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NED UNIVERSITY OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF EARTHQUAKE ENGINEERING

Cowasjee Earthquake Study Centre
NED
NEWSLETTER

Inaugural Session of SHAKE (SouTH Asia EarthquaKE Network)

An international workshop entitled Recent Advancements in Earthquake Engineering and Seismology in South Asian Countries was organised by Department of Earthquake Engineering at NED University on 9-10 August 2016 under the auspices of SHAKE (**S**out**H** **A**sia Earthqua**KE** Network). This was also the first meeting between core partners of SHAKE (**Figure 1**). The network SHAKE which was created in 2012 is a multi-national joint initiative to encourage a regional structured approach to seismic risk mitigation, leading to reduced monetary losses and casualties. The focus of SHAKE is on the earthquake hazard quantification, and vulnerability and risk assessment of the infrastructure in Pakistan, India, Nepal, Bhutan, Sri Lanka and Bangladesh using state of the art technologies. The participants from these countries participated in the workshop.

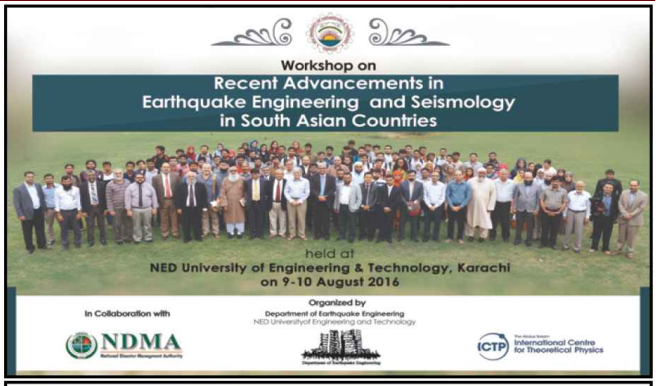

Figure 1: Workshop group photo (Participants with members of SHAKE)

The workshop was supported by Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy. Prof. Abdelkrim Aoudia participated in the workshop on behalf *(Continued on page 2)*

International Workshop on Earthquake Engineering

Pakistan is considered an area of high seismic activity and has been subjected to earthquakes regularly. Strategic planning and indigenous seismic design considerations are needed so that loss of human life and sufferings can be minimized. The ultimate objective of earthquake engineering is the reduction of loss of life and property due to earthquakes. To achieve this objective, it is necessary that knowledge concerning all aspects of the earthquake problem be extended.

Figure 2: (Left) Syed Tanvir Wasti (Right) Prof. Polat Gulkan

Department of Earthquake Engineering at NED University organised a three day International Workshop on Earthquake Engineering in collaboration with Institution of Engineers Pakistan (IEP) from 29-31 July 2016 at IEP Convention Centre, Karachi. The aim of the workshop was at to introduce the basic fundamentals of earthquake engineering and to share the latest advances in earthquake science with design code advancements, best practices in construction and research.

Prof. Syed Tanvir Wasti, Professor Emeritus in the Civil Engineering Department at Middle East Technical University (METU), Turkey and Dr. Polat Gulkan (**Figure 2**), Former President of International Association for Earthquake Engineering (IAEE) conducted the Workshop. More than 80 participants from various organizations, including governmental, private, educational and NGO's, participated in the workshop, (**Figure 3**). The topics covered by the speakers included dynamic response of buildings, response spectra earthquake damage evaluation and assessment, structural rehabilitation, rehabilitation of non-engineered (masonry) structures, current approaches to structural rehabilitation, base isolation techniques, seismic assessment and rehabilitation of historic structures. Case studies of structural upgrading, and assessment and rehabilitation were also discussed with the help of videos.

Prof. Sarosh Hashmat Lodi presented the concluding remarks and appreciated the efforts of IEP. Dr. Sahibzada Farooq Ahmad Rafeeqi, Chairman, IEP Karachi Centre presented the shields to the guest speakers.

Figure 3: Group photo of workshop participants

EDITORIAL

The Second issue of volume 16 of CESNED NEWSLETTER completes yet another year of successful publication of the Newsletter. A summary of different research activities and news of recent earthquakes have been included in this issue.

I hope that the information contained in this issue will be of interest to our readers which are growing with time. — Editor

Inside this Issue:

Continued-Inaugural Session of SHAKE (SouTH Asia EarthquaKE Network)

of ICPT and discussed the importance of education, training and networking for a sustainable research in earthquake prone regions, and the ways of strengthening and sustaining SHAKE long term objectives.

