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NED UNIVERSITY OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF EARTHQUAKE ENGINEERING

# Cowasjee Earthquake Study Centre NED

# NEWSLETTER

## A 7.6 Magnitude Earthquake shakes the 10th Anniversary of the 2005 Kashmir Earthquake

An earthquake of magnitude 7.6 occurred on 26 October 2015 in the Badakhshan province in northeastern Afghanistan. This earthquake was the result of reverse faulting at approximately 210 km below the Hindu Kush Range. Since the Badakhshan province borders Pakistan, Tajikistan and China (**Figure 1**), the effects of this earthquake were also felt in Pakistan and at least 237 people were killed with more than 1,500 injured. The population in the affected region, in general, resides in structures that are highly vulnerable to earthquake shaking.

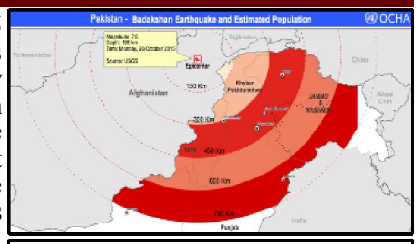


**Figure 1: Epicenter of the Afghanistan Pakistan Earthquake (Source: BBC.co.uk)**

Ten years ago on 8 October 2005, a 7.6 magnitude earthquake killed more than 80,000 people and left more than 3 million homeless in the northwest of Pakistan and in the Muzaffarabad, the capital of Pakistan-administered Kashmir. Eighty-four percent of the total housing stock was damaged or destroyed in Kashmir and 36 percent in the Khyber Pukhtoonkhwa (KPK). The earthquake also damaged or destroyed more than 600,000 houses, 6,298 education institutions and 782 health facilities in the affected areas of KPK and Kashmir. The damages caused direct economic loss of USD 5.2 billion which amounted to the 20% of national budget. The 2005 earthquake was among the worst to ever hit the region and the largest earthquake in Northern Pakistan in its recorded history. The present earthquake on 26 October 2015 coincided with the 10$^{th}$ anniversary of the 2005 Kashmir earthquake.

Contrary to the 2005 Kashmir earthquake, the damage to the property and loss of life is significantly less this time. A wide range of local, national and international agencies were called in to carry out relief work after the 2005 Kashmir earthquake affected regions. They were faced with *(Continued on page 3)*

## 8.3 quake triggers mass evacuation and tsunami alert in Chile

A powerful 8.3 magnitude earthquake struck at west of Illapel, Chile around 19:54 local time (22:54 GMT) (**Figure 2**). The city has a population of roughly 23,000 people and is about 177 miles north of the capital, Santiago. The shaking lasted for three minutes which caused shaking of the buildings in cities around the country. The authorities were forced to evacuate one million residents along the 2,690-mile coast after tsunami warnings were issued. Tsunami warnings were also triggered in Japan, New Zealand and Russia, as well as the US states of California and Hawaii.

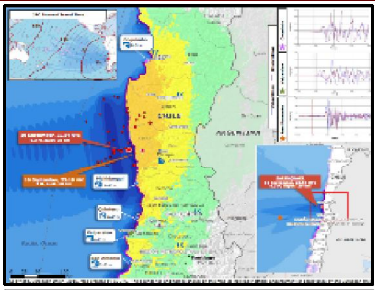

**Figure 2: Epicenter and tsunami wave heights along the Chilean coast. (Source www.reliefweb.int)**

This earthquake is the strongest in the world this year and the biggest to hit Chile since 2010. Chile is one of the most seismically active locations on the globe (**Table 2**). It is on a subduction boundary, which means that tectonic plates beneath the Pacific Ocean are diving under the continental crust holding the South American country. These types of plate boundaries are known for producing violent mega earthquakes. Chile runs along the boundary between the Nazca and South American tectonic plates. This event occurred as the result of thrust faulting on the interface between the Nazca and South America plates in Central Chile. The Nazca plate is moving towards the east-northeast at a velocity of 74 mm/yr with respect to South America.

