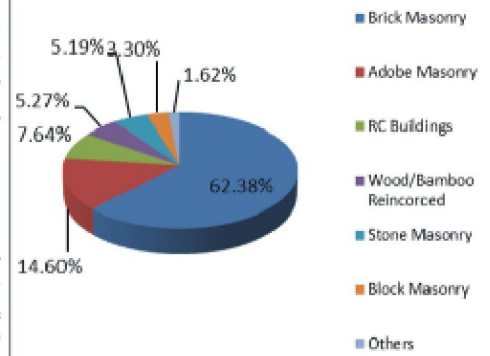




## Shake Table Test of Unreinforced Masonry Structure at the Department of Earthquake Engineering

The 2005 Kashmir earthquake illustrated earthquake hazard and vulnerability of buildings in Pakistan to earthquakes. A large number of buildings in Pakistan consist of unreinforced masonry (URM) structures (Fig. 1) and historically, these have performed poorly during earthquakes. The reasons for this poor performance are the inherent brittleness, low tensile and shear strengths.

The Department of Earthquake Engineering has started a programme of experimentally testing performance of non-engineered construction prevalent in the Country. A shake table test was conducted on a block masonry house on 29<sup>th</sup> February 2012 (Fig. 2). The objectives of the test were the identification of damage patterns in order to determine the need for seismic retrofitting of similar structures.



**Fig 1. Building typology in Pakistan (Source: 1998 census report of Pakistan)**



**Fig 2. Unreinforced masonry structure with instrumentations attached**

The size of the structure was 2.5x2.7 m in plan with a height of 2.25 m. The cement concrete blocks of size 100x200x300 mm were employed in the construction. The thickness of the wall was 100 mm. The blocks were joined with a cement-sand mortar of ratio of 1:3. The roof consisted of GI sheets which were rested on bamboos. The later were spanned at 300 mm at centre. The top of the roof was loaded with several sand filled bags having a total mass of 140 Kg. The instrumentation consisted of accelerometers, LVDT's and strain gauges. The data were acquired using a data acquisition system. These data are being analysed, presently.

## Department of Earthquake Engineering Established at NED University

Cowasjee Earthquake Study Center (CESNED) has been working on various aspects of earthquake mitigation since its creation in 2001. The Center was previously administered by the Department of Civil Engineering. The experience gained through the activities of CESNED in the last one decade and the expertise developed in the area of seismology and earthquake engineering provided a strong basis for the establishment of Department of Earthquake Engineering which was established in 2011.

Prof. Muhammad Masood Rafi has been appointed as Chairman of the Department of Earthquake Engineering. The underlying purpose of the Department is to develop highly skilled professionals and researchers who are trained in various aspects of earthquake mitigation so that they are able to serve the society through better planning and preparation.

Currently, the Department offers Master degree in Structural Earthquake Engineering. The programme is designed to suit the needs of professional engineers working in the construction industry as well as to strengthen already existing research activities in the area of earthquake engineering and related disciplines. Degree program in Geotechnical Earthquake Engineering and Engineering Seismology courses will be offered in future.

EDITORIAL	Inside this Issue:	
<p><i>This issue of CESNED Newsletter, in hand, is the first issue which is published by the Department of Earthquake Engineering, after its establishment in 2011. All the published articles in this issue are taken from on-going research projects in the Department. The research work conducted during April 2011-April 2012 has been reported in this issue. — Editor</i></p>	<i>Building Capacity in Pakistan to Seismically .....</i>	2
	<i>Seismic Vulnerability Assessment of Pakistan .....</i>	3
	<i>A Case Study on Pakistan's Built Environment .....</i>	3
	<i>3rd General Assembly of Earthquake Model .....</i>	3
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# Building Capacity in Pakistan to Seismically Retrofit Essential Structures

## HEC-USAID Project Completed (2007 to 2012)

The 2005 Kashmir earthquake killed more than 73,000 people and injured 128,000. Millions of people were made homeless in northern Pakistan region. In response to this disaster, Pakistan-US Cooperative Program in Earthquake-Related Research funded a project in 2007. The NED University of Engineering and Technology, Pakistan and GeoHazards International (GHI), a California based non-profit organization collaborated in this project. The project was aimed at improving Pakistan's earthquake engineering education capacity. This project has come to an end in 2011. The project provided an opportunity to Pakistani engineers and academicians to involve with the global earthquake engineering community. Summary of the main achievements from the project is given in Table 1. Salient features of this table are listed as under:

Effective capacity building was carried out of more than 300 professionals from different stake holders such as universities, engineering consulting firms, architecture firms, civic agencies and construction contracting firms. These professionals were trained in seismic vulnerability assessment and/or developing retrofit solutions.

