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NED UNIVERSITY OF ENGINEERING & TECHNOLOGY
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Cowasjee Earthquake Study Centre
NED
NEWSLETTER

Third M>7 Earthquake to Rock Baluchistan in Three Years

A 7.7-magnitude earthquake struck about 145 miles south-southeast of Dalbandin in Baluchistan province in Pakistan on the afternoon of 24th September 2013, at a depth of 20km (13 miles) north-east of Awaran (Figure 1). The earthquake was felt throughout the region in different cities, including Karachi and New Delhi. USGS reports that the event occurred within the transition zone between northward subduction of the Arabian plate beneath the Eurasian plate and northward collision of the Indian plate with the Eurasia plate.

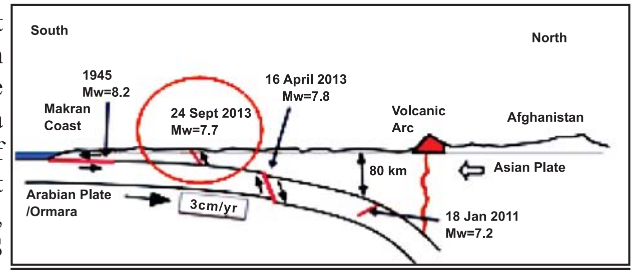

Figure 1: Major earthquakes in the Makran collision zone (1945 to Sept 2013). Three have progressively occurred southward in the past 2.5 years). (Source: http://cires.colorado.edu/~bilham/Awaran_Earthquake/Awaran24Sept13.html).

The National Disaster Management Authority, Pakistan (NDMA) estimated that 386 people were killed, 816 people, including the minor children and women, were seriously injured, 32,638 houses were completely demolished and another 14,118 houses are partly damaged in earthquake-hit areas including Mashkai, Mangoli, Awaran, Malar and Dandar (Figure 2). More than 30 villages, containing about 20,000 homes, were flattened across 15,400 square miles of the remote Baluchistan region. Officials in Baluchistan declared an emergency in Awaran, which sustained the worst damage in the earthquake.

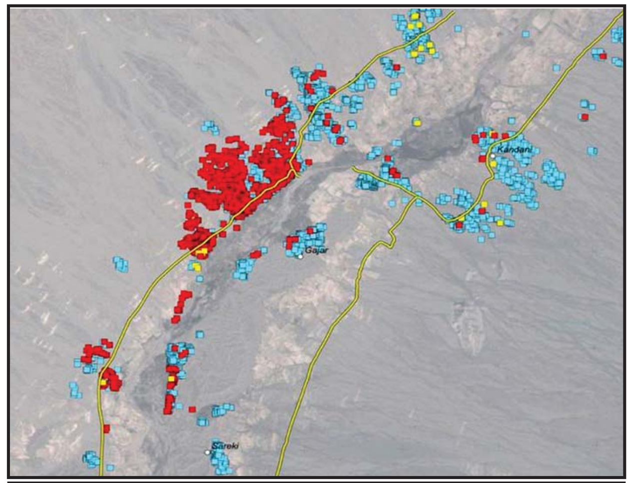

Figure 2: Destruction in Gajar, Awaran, as detected by Satellite Spot Images (Source: UNITAR/UNOSAT on behalf of UNICEF).

After the earthquake, an island appeared off the coast near the port of Gwadar (Figure 3) which is reported to be about 200 m long, 100 m wide and 20 m high. Since 1945, there have been four incidents in which similar islands appeared. Of these, two islands appeared in 1945 after the Pasni earthquake, one each in 2010 and 2012 and the recent is after the September 2013 earthquake.

Figure 3: View of Islands that appeared along the Baluchistan coastline (Source: http://cires.colorado.edu/~bilham/Awaran_Earthquake/Awaran24Sept13.html).

On 28th September 2013, an aftershock of 6.8-magnitude at a depth of 14 km was recorded by USGS. It was located approximately 30 km to the north-northeast of the 24 September 2013 earthquake; it struck with a similar faulting mechanism. The National Seismic Monitoring Centre of Pakistan at the Pakistan Meteorological Department in Islamabad classified it as a new earthquake.

