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NED UNIVERSITY OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING

Cowasjee Earthquake Study Centre
NED
NEWSLETTER

Earthquakes Cause Damages in Pakistan, Iran, Japan and Morocco

Pakistan, Iran, Japan and Morocco were severely hit by earthquakes. These earthquakes caused deaths, injuries and large scale damages. A report of earthquakes in these countries is as under:

Pakistan

Parts of the NWFP, Azad Kashmir and Islamabad were struck by an earthquake on February 14, 2004. The magnitude of this earthquake was measured as 5.7 on Richter scale. The main shock was followed by an after shock measuring 5.5 on Richter scale.

Fig. 1 Epicentral Region of Earthquake (Source: BBC News)

The epicenter of this earthquake was 200 kilometers (125 miles) northeast of Peshawar (Fig. 1). The border region where Pakistan, Afghanistan and India meet has some of the world's highest mountains and experiences periodic earthquakes. The earthquakes on February 14 killed 24 people and 40 others were injured. Victims were killed either by collapsing buildings or landslides on the roads. The earthquakes caused damages to about 206 houses. Out of these 6 structures collapsed completely and about 200 were partially damaged.

Both tremors badly hit snow-clad Kaghan Valley, Knosh and Bhogarmang valleys of the Mansehra district and Allai tehsil of Batgram and were felt in several cities of the northern regions, in Islamabad and parts of Azad Kashmir.

Heavy snowfall and landslides in the Kaghan valley blocked the main road and relief efforts in the area were badly hampered.

Morocco

A strong earthquake occurred in near north coast of Morocco on February 24, 2004. The magnitude of this earthquake was recorded as 6.4 on Richter scale. The earthquake occurred near the eastern end of the Rif mountain belt, which is part of the diffuse boundary between the African and Eurasian plates. This quake occurred near the epicenter of the May 26, 1994, magnitude 6.0 Al Hoceima earthquake that injured one person and caused significant damage to adobe buildings. According to USGS spokesman Butch Kinerney, the earthquake's epicentre was in the Strait of Gibraltar separating Morocco and Spain and there had been hundreds of small tremors in the Morocco since 1990.

A magnitude of 6.0 can cause severe damage. The earthquake on February 24 is the worst quake to rock Morocco in more than 40 years. Morocco's worst recorded quake was in 1960. It destroyed the southern Atlantic city of Agadir, killing 15,000 people. In Al Hoceima, residents were reported to have jumped out of their beds and rushed into the streets when the earthquake struck.

The earthquake killed 628 persons and 405 people were injured in the Al Hoceima region. Many of the deaths were around

(Continued on Page 2)

Moroccan people clearing rubble with their bare hands following an earthquake in the town of Al Hoceima (Source: Reuters)

EDITORIAL

The first issue of Volume 4 of CESNED NEWSLETTER marks the completion of 3 years. While we have kept our promise to keep you well informed about earthquake happenings all around the globe, along with regular feature of Earthquake Mitigation, we have yet to receive any contribution from the reader.

Aspects of mitigation would have taken a new look if professionals working in earthquake prone areas would have contributed. We, however, in a subtle way have shifted slightly to discuss the issues at home, which should come to notice. Non-engineered construction in most of our rural area and partly engineered in the urban areas are the major threat to most of our cities. A joint effort of planners, constructors, civic agencies and civil society is needed to mitigate earthquake hazards.

Editor

Earthquakes Cause Damages ...

(Continued from Page 1)

the city of Al Hoceima. Other deaths were reported in nearby, remote

Inside this issue:

Earthquakes during October 2003 and April 2004

The earthquakes that occurred during October 2003 and April 2004 are shown in Fig. 1. Detail of these quakes and the fatalities caused are summarized in Table 1.