Prof. Roger Bilham, University of Colorado, Boulder, USA also participated as a keynote speaker in the programme and delivered a lecture entitled History of Great Himalayan Earthquakes. Other presenters included the following: Prof. Sarosh H. Lodi, Prof. Muhammad Masood Rafi, Dr. Mukesh Kumar, Dr. Muhammad Waseem and Mr. Naeeem Iqbal from Pakistan; Dr. Amod Mani Dixit and Mr. Kuber Bogati from Nepal; Prof. Raquib Ahsan and Mr. Nurul Alam from Bangladesh; Mr. Phuntsho Pelgay from Bhtan; Dr. Amit Kumar from India; Prof. Ranjith Dissanayake and Dr. Kushan Wijesundara from Sri Lanka. These speakers made country presentations on behalf of their respective countries.

Figure 4: Prof. Abdelkrim Aoudia, ICPT, wearing traditional Sindhi Cap and Sindhi Ajrak presented by VC, NED University (Right), with Prof Lodi (center).

More than 40 participants attended the workshop that was divided into five technical and one inaugural session. Prof. Sarosh Hashmat Lodi, Dean of Faculty of Civil Engineering and Architecture, NED University welcomed the participants of the workshop. He highlighted the purposes and objectives of the event. Prof. Muhammad Afzal Haque, Vice Chancellor, NED University, presented vote of thanks and concluded the inaugural session with the distribution of souvenirs to the presenters (**Figure 4**). The presenters from each of the participating countries discussed various aspects of seismic hazard and vulnerability, and the efforts being made to reduce seismic risk in their countries.

A panel discussion was held in the last session of the workshop. Prof. Sarosh Lodi presented a concept for creating mutual working environment, to deal with the common scientific problems in the South Asian region. Prof. Abdelkrim shared his best experiences of such networks in the world that he is associated with. He emphasized on the role of students as the main problem solver body for the participating countries. He mentioned that the involvement of students is also encouraged by ICTP. The participants agreed to form a core group of coordinators to become a liaison between SHAKE and their countries. The group consists of the following: (a) Prof. Muhammad Masood Rafi – Overall Programme Coordinator; (b) Prof. Raquib Ahsan – National Coordinator, Bangladesh; (c) Mr. Phuntsho Pelgay – National Coordinator, Bhutan; Mr. Kuber Bogati – National Coordinator, Nepal; Dr. Mukesh Kumar – National Coordinator, Pakistan; and Dr. Kushan Wijesundara – National Coordinator, Sri Lanka.

Response Reduction Evaluation for RC Frames

Reinforced concrete frame structure with infill masonry is a common building type in Pakistan. In past, the influence of infill masonry in RC structures has been investigated widely and it constitutes a critical role in the lateral load response of RC structures. The behaviour of masonry is highly non-linear; therefore, it is necessary to incorporate the homogenous properties and failure modes of infill through a rational computational model approach.

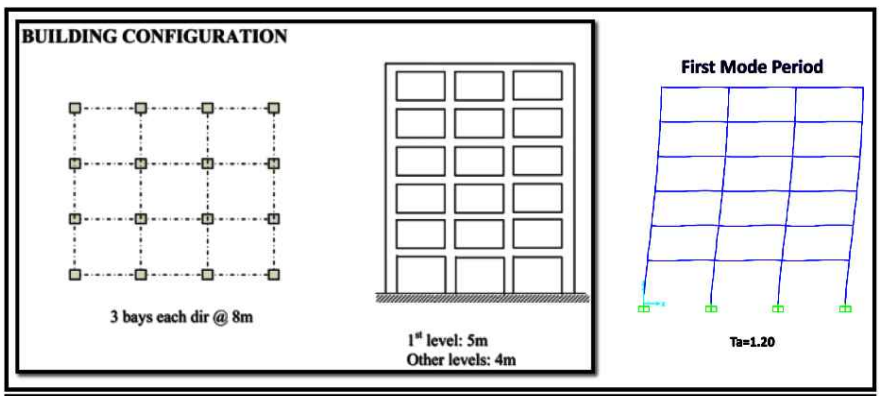

Figure 5: Prototype building with mode 1 analysis

Different procedures are used to analyse the infilled frames such as finite element formulation and simplified macro models. Micro-modelling approach discretizes the masonry model into several elements which makes it more complex computationally. A research study is being focused on macro-modelling technique which provides a global response of structure more efficiently. The nonlinear response of a structure, (**Figure 5**), is assessed through a response reduction factor 'R' which allows the practitioner to use a linear elastic force-based design while accounting for nonlinear behaviour and deformation limits.

Prof. Sarosh Lodi and Dr Aslam Faqeer Muhammad are supervising this research study on estimating the rational value of 'R' for RC buildings in the locality of Karachi and to check its compatibility with code recommended values of 'R'. Ms. Kainaat Nadeem has commenced this study as a research assistant. She is using computer code Open Sees to analyse 2D frames with and without infilled masonry subjected to a series of monotonic and non-monotonic pushover analysis.