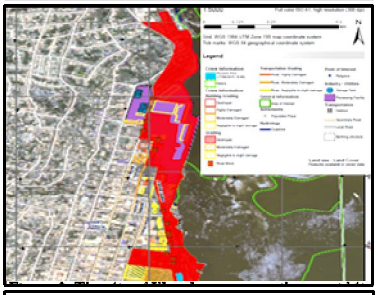

**Figure 3: The city of Illapel was among the worst hit. (Source Reliefweb.int)**

Although there are no large cities in the immediate vicinity of the earthquake, adobe houses and infrastructure in towns and rural areas (especially in northern Chile) were damaged (**Figure 3**). A series of tsunami surges (some as high as 4.5 metres (15 ft)) (**Figure 2**) swamped towns along the Chilean coast and with power and phone outages making extent of devastation difficult to assess. At least 40 aftershocks also hit the region. Of these one was at a magnitude of 7 and seven were at magnitude of 6 or above and at least 40 were at magnitudes greater than 5. *(Continued on page 4)*

### EDITORIAL

*Cowasjee Earthquake Study Centre NED, shares the grief and expresses its deepest and most sincere condolences to all those who lost life and remembers the victims of the 8th October 2005 Kashmir Earthquake. Knowing the faced challenges, CESNED vows its commitment to build the capacity of government officials and the citizens through disaster risk management knowledge and trainings and takes responsibility for preparedness towards increased safety, reduced losses, and ensuring a speedier recovery when the next major earthquake strikes. — Editor*

### Inside this Issue:

## Simulation of Post-Earthquake Urban Mass Fire-Spread

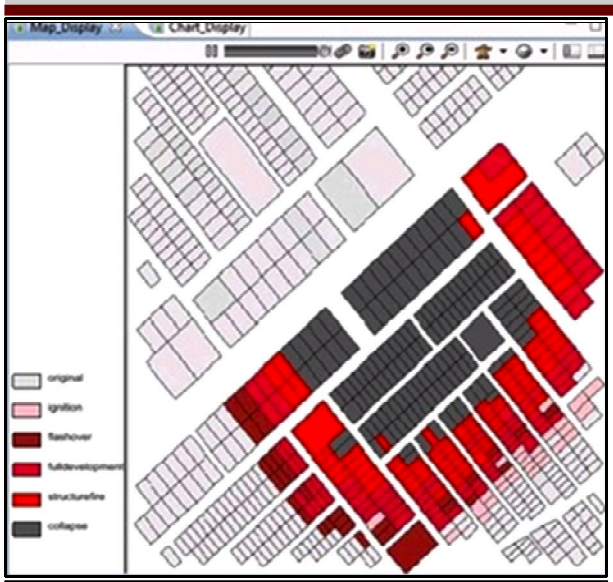


**Figure 4: GIS Mapping of densely built environment and spread of fire.**

Mass fire-spread after an earthquake is a potential threat to densely built urban areas. Several examples exist around the world, when the fire became wide spread after an earthquake and caused significant life and property losses by burning out major parts of a city. In fact, the largest urban conflagrations (in San Francisco in 1906 and in Tokyo in 1923) were post-earthquake fires. More recently, fire caused significant damage following the 1995 Kobe, Japan, earthquake.

It is normal after a large earthquake for multiple fires to break out simultaneously. Under such conditions, fire-spread is likely to overwhelm any of the available fire-fighting capabilities which will cause wide spread damage. Densely built environments are highly vulnerable to disasters, (**Figure 4**). Common problems include: (a) narrow streets enabling fire to spread easily from one building to another; (b) streets cluttered with collapsed buildings in an earthquake restricting fire engine access; (c) shortage of open spaces which function as fire breaks or evacuation sites. One of the reasons behind the lack of urban management is attributed to legislations such as the Building Standard Law and the City Planning Law. They are not authorized to forcibly implement appropriate construction without social consensus on the need for controlled urban reconstruction.