EDITORIAL

The second issue of volume 13 of CESNED NEWS LETTER is an effort of keeping our readers informed of the activities the Department of Earthquake Engineering is carrying out in regard to playing its role in earthquake mitigation in Pakistan. The articles selected for the issue also provide some glimpses of the outcomes of research activities carried out by the Department since the publication of the last issue. Readers across the globe are encouraged to send us comments on any aspect of issue of the Newsletter. — Editor

Inside this Issue:

Successful Shake Table Test of Hunza Ha

The Department of Earthquake Engineering carried out a shake table test on 27 September 2013 of a vernacular building constructed in the Northern areas of Pakistan. The construction is typically known as Hunza Ha. A large audience consisting of students, consultants, media and government officials witnessed the first which was one of its kind in Pakistan (Figure 4). The testing of this structure was part of the activities under the project entitled Applied Research on Safer Construction and Technology Transfer. This project is a joint collaboration between Department of Earthquake Engineering at NED university of Engineering and Technology, Disaster Risk Management Initiative (DRMI) of Aga Khan Development Network (AKDN) and Aga Khan Cultural Services (AKCS, P).

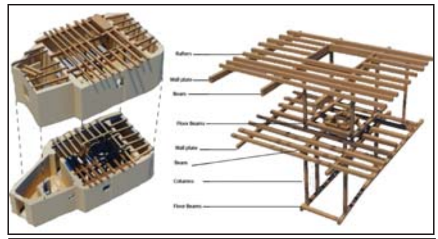

Figure 4: Details of a typical Hunza Ha.

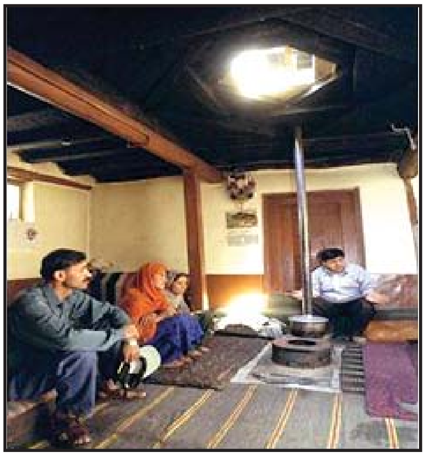

Figure 5: Inside view of Hunza Ha.

The building structure of Hunza HA consisted of load bearing walls with a complex wooden roof structure which rests on four timber posts. The posts are placed around central core of a large roof opening which is called Ha in the local language. The roof opening is provided for day light and air circulation (Figure 5). These types of houses are usually constructed in Hunza and are typically two storeys high. The ground storey is used during winters which are harsh in the region whereas first storey is used for living during summer. The uniqueness of this type of construction brings more challenges in the prediction and understanding of its seismic behaviour.

All required material and craftsmen were transported from Hunza for the construction of the building in order to replicate the construction as much as possible. In view of the shake table size a one-third scaled model of the building was constructed (Figure 6). The dimensions of the model and the testing protocols were developed using principles of similitude and dimension analysis. The structure was subjected to El Centro ground motion with variable PGAs until complete failure of the structure took place. All the partners of the project are hopeful that such shake table tests will result in better understanding of the structural resilience and weakness of the traditional construction which exist in large numbers in the Gilgit-Baltistan province of Pakistan. This will result in creating a seismic resistance built environment for a community which may be at risk presently.

Figure 6: Construction of 1/3rd model of Hunza Ha on the shake table.

Disaster Risk Management Plan and Planning Map of Gadap Town

The Department of Earthquake Engineering is working on a project entitled Disaster Risk Management Plan and Planning Map of Gadap town, Karachi in collaboration with United Nations Human Settlements Programme (UNHABITAT). Gadap Town (Figure 7) is spread over 1,200 square kilometres and is located in the north-western part of Karachi. The Hub River is on its western sides which also forms the provincial border between Sindh and Baluchistan. On the north and east of the town are Dadu District and Kirthar Mountains. The area of the town makes it the biggest town of Karachi; it has been divided into eight union councils (UCs). The population of the town is estimated at around 300,000. The trend of population settlement in Gadap town makes it the most sparsely populated unit of the city.

