and innovative as before and is becoming increasingly multidisciplinary and flexible.

Flood risk is measured in terms of improbability in water resources taking place from the natural inconsistency of geophysical progressions and their likely consequences. The increasing frequency and intensity of the flood hazard in combination with the socio-economic parameters result in high levels of vulnerability of the population, and physical and economic assets. The estimation of flood hazards has traditionally been based primarily on instrumental records of floods from the last 100 years or less. This short historical record provides only sparse information about extremely large floods, and is unlikely to include many of the largest floods that could occur at the site under present conditions.

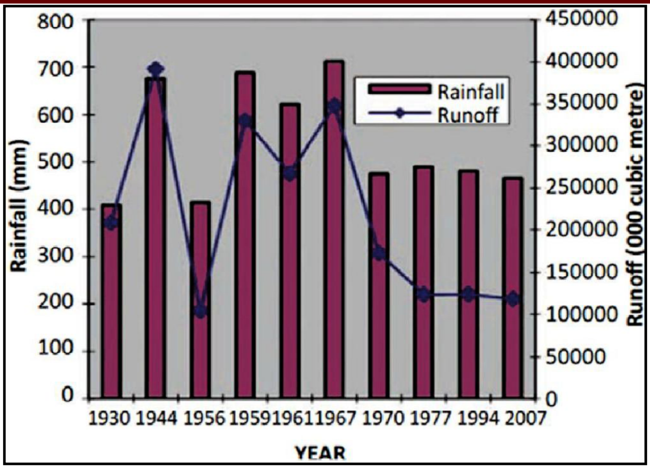

Figure 3: Flooding- Extreme events (Source: Department of Geography, University of Karachi).

Karachi has a history of urban flooding which dates back in the Colonial era when the city was flooded during the 1944 monsoon rains, (**Figure 3**). In 1977, severe flood occurred in the flood plains of the Malir River and the Lyari River (**Figure 4**). However, with time, the problem of urban flooding has been intensifying in Karachi, similar to other major cities of the world. Urban sprawl and urban encroachment are the major factors behind this issue which have resulted in reduced rainwater infiltration and increasing surface runoff (**Figure 4**). The city had experienced severe floods increcent pastwhich occurred periodically. Recently, many areas of Karachi were devastated due to urban flooding in 2013 in the Malir and Lyari rivers.

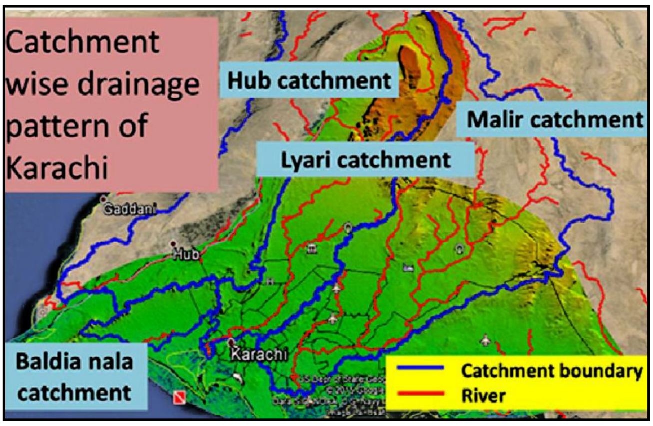

Figure 4: GIS based preprocessing – Delineation of the area.

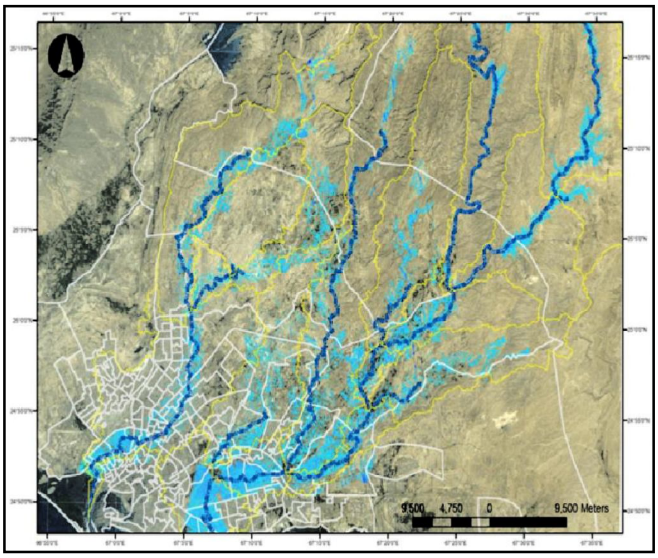

Figure 5: Flood inundation map.