Hands on experience and intensive mentoring for a group of early and mid-career Pakistani faculty members in applying advanced earthquake engineering techniques to existing buildings.



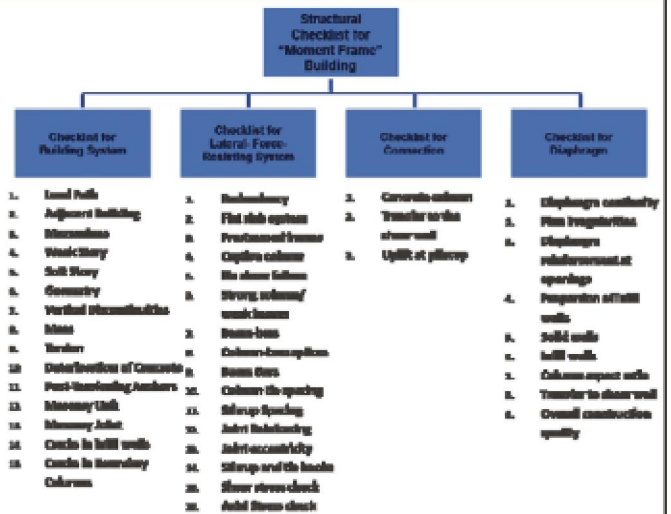
**Fig 4. Building case studies for seismic assessment and retrofit design**

Greatly enhanced understanding of building seismic behaviour and the effects of masonry infill walls within the Pakistani engineering community, which will lead to better-designed new buildings as engineers consider the contribution of infill walls during structural design.

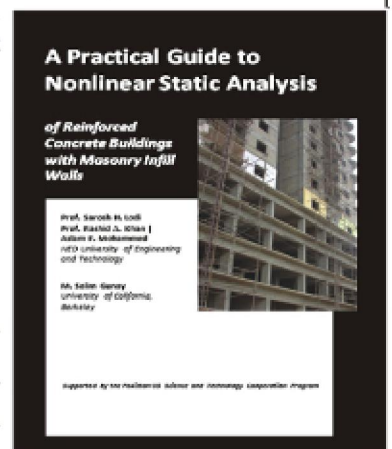
Results and products to enrich future capacity building efforts, including 10 case study buildings with documented assessments, computer analyses and retrofit designs (if retrofit was needed); a Pakistan-specific checklist for building vulnerability assessment; a practical guide to nonlinear static analysis for engineers; practical courses on building vulnerability assessment and retrofit; and modules for use in academic courses.

New and innovative applications of retrofit methods to common urban buildings in Pakistan, and the formation of an international research-practice collaborative network called the Framed Infill Network to make concrete buildings with masonry infill safer through innovative designs that make beneficial use of infill walls.

Significantly strengthened relationships between academia and professional engineers in Karachi, and between researchers in Pakistan and the US.



**Fig 3. Seismic vulnerability assessment checklist for RC buildings, modified for Pakistan**



**Fig 5. Performance based design manual for RC buildings**

Indicators	Reporting Period				
	2007	2008	2009	2010	2011
<b>1. No. of higher education partnerships between Pakistani and U.S. institutions</b>	27	6	14	20	14
<b>2. No. of journal articles, technical reports, books, or book chapters (published or accepted for publication)</b>	NIL	NIL	3	5	12
<b>3. No. of training events (courses, workshops, seminars, conferences, stakeholders' meetings)</b>	5	4	2	4	3
<b>4. Total number of Pakistani PhD students involved in the project</b>	1	1	2	1	3
<b>5. Total number of Pakistanis trained as a result of participation</b>	51	68	62	71	136
Number of women	11	13	9	4	37
Number of men	40	55	53	67	99
<b>6. Total number of all Americans who participated in the project</b>	8	8	8	8	8

**Table 1. Building capacity in Pakistan to Seismically Retrofit Essential Structures (Project Summary)**



# Seismic Vulnerability Assessment of Pakistan

## Earthquake Model for Middle East



The Department of Earthquake Engineering is working on an internationally funded project entitled as Earthquake Model for Middle East (EMME). The project is aimed at the assessment of seismic hazard of Pakistan, building vulnerability assessment, and life and economic loss estimate. This work will help in determining the requirements of seismic strengthening of existing buildings. The project is funded through Japan Tobacco International (JTI).