The objective of this project is to carryout vulnerability and disaster risk assessment and to develop risk reduction map for Gadap town. The hazards considered include earthquake, flood and fire. The study will be conducted both on macro- and micro-level. The former study will be carried out for the Gadap town as a whole whereas the latter study will focus on UC4 of the town. A GIS database of building, population and lifeline systems will be developed to achieve the objectives of the study.

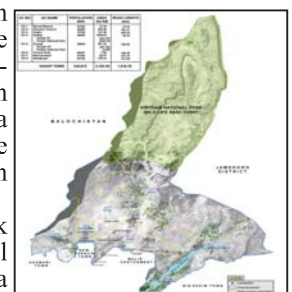

Figure 7: Map of Gadap Town

Earthquake Model of the Middle East Region (EMME) Project Completed

The closing ceremony for the project entitled Earthquake Model of the Middle East Region (EMME) took place from 30 September 2013 to 2 October 2013 at Bogazici University, Turkey. The final meeting was attended by a large number of researchers and policy makers from Cyprus, Georgia, Iran, Jordan, Lebanon, Pakistan, and Turkey. All the EMME representatives from each country presented the results of the work carried out over four years (2009-2013) related to earthquake risk reduction in the Middle East Region. The different work packages (WPs) focused on calculation of earthquake hazard, validation of earthquake and shaking probabilities (using regional and global data), communication of earthquake risk to all users, integration of local expertise in a regional and global context, building capacity in the whole region and establishment of dialogue with decision-makers to plan mitigation of seismic risk in their cities.

The NED University Pakistani team was led by Prof Sarosh H Lodi. Prof Lodi presented the research work on behalf of Pakistani team on Seismic Risk Assessment for Pakistan (WP4) and Karachi City Scenario (WP5) during the programme.

Physical Facilities Assessment (PFA)

The 2005 Kashmir earthquake has been the most devastating earthquake in the recent history of Pakistan. This 7.6 magnitude earthquake caused widespread damages to the built environment. As a result of building collapse, approximately 87,350 including 19,000 children died; most of these children died due to the collapse of more than 6000 school buildings. In view of these destructions, Aga Khan Planning and Building Services, Pakistan (AKPBS,P) has started a programme entitled Physical Facilities Assessment (PFA) along with the Department of Earthquake Engineering at NED University of Engineering and Technology. The objective of this programme is to carryout seismic assessment of schools in the Gilgit-Baltistan region of Pakistan.

Figure 8: School in Gilgit—Type Post R&D Era.

A database of different features of school buildings, such as topography of the place, level of hazard, structural and non-structural features, accessibility, safety, etc, for nearly 250 schools will be developed. These were constructed during the Self-Help School Construction Programme (SHSCP) by Aga Khan Education Service, Pakistan (AKES,P) and are located in Gilgit-Baltistan and Chitral (GBC) of Pakistan. Physical survey of the school buildings region will be conducted to record the data. The seismic risk for these schools will be determined using the level of seismic hazard in the region and seismic vulnerability of these buildings. Structural analysis of the buildings will be carried out to determine the capacity of the structural members; this will be compared with the provisions of the codes and retrofitting solutions will be developed.

Figure 9: School in Gilgit—Type A of Sikandar Ajam Era.

The project will produce the following key outcomes

- Comprehensive AKES,P facilities database and baseline
- Identification of buildings requiring urgent attention
- Recommendations for the prioritized interventions for major repairs
- Preparation of maintenance upgrading, retrofitting and implementation plan

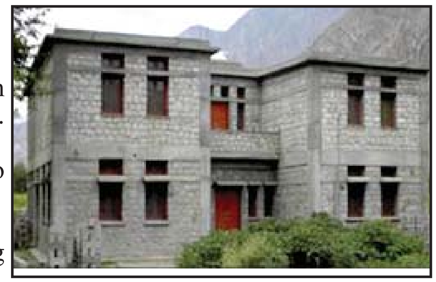

Figure 10: School in Gilgit-Type C of Sikandar Ajam Era.