Computational Modelling of Infill Walls

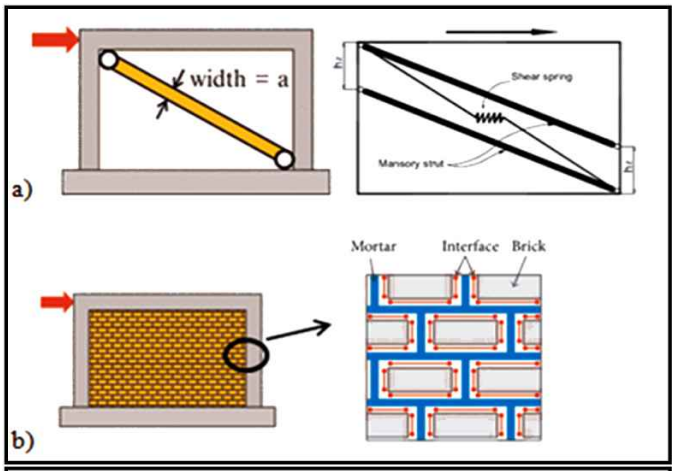

Figure 6: a) Macro models: equivalent strut and shear strut model
b) micro modelling

Infill walls play an important role when the structure is subjected to earthquake lateral forces. It is well-known that masonry infill walls enhance the lateral behaviour of frames by increasing its strength, stiffness and energy dissipation capacity. In Pakistan, infill walls are considered as non-structural elements and are not incorporated while designing the RC structures. Methods of incorporating the behaviours of infill walls are required to prevent undesirable effects.

Dr Mukesh Kumar along with his research assistant (Ms. Fatima Khalid) are carrying out a numerical study to understand the effect of infill walls and to develop simple approach to incorporate them in while designing. There are two types of modelling techniques: macro modelling and micro modelling. Macro modelling include equivalent compression diagonal strut models, multiple strut models and strut models with shear springs to represent the global behaviour of the frame. On the other hand, micro modelling includes detailed modelling using finite element method to represent the local behaviour, (**Figure 6**).

For numerical modelling, the real data of Pakistani masonry is required. Due to this, a full-scale 2.78 m x 2.71 m, single bay single storey reinforced concrete frame was tested in the Advance Material Testing Laboratory of the Department of Earthquake Engineering. A fatigue rated dynamic hydraulic actuator was used for the lateral load testing, and the global displacements were monitored using linear variable displacement transducers (**Figure 7**).

A research is in progress for determining the best parameters to represent the infill behaviour in Pakistan for different models. Some of the parameters are taken from the previous study and the remaining ones are found by sensitivity analysis. The macro and micro models will be modelled and verified with experimental results using commercial software SeismoStruct and TNO Diana, respectively. This will help to find the effectiveness of suggested models by different researchers which can then be incorporated in the seismic design and assessment of structures.

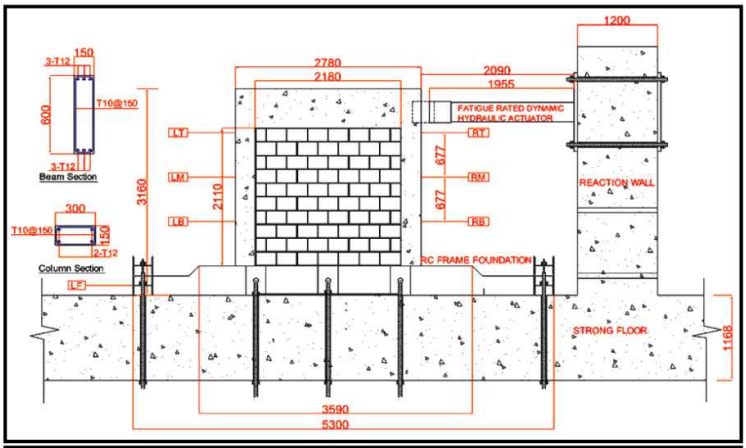

Figure 7: Dynamic test setup of infill RC frame

Higher Mode Response of Masonry Infilled RC Frames

Figure 8: Infill modify global behavior

Masonry-infilled frames have been in use for the past 200 years. They can be found in interior and exterior walls in both reinforced concrete and steel frames all around the world. The interaction of infills with the surrounding frames has a major influence on the structural response of the composite structures. Their most influential property is that of a high initial stiffness and considerable strength. Even today, during the design and assessment of the existing structures they are considered as non-structural members and their contribution in the structural response is over looked. However, numerous research and observations by experts on the damaged buildings (**Figure 8**) reveal that they can have positive or negative effects on the structure and their inclusion in designing and assessment of a structure is imperative.