Building vulnerability assessment is carried out by developing fragility curves of existing building typology in Pakistan. A typical example of these curves is illustrated in Fig. 6. The data of building typology were obtained using census data which was carried out in 1998. A summary of building typology in Pakistan is given in Table 2. These curves enable to determine the probability of damage to different buildings against different levels of ground shaking.

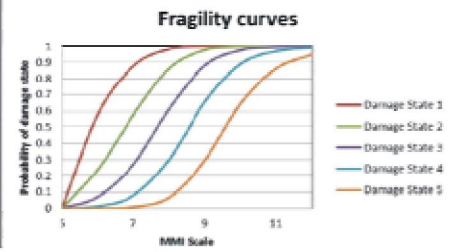


Fig 6: Developed fragility curves for masonry buildings in Pakistan

CONSTRUCTION MATERIAL USED IN	HOUSING UNITS BY PERIOD OF CONSTRUCTION (IN YEARS)					HOUSING UNITS	
	UNDER CONSTRUCTION	LESS THAN 5	5-10	MORE THAN 10	TOTAL	PERCENT	
1	2	3	4	5	6	7	
<b>OUTER WALLS</b>							
BAKED BRICKS /	85,635	1,582,654	2,287,821	5,030,234	8,986,344	57.81	
UNBAKED BRICK	34,817	911,030	1,353,379	1,204,125	5,523,351	35.41	
WOOD / BAMBU	11,635	267,465	213,817	347,552	840,469	5.4	
OTHERS	4,085	58,230	49,817	132,972	245,104	1.57	
<b>ROOFS</b>							
BCC / RBC	41,700	552,650	748,942	1,589,379	2,933,671	18.81	
CEMENT / IRON	33,158	487,884	533,100	1,048,739	2,013,871	12.91	
WOOD / BAMBU	80,785	1,595,918	2,386,524	5,411,598	9,374,825	59.85	
OTHERS	12,539	282,925	355,263	665,177	1,315,904	8.44	
<b>TOTAL</b>	<b>138,182</b>	<b>2,639,381</b>	<b>3,984,629</b>	<b>8,714,883</b>	<b>15,597,255</b>	<b>100</b>	
<b>PERCENT</b>	<b>0.89</b>	<b>18.7</b>	<b>25.04</b>	<b>55.87</b>		<b>100</b>	

Table 2. Housing classifications of Pakistan available in 1998 census report

Another component of the project is to conduct city scenario for Karachi. This component focuses on developing better understanding about seismic threats to Karachi and their possible consequences. This would enable the city authorities to carry out better planning for the City. One of the towns in the City (Gulshan-e-Iqbal Town) was selected as a pilot study and physical survey was conducted to obtain the information on buildings and population. The data of life line inventories for the City was obtained from different authorities. A geographical information system (GIS) has been developed for the aforementioned information (Fig. 7).

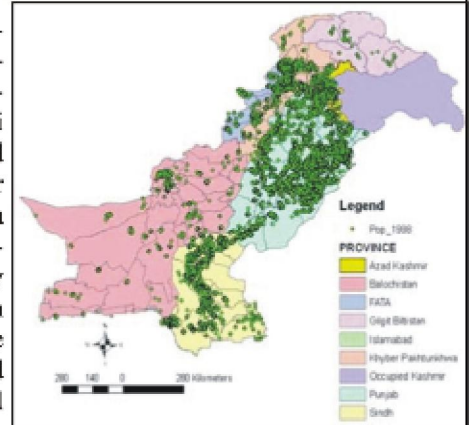


Fig 7. Spatial combination of administrative map with populated region map for Pakistan (Source: 1998 census report)

### A Case Study on Pakistan's Built Environment

A study project related to the development of inventory/database of housing typologies of Pakistan has been recently started by the Department of Earthquake Engineering. The aim of this project is to document detailed information on the built environment of Pakistan (Fig. 8). This may help in carrying out studies related to determining seismic vulnerability of buildings. The information can then be incorporated in the World Housing Encyclopaedia.



Fig 8. Vernacular house in Thar

Furthermore, the collected data will provide details of not only the construction materials but also the methodologies adopted in different parts of Pakistan. Based on the information, environmental impact assessment can be carried out in future to determine the influence of these construction related factors on the natural environment of Pakistan.

The outcome of the study will highlight the construction practices throughout Pakistan. This would help various agencies such as governmental organizations, NGO's and legislating bodies in carrying out policy making decisions, infrastructure management programme and future planning for built environment.