Aga Khan Foundation started Self-Help School Construction Program (SHSCP) in 1983 with the aim of constructing earthquake resistance school buildings in the Northern Areas and Chitral. The objectives of SHSCP are as under

- All schools seismic resistance, also act as temporary shelter in earthquake, responsive to cold winters, heat and solar radiation in summer
- Community ownership
- Local cost and low maintenance with available construction materials and existing construction practice

The design of school buildings had to respond to often difficult terrain and to an environment, in many cases, owing to the fact that there were few large flat building sites available in these in t areas. Climatically, the design had to respond to the long cold winters as well as to the heat and solar radiation of the summer months in certain areas. Local cost and low maintenance with available construction materials and existing construction practice.

The SHSCP built environment is divided into four distinctive eras of construction (Figures 8 to 10) these correspond to the needs of community along with both the changes in design codes and technical evaluations of previous designs. It is hoped that the project will enable AKPBS,P to improve the traditional human habitats in the region.

Field Visit of Schools in Gilgit and Adjoining Areas

A four-member team consisting of Dr. Rashid Ahmed Khan, Professor, Department of Earthquake Engineering, Mr. Amir Nizam, Senior Lab Engineer, Department of Civil Engineering, Mr Adnan Rais, Lecturer, Department of Civil Engineering, and Mr. Adam Abdullah, Research Assistant, Department of Earthquake Engineering, visited the schools buildings in Gilgit and adjoining areas from 29th June to 7th July 2013 (Figure 11). This visit was the first activity of the research project entitled Physical Facilities Assessment (PFA). The Department of Earthquake Engineering is carrying out this project in collaboration with Aga Khan Planning and Building Services, Pakistan (AKPBS,P).

AKPBS,P has been collecting information related to various aspects of school buildings in Gilgit-Baltistan region of Pakistan to assess their vulnerability to seismic hazard. Survey teams have been collection the information using questionnaires. The objective of the visit was to assist AKPBS,P in ensuring the accuracy of the data collected by collecting the data gathered by the survey teams in the field. A sample of seventeen schools was surveyed during this visit; these represent four prototypical era of construction. Technical audit protocols have been developed to address the shortcomings in the collected data taking the help of photographs, interviews survey team members and rating based checklist. This audit helps in evaluating the overall condition of the schools and to assess the awareness of the surveyors to the data collection.

Figure 11: NED team with AKPBS,P survey team at a school in Gilgit.

City Scenario for Gulshan-e-Iqbal Town Karachi (WP5 of EMME Completed)

This work was a part of Work Package 5 of the project entitled Earthquake Model for Middle East (EMME). The objective of this study was to develop a seismic city scenario for Karachi. The Gulshan-e-Iqbal town of Karachi was selected as a case study region. A deterministic as well as probabilistic seismic hazard assessment was conducted for Karachi. Peak ground accelerations at various locations of the City were calculated by assigning the maximumof the credible earthquake (MCE) to active faults in the vicinity of Karachi. The probabilistic seismic hazard assessment is conducted by considering the area source zones and historical seismicity to estimate the peak ground accelerations and spectral accelerations for various return periods (Figure 12).

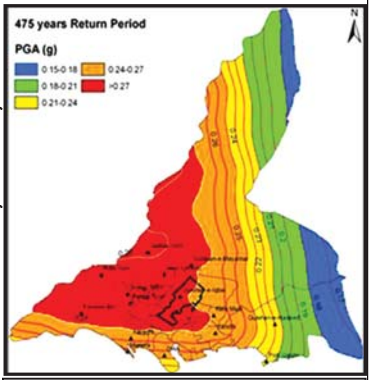

Figure 12: PGA map for Gulshan-e-Iqbal town for 475 year return period

A building inventory is developed for the Gulshan-e-Iqbal town with the help of photographic and physical surveys. Three major groups of buildings were identified; these include reinforced concrete (RC) structures, cc block masonry load bearing structures, stone masonry load bearing structure. Rest all buildings were categorised as others. The study revealed that the majority of buildings in the town (85%) are RC frame structures with cc block masonry infill walls.