The mitigation of fire hazard is a key challenge in Pakistan in the absence of lack of knowledge of fire science and dynamics, lack of understanding of both the level of this hazard and the importance of fire risk management. The mitigation of fire hazard in the country calls for an urgent need of capacity building in fire risk management of civic agencies, structural engineers, academia and construction industry.

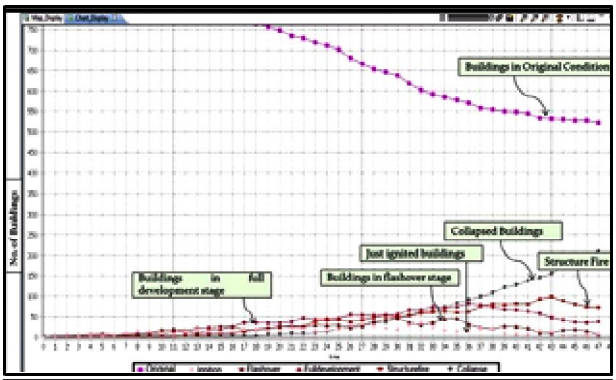


**Figure 5: Visualization of fire spread and simulation results in graphical form**

The Department of Earthquake Engineering initiated a study to develop a model to simulate city conflagration in the aftermath of a natural disaster or a situation similar to a disaster. The development of this model is based on the five key stages of fire development in a compartment fire in addition to considering building-to-building fire spread in an urban settlement. The model allows seamless integration of the building information data in an urban area stored on the geographical information system (GIS) platform and an agent-based simulation platform, (**Figure 5**). The work will provide an effective tool to the disaster agencies and city planners to carryout planning for the reduction of fire risk in Pakistan.

## International Conference on Structural Engineering 2015

Prof. Muhammad Masood Rafi was invited for as a speaker by The Society of Structural Engineers, Sri Lanka (SSE-SL) in the International Conference on Structural Engineering 2015. The conference was organized to celebrate Silver Jubilee (2005-2015) of SSE-SL. The theme of the three-day conference was Towards Excellence in Structural Engineering. Thirteen other speakers from around the world were also invited to cover four main technical sessions of the conference.

**Figure 6: Prof. MM Rafi during the presentation**

Prof Rafi presented the findings on the dynamic behaviour of a reduced scale vernacular stone masonry building model using a shaking table test (**Figure 6**). The tested building model represented traditional construction called Hunza Ha. These buildings exist is large numbers in the mountainous region of Hunza in the Gilgit district of Gilgit-Baltistan (GB) province. The structural system of Hunza Ha consists of load bearing walls constructed with rubble stone blocks which are joined together with mud mortar. In most cases, the building is two-storey high comprising of one multi-purpose room at each storey. The testing of the model was part of the activities to determine seismic vulnerability of existing building stock and need of risk mitigation in the region which lies in a seismically active zone.

A one-third model of a prototype building was tested using the shaking table test. The construction of the model follows the principles of similitude and dimension analysis. The objective of carrying out the test was to investigate the dynamic response and seismic resistance of the model under earthquake loading. The damage patterns and locations where the damage is initiated or concentrated were investigated. The data of damage, failure patterns, displacement and shear demands observed during the test were recorded. These data can be employed in the designing of retrofitting solutions and interventions for this type of construction.

## Anniversary of the 2005 Kashmir Earthquake *(Continued)*

several obstacles such as inaccessible mountainous terrain, the onset of winter, the challenges of coordination between providers of humanitarian assistance, and large number of people in humanitarian need. Despite these challenges, the response to this natural calamity was judged as the most effective response ever to a natural disaster of this magnitude.