The available studies have indicated that changes in climate trend is surprisingly different for Karachi with an exponential increase of and decrease in annual precipitation. Therefore, study of meteorological parameters and quantifying flooding with hydrologic/hydraulic distributed simulation models can help in the development of flood inundation maps, (**Figure 5**), for managing and reducing flood disaster risk, while providing strong adaptive mitigation measures for the city government of Karachi.

The main objective of the study is to develop flood inundation maps for planning and disaster risk reduction for Karachi using computer simulation hydrologic/hydraulic modelling, (**Figure 6**). However, data collection and transmission networks need to be strengthened and augmented for generation of more effective flood warnings and land use practices need to be projected with foresight keeping in mind the future areas of concentrated growth and their proximity to flood risk zones.

Due to observed and recorded nature of the rain datasets, many large floods are not gaged. As a result discharges are computed by indirect methods based on observed flood levels. The channel hydraulic characteristics rationalizes the use of a variety of available methods, with the selection of any one method depending on the objectives and data available, or the selection of multiple methods to provide confidence in results. These are based on a number of statistical approaches, broadly classified as streamflow-based or rainfall-and-runoff-based approaches.

The developed flood prediction model presents information on various aspects of flood hydrology: rainfall runoff estimation, estimation of flood volume, alternate routing of flood water for dissipation in advanced real time data. Results are combined and weighted by a team of hydrologists and are used as the basis for case-specific risk analysis.

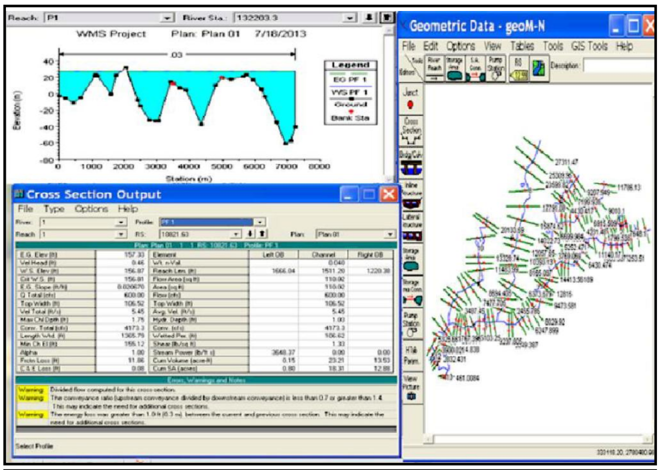

Figure 6: Geometric data alignment.

Tsunami Risk Assessment Model for Gwadar and Pasni

Indian Ocean tsunamis have claimed about a quarter million lives recorded in the tsunami of 26 December 2004 and further about 20,000 lives in Japan in the tsunamis, 2011, (**Figure 7**). These and other events, demonstrate the need for mapping the plausible limits of tsunami inundation, particularly for the densely populated areas in the coastlines of South Asia.

Figure 7: Map of major tsunami.

Shores of the Northern Arabia Sea are prone to tsunamis generated by subduction of the Arabian Sea Plate beneath the part of Eurasia plate. In 1945, a tsunami originated during an earthquake of Mw 8.1 from thrust rupture along about 200 km of the eastern part of the Makran Subduction Zone, creating a maximum tsunami wave height of approximately 4-5 m in Pasni (although some reports suggest wave heights of 12-15 m), about 1.5 m in Karachi, and 2 m in Mumbai with the death tolls ranging from a few hundred to 4,000 people inadequatity at that time. This information has been taken from the records and documents which are unfortunately maintained inadequately.

Available studies suggest that to the energy in the 1945 tsunami was trapped along shore in areas where the continental shelf is narrow, causing sustained oscillations for a long period of time which resulted in multiple surges arriving shore within very short time duration. This phenomena also causes later waves to be of higher amplitude than the initial ones. Other studies suggest that the 1945 earthquake was accompanied by a land-slide which resulted in the tidal waves (rather than the displacement of the sea floor) and the late arrival of the waves (the second wave came almost after 4 hours of the first one). Other than this delay, the second wave which was the highest, arrived in Karachi 15 minutes earlier than in Pasni, which was closer to epicenter.

The Makran subduction zone, is an active boundary between tectonic plates, which poses the main tsunami hazard in the western Indian Ocean, but the nature of this hazard is still poorly understood. The proposed sources of the documented tsunamis in Indian Ocian include tectonic deformation, submarine slides and mud volcanoes. However, whether the zone can produce even larger or further tsunamis is an open question. The zone is still regarded as capable of producing large waves that would reach adjoining shorelines in a few tens of minutes. Such fast-arriving waves add to the challenges of tsunami warning and tsunami education for the coastal regions of Pakistan, such as Gwadar, Pasni and Karachi.

To address the above challenges and on the special occasion of the inauguration of the national multi-hazard early warning system in Oman, an international conference on Reducing Tsunami Risk in the Western Indian Ocean was recently held on 22-23 March 2015, in Muscat, Oman. The conference was jointly organized by the Intergovernmental Ocean Commission of UNESCO and Oman's Directorate General of Meteorology.