Moreover, in case of a seismic event the structure enters into a nonlinear stage; therefore, new approaches based on nonlinear analysis are needed to flourish for realistic investigation on seismic behaviour and damage mechanism of the infilled structures. According to the modern philosophy (Performance-based Earthquake Engineering) simple nonlinear static analyses are mostly used in order to determine the structure's behaviour in the nonlinear stage. All these simplified design methods are based only on the fundamental mode of vibration neglecting the effects of higher modes or considering them as elastic. Both of these assumptions are approximations (especially in high-rise buildings) which have a long period. Thus, Dr Mukesh Kumar has started a study together with Ms. Samra Masood (research assistant) in an attempt to evaluate inelastic seismic response of masonry-infilled RC structures. The work will also demonstrate that this response could be several times greater than the design demands from conventional approaches and that the response of an infilled frame is disproportionately dominated by higher vibration modes.

Norcia, Italy, Mw 6.2 Earthquake of 24 August 2016

Figure 9: Epicentre between Norcia and Accumoli (Reuters)

An earthquake of magnitude 6.2 struck central Italy on 24th August 2016 in the vicinity of Amatrice (**Figure 9**). The epicentre of the earthquake was 100 km (65 miles) north-east of Rome. The earthquake caused building damages and collapse and resulted in more than 250 casualties. Nearly 4,000 people were made homeless due to building damages. Recent large earthquakes in this area have been caused by movement on SW dipping normal faults. An earthquake in 2009 near L'Aquila in the Abruzzo region killed over 300 people and displaced about 65,000.


Figure 10: Side by side: Historical center of the town of Amatrice was completely wiped out but the newer part of town appears to remain standing (Reuters)

The earthquake struck in the regions of Umbria which is known for its truffles, wine, abbeys, art, monuments and beautiful forests. It is also home to the tallest man-made waterfall in Italy (272 ft Roman-built Cascata delle Marmore) and Lake Trasimeno. The worst hit towns included Accumoli, Amatrice, Norcia, Posta, and Arquata del Tronto and Pescara del Tronto (**Figure 10**).

Amatrice has been hit by earthquakes in the past as well. The 24th August earthquake occurred in a shallow fault in the chain of mountains of Apennines which is well known for being a highly complex and geologically active region. The region sits at a point where several tectonic plates grind against each other. The earthquake was caused by the opening of the Tyrrhenian basin occurring faster than the compression between the Eurasian and African plates, causing the earth's crust to stretch. According to the US Geological Survey, at the location of the earthquake, the Eurasian plate moves towards the northeast with respect to the African plate at a rate of around 24 mm per year.

The strong ground motion of this earthquake was recorded by 162 stations at epicentral distances ranging from about 9 to 359 km. The peak ground acceleration, at a distance of about 9 km, was recorded as 0.43g. The highest peak ground velocity was recorded as 30 cm/sec at about 14 km from the epicentre.


Figure 11: Clock tower amid rubble of town (Reuters)

The court of Rieti discovered that not all the buildings of the affected cities were constructed or renovated under the antiseismic law of 1974 which explains the construction techniques of earthquake resistant buildings. The investigation is continuing to discover the causes that allowed so much damage to buildings and structures of the affected cities, especially Amatrice. The clock tower of Amatrice remained undamaged and was standing amid the rubble of the town. It has become an iconic image as the clock tower was reportedly built in the 13th century. Its solid stance is provides lessons to understand how this remarkable structure has evaded destruction at least twice in the past 800 years (**Figure 11**).

Inauguration of Advanced Material Testing Laboratory

Figure 12: Prof. Ahsan Iqbal inaugurating the advanced material testing laboratory

Prof. Ahsan Iqbal, Federal Minister of Planning, National Reforms, and Development inaugurated the Advanced Material Testing Laboratory in the Department of Earthquake Engineering at NED University on 27th July 2016 (**Figure 12**). He also visited the 3D Printing Facility, Platform for Design, Creativity and Engineering Innovation which is operated by the Office of Research, Innovation & Commercialization at NED University. Prof. Iqbal thereafter addressed the Faculty. He highlighted the policy of Government of Pakistan in higher education sector and the actions taken by his ministry so far in this regard including launching knowledge corridor programme together with USA. He also informed that the Planning Division has already provided the grant of Rs. 750 million to NED University for its infrastructure development. On the other hand, the federal government is ready to provide Rs. 900 million in the next three years for completing new mega projects by the University.

Magnitude 5.9 Tanzania Earthquake

A magnitude 5.9 earthquake struck Tanzania 22 km (14 miles) northeast of Nsunga, Kagera Region on 10 September 2016 at a depth of 40 km (25 miles). The earthquake was the result of shallow oblique faulting within the lithosphere of the Nubia (Africa) plate.

The shock had a maximum intensity of VII (very strong). Tremors were felt as far away as western Kenya and parts of Uganda, which share the waters of Lake Victoria, and also in Kigali, Rwanda. At least 19 people were killed and 253 others injured in addition to widespread infrastructure damage.

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