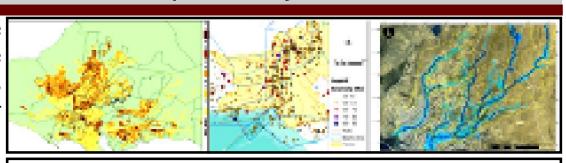

**Figure 7: (Left) Building Density Map (Center) Seismic Hazard Maps (Right) Flood Inundation Maps**

The 2005 Kashmir earthquake created a wave of changes in policies, planning, and actions in Pakistan and transformed the perception and attitude of both institutions and the general population about the earthquake risk in the country. Therefore, in 2006, National Disaster Management Ordinance was promulgated and the National Disaster Management Commission (NDMC) was established under the Chairmanship of the Prime Minister. Further, under the National Disaster Risk Management Framework (NDMRF), National Disaster Management Authority (NDMA) (the executive arm of NDMC) is responsible to manage complete spectrum of disaster management at National level. The pre-reactive emergency response approach was replaced by a proactive approach adopted through the Hyogo Framework for Action (HFA) towards disaster risk management in Pakistan.

**Figure 8: Shaking Table Test of Hunza Ha**

Cowasjee Earthquake Study Center (CESNED) under the auspices of the Department of Earthquake Engineering (EQD) at NED University of Engineering and Technology has been carried out efforts to establish new seismic networks, monitoring systems and better engineering practices in Pakistan.

| **Table 1 CESNED Achievements (2005—2015)** | Commercial Projects | Research Project | Linkages | Reconnaissance/ Trainings | Seminar Workshops Conferences | Publications |
|---|---|---|---|---|---|---|
| | 20 | 40 | 50 | 6/50 | 80 | 50 |

CESNED, since its establishment in 2001, has been on the forefront of the information age, and with developed expertise in disaster risk reduction (DRR) planning, monitoring, numerical modelling, physical assessments and retrofitting strategies. The center has become one of the leading places in the Country to study and understand earthquakes and their associated risk. The research activities of CESNED are supported by the state-of-the art laboratory facilities such the Shaking Table Laboratory and the Advanced Material Testing Laboratory. It has developed linkages with several national and international organizations such as GeoHazards International, Earthquake Engineering Research Institute (EERI), Earthquake Model for Middle East-Global Earthquake Model (EMME-GEM), United Nations Development Programme (UNDP), United Nations Human Settlements Programme (UN-Habitat), Computers and Structures Inc (CSI), National Disaster Management Authority (NDMA), Provincial Disaster Management Authority (PDMA), etc. A summary of the major achievements made by CESNED in the last one decade is given in (**Table 1**).

As a part of DRR activities of CESNED a team carried out reconnaissance survey in Islamabad and KPK on the very next day of the 2005 Kashmir earthquake and mapped structural failures in these areas. A reasonable amount of data exists with CESNED related to both the seismicity of Pakistan to map the associated hazards, and the vulnerabilities of structures and construction techniques. It has carried out several seismic retrofitting projects of non-engineered vernacular buildings in different parts of Pakistan.

CESNED has also been actively engaged in different activities to build capacity in Pakistan for instruction, research, and practice in earthquake engineering and seismic retrofitting of structures. In this regard, a three-year research project was conducted in collaboration with GeoHarazds International; the project was funded through USAID. This work has led to the inclusion of CESNED experts on the legislative and regulatory bodies. Prof Sarosh Lodi played a pivotal role in the development of the Building Code of Pakistan 2007.

Recently, a study entitled Development of Probabilistic Flood and Seismic Risk Assessment of Karachi was carried out by the experts of CESNED (**Figure 7**) to evaluate and mitigate risk to this mega city and to ensure that a resilient city is created. The project was funded by The World Bank. Similarly, a number of other projects related to understanding the behaviour of typical construction in Pakistan have been completed by the CESNED DRR experts (**Figure 8**). These projects were funded by Aga Khan Development Network, Aga Khan Cultural Services, Pakistan, UN-Habitat and Provincial Disaster Management Authority, Baluchistan.