Dr. Haider Hasan and Ms. Hira Ashfaq Lodhi presented a research paper in the conference on the findings of tsunami inundation limits for two important coastal cities; Gwadar and Pasni. Maximum inundation depth and maximum inundation distance were found on the basis of two worst case scenarios. The results were compared with eyewitness accounts of the 1945 Makran tsunami to verify the results and to identify potential safe evacuation sites in case of future events, (**Figure 8**).

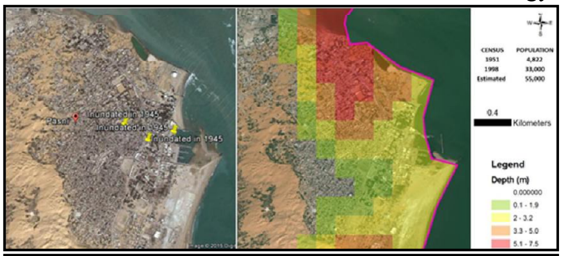

Figure 8: City of Pasni (left); Induction map (Right).

The two scenarios were modelled using Geoclaw which is an open source code and the results obtained were post processed in ArcGIS to derive the inundation limits. In Geoclaw, tsunami propagation is modelled by using non-linear shallow water wave equations that takes Coriolis force and bottom friction into account. Geoclaw uses rectangular latitude-longitude grids coupled with wetting/drying algorithms to handle inundation (**Figure 8**).

Seismic Assessment of 250 Schools across Pakistan Completed

Lessons learnt from the past earthquakes indicate that the seismic performance of schools deserves special attention because of their unique occupancy characteristics and important post-earthquake role as Safe Heaven. Post disaster responses demonstrate that the vulnerability of schools is higher compared to other structures owing to the factors such as irregular configuration coupled with the design and built

An exercise of carrying out vulnerability assessment of schools in the most demanding terrains (with active tectonic settings) of Gilgit-Baltistan and Chitral which are situated in Northern Region of Pakistan is carried out. More than 250 schools (**Figure 9**) managed and owned by Aga Khan Education Service, Pakistan (AKESP), an agency of the Aga Khan Development Network (AKDN) of the Aga Khan Foundation, Geneva were analysed by a team of the Department of Earthquake Engineering. This was perhaps the first ever exercise in Pakistan on such a large scale. Some of the schools in the plain terrains of Sind and Punjab provinces were also included in the assessment exercise.

Figure 9: AKES,P owned schools across Pakistan.

This project entitled "Physical Facilities Assessment (PFA)" was initiated by Aga Khan Planning and Building Services, Pakistan (AKPBS,P) in collaboration with the Department of Earthquake Engineering nearly 2 years ago. It has created databases of demography, GIS mapping, hazard and risk classification and adequacy of each school facility as safe haven in accordance with the prevalent codes. Retrofitting solutions to adequately address structural deficiencies are proposed so that the buildings are able to serve as a refuge in the aftermath of earthquakes. The results and findings of the research will be presented later in national and international events.

Seminar on Community Based Disaster Risk Management (CBDRM) Model

Figure 10: Participants during group discussion.

The growth, development and progress of Pakistan is increasingly being undermined by the impact of a variety of hazards, both natural and man-made. However, disasters are problems of poor development planning, exacerbated by rising populations, increasing poverty, environmental degradation and lack of preparedness of many sectors of society determine the outcome of hazardous events. Local communities play a key role in preparing for disastrous events and are normally the first responders to take action.

Department of Earthquake Engineering and Save the Children with the support from PDMA Sindh, organized a seminar on the Community Based Disaster Risk Management (CBDRM) Model on 18 December 2014 in Karachi (**Figure 10**). Mr. Syed Murad Ali Shah, Finance and Energy Minister, Government of Sindh was the Chief Guest of the programme.

Ms Shahida Arif from Save the Children stated that while increasing frequency and intensity of meteorological events is partly to blame, but awareness, preparedness and resilience determine the outcome of the impact of any hazard, be it drought or flood, earthquake or cyclone. She then shared the learned experiences of implementation of CBDRM model in Mirpurkhas, Sindh. Thirty five participants from various governmental organizations, NGOs, academics and rescue organizations, were invited to ensure that the proposed approaches in the CBDRM model are replicated in other parts of the province. The changes in the citizens perceptions, response and preparedness through information and education will lead to substantial reductions in disaster risk and to strengthen risk reduction and resilience through education in Sindh province.

Seminar on School Based Disaster Risk Management (SBDRM) Model

Figure 11: Participants of Seminar of SBDRM.