In addition to building infrastructure, lifeline structures such as bridges and buried pipelines were also considered within the scope of the study. For determining vulnerability of load bearing structures a macro-seismic method was employed and help was taken from the data of damages in the 2005 Kashmir earthquake. An adaptive pushover analysis was carried out for the development of fragility curves for RC buildings and bridges. Finally, fragility curves for pipelines were obtained from the existing literature elsewhere. or the assessment of losses based on the data for the seismic hazard and building vulnerability, the loss estimation programme entitled Earthquake Loss Estimation Routine (ELER) was employed. Seismic hazard was defined using a return period of 475 years along with taking the local soil effects into account. The distribution of the damage level extensive to complete is illustrated in (Figure 13). The results from ELER simulation indicated that significant number of buildings may be severely damaged in Gulshan-e-Iqbal town. The vulnerability analysis of the City water supply network also indicated severe damages to the network. Nevertheless, the bridges were found to be less vulnerable and the results indicated damage of only 3% of bridges out of a total 199 bridges in the City.

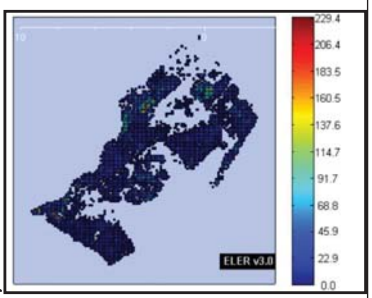

Figure 13: Distribution of extensive to complete damage for RC buildings.

Seismic Hazard/Risk Assessment for Pakistan's Built Environment Completed

The Department of Earthquake Engineering has developed a complete inventory Pakistan''92s building typology on GIS platform. This data can become a useful tool for the assessment of seismic risk to the built environment in terms of building damages, casualties and economic losses. The data of building typology has been digitised on a 1x1 km grid in GIS (Figure 14). The work allowed categorising the built environment of Pakistan into seven types of building (Figure 15). These categories were kept the same as European Macro Seismic Study (EMS-98) to allow a comparison of vulnerabilities of buildings in both regions. Seismic vulnerability assessment of buildings has been carried out and loss estimation models have been developed. Seismic vulnerability of buildings has been represented as fragility curves for each type of building (Figure 16). The loss estimation programme entitled Earthquake Loss Estimation Routine (ELER) was employed for estimating losses using the data of seismic hazard assessment and building vulnerability. The data of damages caused by the 2005 Kashmir earthquake were validated with the help of ELER. The results from ELER simulation indicated damages to 401,512 buildings as compared to the actual 473,839 damaged buildings which was 15% less than the predicted damages.

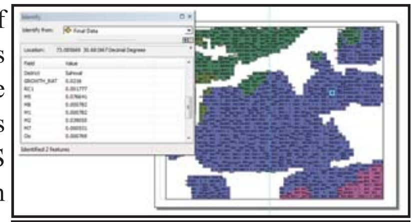

Figure 14: GIS data of buildings in Pakistan on a 1x1 km grid format.

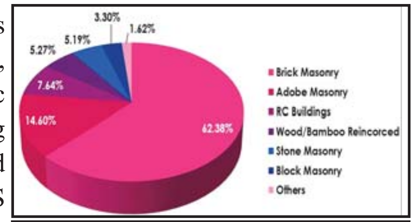

Figure 15: Distribution of building typology of Pakistan.

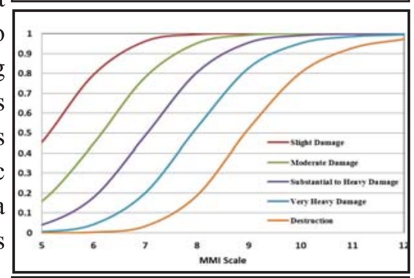

Figure 16: Fragility curve for the dominated brick masonry buildings

RESOURCE PERSONS:

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Information, news items, short notes on research findings are invited from across the globe.