CESNED is also collaborating with government and public agencies, building owners, and the engineering community to transfer the benefits of the conducted scientific studies to the common people in Pakistan. All essential facilities and community-serving infrastructures is the main focus of these activities so that strategic investments can be made in these infrastructures to mitigate the threat of earthquake. This collaboration provides the basis of a strong university-industry partnership.

CESNED is now ensuing in the development of an action agenda to specifically look at what is needed to develop a culture of preparedness (both short- and long-term) so that the residents, businesses and governments are not only made aware of the risks they are also made responsible for its management for increased safety, reduced losses, and a rapid recovery when the next major earthquake strikes.

## Establishment of Fire Engineering Laboratory

Fire incidents are becoming more common in most densely-built cities of Pakistan due to the absence of arrangements for prevention and tackling of fire incidents. A fire staring in a densely-built urban area easily spreads to adjacent buildings. The spread of such fires may overwhelm the ability of firefighters and damage large areas, causing deaths and loss of millions of rupees in revenue.

Karachi is a densely populated city where on average 3-4 fire incidents take place every day. The presence of centuries old markets and godowns located in Boltan market, Lee market, Joria bazar, Meetadar, Kahradar, Bohra Peer, etc, without necessary fire prevention and with lack of robust regulatory systems, has put the lives of citizens in permanent danger. There are over 12,000 industrial units in Sindh with inadequate fire brigade / fire fighting services and equipment. The Department of Earthquake Engineering at NED University, recognized increasing demand of fire testing facilities in the country and has set up a small scale fire lab with a couple furnaces to conduct research on material properties typically used in the construction in Pakistan.

## Zafar Razzak Memorial Lecture Series

Figure 9: (LEFT) Mr. Zafar Razzak (Right) Participants of the Seminar

The Department of Civil Engineering at NED University of Engineering & Technology has started Zafar Razzak Memorial Lecture Series to pay tribute to the services of Late Mr Zafar Razzak Wadalawala for the Department of Civil Engineering and to recognise his contribution in the field of structural engineering and earthquake mitigation in Pakistan. Mr Wadalawala, who served the Department of Civil Engineering as a faculty member since 1989, passed away in 2008 (**Figure 9**). The lecture series consists of bi-annual theme lectures on different aspects of structural engineering. It will revolve around the cutting edge research in the field of structural engineering and disaster mitigation. Renowned international and national experts will be invited to deliver the lectures.

Mr Wadalawala was one of the founding and active member of CESNED and a renowned structural engineer in the country. He was also the member of the first reconnaissance team to collect information on the extent of the 2001 Bhuj Earthquake damages in the affected areas of Badin and Hyderabad. The work provided the basis of beginning of efforts for the hazard mapping in Pakistan. The findings were later presented in a seminar. He took pleasure of announcing the creation of Earthquake Engineering Study Centre (EESC) in the inaugural session of the seminar. EESC was later renamed as Cowasjee Earthquake Study Centre NED (CESNED) after the name of its patron (Late) Mr. Ardeshir Cowasjee.

The first lecture of the series was held on 28th April 2001. Dr Sahibzada Farooq Ahmad Rafeeqi was the speaker who talked about aspect of Disaster Mitigation. Mr Wadalawala and Dr Rafeeqi developed a seismic evaluation and risk rating system for existing buildings in Karachi in 2003.

## Chile 2015 Earthquake *(Continued)*

In 2010 the 8.8-magnitude earthquake in southern Chile killed 525 people, many of them in a tsunami in the south-central part of the country. Another 12,000 were injured and a total of 1.8 million people were impacted throughout the region. A lack of preparation in 2010 was indicated when more than 370,000 houses were destroyed along with 4,013 schools and 79 hospitals. Since then, residents and politicians have both pushed for preparation, retrofitting buildings and increasing mitigation efforts.