Every child should have the right to both safety and survival, as well as to a continuous and high quality basic education. These rights are threatened by hazards that cause large and small scale disasters. Disasters affect the education sector and children's safety and access to education in a number of ways. When education is interrupted or limited, students drop out with negative and permanent economic and social impacts for themselves, their families and their communities. School based disaster risk management (SBDRM) is designed to contribute to protecting these rights.

Department of Earthquake Engineering and Save the Children with support from PDMA Sindh, organized a seminar on the School Based Disaster Risk Management (SBDRM) Model on 30 December 2014 in Karachi (**Figure 11**). Dr. Shereen Mustafa, Secretary (Planning), Planning, Development and Special Initiatives Department, Government of Sindh was the Chief Guest of the programme.

The speakers of the seminar highlighted the situation of disasters in different parts of Pakistan and shared the learnings and experiences of implementation of SBDRM model in Mirpurkhas, Sindh. The stakeholders of Sindh, 45 participants belonging to the various governmental organizations, NGOs, academics and rescue organizations were invited to ensure that the proposed approaches in the SBDRM model are replicated, such as community mobilization, facilitation skills, vulnerability and capacity assessments (VCA), hazards and capacity mapping, development of seasonal calendars and counter-measures to reduce the impact of disasters in other parts of the province and to strengthen risk reduction and resilience through education in Sindh province.

World Bank Initiates Flood and Seismic Risk Assessment of Karachi

Karachi is the provincial capital of Sindh and is the third most congested city in the world with a population density of over 4000 per km^2. It is faced with multidimensional challenges signified by the high population density sprawled in a poorly built environment (generally non-compliant to seismic code) with active tectonic settings coupled with other hazards, such as fire, flooding, etc. This scenario warrants a careful disaster risk planning, assessment and management framework for the City.

A project entitled **Development of Probabilistic Flood and Seismic Risk Assessment of Karachi** was initiated by the World Bank. The project aims to develop disaster management framework for Karachi. A team from the Department of Earthquake Engineering took part in this project to carryout seismic risk assessment of karachi.

The scope of the work consists of the following six components

1) Development of input datasets for Probabilistic Seismic Hazard
2) Development of input datasets for Probabilistic Flood Hazard
3) Development of Exposure Datasets at appropriate scales for
4) Seismic and Flood Risk Assessment
5) Probabilistic and Deterministic Seismic and Flood Hazard and Risk Analysis
6) Dissemination of developed datasets, analysis, and results, to World Bank towards strengthening the internal governance and management system of Government of Sindh

The completion of project in 6 months is expected to provide probabilistic seismic hazard assessment (PSHA) and probabilistic flood hazard assessment (PFHA) datasets and models for the inter-city areas of Karachi. The datasets and models will consist of collected, updated/modified with integrated ancillary hazard GIS, which will quantify the rate (or probability) of exceeding various scenarios for people and assets at possible risk and the key actions required to make Karachi a more resilient city in addition to identifying the critical governance, institutional, technological gaps and constraints. The risk information generated through the assessment would better apprise preparedness, as well as response measures of local and provincial government authorities to natural disasters.

Continued-South Asia Earthquake Network (SHAKE)

The SHAKE network is sub-divided in three groups based on the area of specialization as

a) Seismology Group (SG)
b) Hazard Group (HG)
c) Risk Group (RG).

Active members of SHAKE network includes young scientists (geologists, seismologists and engineers) from the partner countries and around the world. SHAKE is structured as a partnership among a diverse group of South Asian countries. It includes the following countries: Pakistan, India, Nepal, Bhutan, Sri Lanka and Bangladesh. The partner institutions of SHAKE includes NED University of Engineering and Technology, Pakistan; National Centre of Excellence in Geology; University of Peshawar, Pakistan; University of Baluchistan, Pakistan, COMSATS Institute of Information Technology, Pakistan; Centre for Earthquake Studies, Pakistan; Indian Institute of Technology, Roorkee, India; Wadia Institute of Himalayan Geology, India; Geosciences, Seismology Division, Ministry of Earth Sciences, India; Indian Institute of Geomagnetism, India; Jahangirnagar University, Bangladesh; University of Peradeniya, Sri Lanka; Tribhuvan University, Nepal; National Seismological Center, Nepal; Department of Geology and Mines, Ministry of Economic Affairs, Bhutan.

RESOURCE PERSONS:

- Prof. Sarosh H. Lodi
- Prof. Muhammad Masood Rafi
- Prof. Rashid A. Khan

Mail:
Cowasjee Earthquake Study Centre NED, Department of Earthquake Engineering, NED University of Engineering and Technology., Karachi-75270, Pakistan

Phone:
+92-21-9926 1261- 68
Ext. 2605
Fax:
+92-21-9926 1255
Email:
rafi-m@neduet.edu.pk
Web page:
www.neduet.edu.pk