### 3<sup>rd</sup> General Assembly of Earthquake Model for Middle East (EMME)

The meeting for the 3<sup>rd</sup> General Assembly of Earthquake Model for Middle East (EMME) was held in Istanbul on 28-30 March 2012. Prof. Sarosh Hashmat Lodi, Dr. Mukesh Kumar and Mr. Naveed Alam attended the meeting (Fig. 9).



Fig 9. Mr. Naveed Alam presenting his work towards fragility curves for different building topologies of Pakistan

The annual meeting was held in order to discuss the current status of work of all the countries involved in EMME project. Discussion of strategies to resolve problems in the work and setting future goals was also part of meeting agenda. Dr. Mukesh Kumar and Mr. Naveed Alam presented the work progress on behalf of Pakistan.



## Training Workshop for HEC-USAID Project *Vulnerability Assessment of Buildings Subjected to Earthquake*

One of the components under HEC-USAID Project entitled Vulnerability Assessment of Buildings Subjected to Earthquake (see details on Page 2) was to develop a team of master trainers who are able to disseminate knowledge to others in their organizations. In this context, series of workshops were organized from time to time. The last three workshops under this project were held in Muzaffarabad, Gilgit and Gawadar.

The topics included in these workshops included earthquake basics, earthquake risk in Pakistan, historical earthquakes and the seismicity of Pakistan and vulnerability assessment and mitigation for both structural and non-structural elements of buildings. The participants also took part in a seismic vulnerability assessment exercise of the building in which the workshop took place.

The workshop at Muzaffarabad was organized on 6-8 July 2011. Prof. Dr. Sahibzada Farooq Ahmad Rafeeqi, Prof. Sarosh Lodi, Prof. Muhammad Masood Rafi, Prof. Dr. Rashid Ahmed Khan, Mr. Aslam Mohammed and Ms. Najmus Sahar Zafar were the speakers in this workshop (Fig. 10). Nearly 60 participants, including consulting engineers, builders, and officials from civic agencies, participated in this programme.

The workshop in Gawadar was held on 16-17 November 2011 whereas the workshop in Gilgit was organized on 23-24 November 2011. National Disaster Management Authority (NDMA), Pakistan collaborated in both programmes with the NED University. Prof. Sarosh Lodi, Prof. Muhammad Masood Rafi and Prof. Jabbar Sangi were the speakers in these workshops.



**Fig 10. Group photo of the participants and speakers with the chief guest**

### GIS-based Building Inventory and Building Vulnerability Assessment Survey of Gulshan-e-Iqbal Karachi

Students from these three Departments participated in the programme. The programme was designed to gather data of building typology from field surveys in the Gulshan-e-Iqbal town in Karachi (Fig. 11). This exercise was conducted in relation to the project entitled Earthquake Model for Middle East (see details on Page 3). The data was subsequently employed in carrying out seismic vulnerability analysis of buildings.

During the internship programme, the students carried out hands-on exercise related to geographic information system (GIS) mapping. The gathered data of buildings were also digitized in the GIS by the students.

An internship programme was offered during the month of June 2011 to the students of Civil Engineering, Urban and Infrastructure Engineering and Architecture and Planning Department at NED University. Thirty five (35) students from these three Departments participated in the programme.



**Fig 11. Students with the supervisors involved in survey of buildings in Gulshan-e-Iqbal**

### Preparedness for Tsunami and Coastal Hazard Risk Reduction Workshops

National Disaster Management Authority (NDMA) in collaboration with United Nations Development Programme (UNDP) has initiated a project entitled "Strengthening Tsunami Early Warning System in Pakistan". This project aims at assisting the Government of Pakistan in strengthening its tsunami and other ocean-related hazards warning systems. It also emphasizes on the preparedness for disaster risks of the most vulnerable coastal communities of Pakistan.

A two-day training workshop on "Preparedness for Tsunami and Coastal Hazard Risk Reduction" was conducted under this project on 27-28 October 2011 at the Department of Civil Engineering, NED University of Engineering & Technology.



**Fig 12. Group photo of speakers and participants**

A total of 56 participants from various organizations and government departments in the districts of Gwadar, Lasbela, Badin, Thatta and Karachi participated in the workshop (Fig. 12). The objective of the workshop was to orient the participants about the basic concepts and issues of tsunami and other coastal hazards in the districts of Sind and Baluchistan. It was also aimed at imparting requisite skills in the participants that will enable them to plan and execute disaster management activities in order to strengthen early warning system in their areas.

#### RESOURCE PERSONS:

- Prof. Dr. Sahibzada F A. Rafeeqi
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