| YEAR | CITY | MAGNITUDE |
|---|---|---|
| 1906 | Valparaíso | 8.8 |
| 1922 | Atacama | 8.3 |
| 1960 | Valdivia | 9.5 (largest in modern history) |
| 1995 | Antofagasta | 8.0 |
| 2010 | offshore Bio-Bio | 8.8 (6th largest) |
| 2014 | Offshore Tarapacá | 8.2 |
| 2015 | Illapel | 8.3 |

Table 2: Some earthquakes in Chile of more than 8 magnitude. (Source: www.mapsoftheworld.com)

The recent earthquake illustrates a case study of the value of preparation. This emphasises the fact that the seismic safety is continuously paying off by reducing the damages after each large earthquake (**Table 2**). In the disaster risk reduction community, it's commonly said that every dollar spent in prevention reduces the cost of response by $5. The automated USGS Pager Alert for the earthquake and tsunami predicted a handful of deaths, but damages in the hundreds of millions to billions of dollars.

Most residents of the region currently live in a mix of low-rise reinforced masonry and adobe buildings. As a result of new protocols, the residents have expressed relief that the destruction was limited with a death toll of 11 people even when the earthquake hit at night. Most residents were at indoors at home, not at school or work and reports from the region are indicating mostly superficial damage in Illapel and nearby cities.

## Forum Discussion on Disaster Risk Reduction, Earthquake and Disaster Management

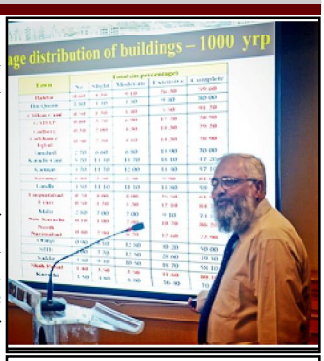


Figure 10: Prof SH Lodi, DM expert,

Institute of Architects Pakistan (IAP), Karachi Chapter, organized a forum and round-table discussion, on 'Disaster Risk Reduction (DRR), Earthquake and Disaster Management' on 27 August 2015 in Karachi.

Mr. Ahmed Kamal, National Disaster Management Authority, Prof Sarosh Lodi, Dean of Faculty of Civil Engineering and Architecture at the NED University and Mr. Tahir Shamshad, Vice President, NESPAK, Islamabad were the panellists. Experts working for different national and international disaster management agencies, civil engineers and architect sat together to discuss an effective strategy for seismic hazard and risk assessment in a city situated in a highly active tectonic setting.

Prof Lodi (**Figure 10**), who has nearly 30 years of experience in studying seismic activity in Karachi, highlighted that although Karachi is very similar to Los Angeles in its geology and demographic settings yet the manner in which infrastructure was built to withstand earthquakes is different for both the cities; almost two-thirds of Karachi has no engineering input with regards to building structures and is thus ill-equipped to withstand the peak ground acceleration of a major earthquake.

Mr Ahmad Kamal emphasized that Pakistan was facing multiple hazards and, as per various international assessments, Pakistan falls in the top 10 (from among 181 countries) most vulnerable to climate change and not enough was being done to prepare for the long-term repercussions of a disaster. He also criticised the lack of coordination between federal and provincial departments in mitigating the effects of natural disasters. In his view, this has added to the impact of the disasters.

Mr. Tahir Shamshad tackled the issue of building codes for various types of construction in Karachi. He warned that the poor evaluation of construction sites along with shabby construction will likely to contribute to higher levels of vulnerability to earthquakes. He further emphasized that poor construction plans in place today do not leave room even for evacuation measures in case of a major earthquake.

The adaptation of the Hyogo framework Action (HFA) for DRR in Pakistan also came up for discussion. However the panellist felt that the implementation is lacking on several agendas as prescribed in the HFA, and this may cause large-scale human and economic losses that will be difficult to overcome.

Participants in the discussion agreed on the necessity of giving disaster risk reduction a more organized trajectory, and bringing together individuals and organizations under one umbrella for efforts to be more widespread and proactive.

**RESOURCE PERSONS:**

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

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