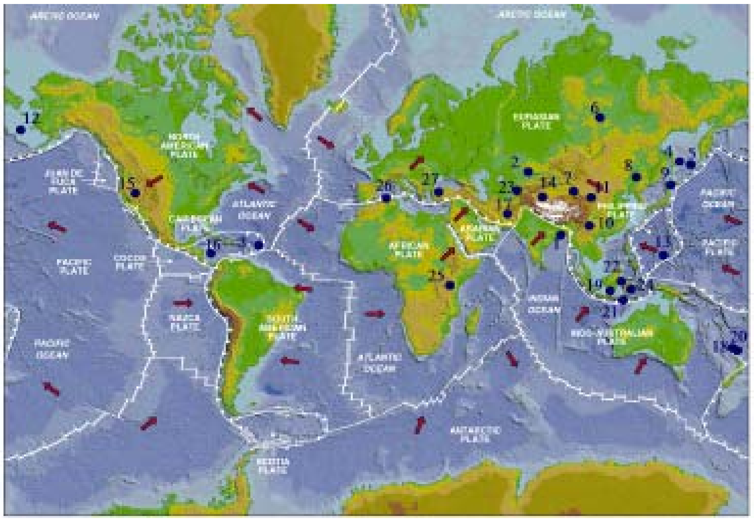


Fig. 1 Location of earthquakes during October 2003 and April 2004

inland villages in Rif Mountains. Residents in rural areas such as Tazaghin, Tizi Ayash and Imzourn live mainly in mud huts that could not withstand such a powerful earthquake. Villages around Al Hoceima were, therefore, badly damaged.

An after shock of magnitude 4.1 on Richter scale also hit near Al Hoceima the same day. The earthquake was felt across much of southern Spain. However, no damage or injuries were reported. According to news reports, it was most noticed in tall apartment blocks of southern Andalucia and southeast Murcia. The quake was also felt in the Spanish North African enclave of Melilla.

Japan

Initial reports of a strong earthquake of magnitude 8.3 on Richter scale that hit Hokkaido, Japan on September 25, 2003 were included in the Issue 2 Volume 3 of Newsletter. The earthquake was followed by many aftershocks and other minor earthquakes. Details of these are as under:

The earthquake on September 25, 2003 occurred at about 60 Km offshore. The danger would have been on a much large scale had this earthquake occurred directly beneath a populated region. It has been suggested that the earthquake occurred as a result of thrust-faulting on the plate interface between the overriding North American plate and the subducting Pacific plate. The Pacific plate is moving west-northwest at a rate of about 8.2 cm per year relative to the North American plate. Hokkaido experiences great thrust earthquakes that originate on the interface between the plates. In addition to these, eastern Hokkaido also experiences great earthquakes that originate from the interior of the subducted Pacific plate. It appears that the recent earthquake has involved rupture of the same section of plate interface that ruptured in 1952.

Aftershocks kept jolting the region and 13 aftershocks were felt till December 29, 2003. However no further damage was recorded.

Iran

An earthquake measuring 6.6 on the Richter scale struck southeastern Iran's Kerman Province on December 26, 2003. The epicenter of the earthquake was near the city of Bam which is 180 km southeast of the provincial capital of Kerman and 975 km southeast of Tehran. Fig.2 shows the view of Arg-e-Bam before and after earthquake on February 26. The earthquake brought a

(Continued on Page 4)

Table 1 Recorded Earthquakes and Associated Fatalities

S. No	Date	Magnitude	Latitude	Longitude	Depth (km)	Region	Fatalities
1	2003/07/26	5.6	22.854	92.306	10	India-Bangladesh Border	2
2	2003/08/16	5.4	43.770	119.643	24	Eastern Mongol China	4
3	2003/09/22	6.5	19.777	70.673	10	Dominican Republic	3
4	2003/09/25	8.3	41.815	143.910	27	Hokkaido, Japan	
5	2003/09/25	7.4	41.774	143.593	33	Hokkaido, Japan	
6	2003/09/27	7.3	50.038	87.813	16	Southwestern Siberia, Russia	3
7	2003/10/16	5.6	25.954	101.254	33	Yunnan, China	3
8	2003/10/25	5.8	38.400	100.951	10	Gansu-Qinghai Border Region, China	9
9	2003/10/31	7.0	37.830	142.629	10	Off the East Coast of Honshu, Japan	
10	2003/11/13	5.1	34.712	103.834	10	Gansu, China	1
11	2003/11/14	5.0	27.372	103.971	33	Sichuan-Yunnan-Guizhou Region, China	4
12	2003/11/17	7.8	51.146	178.650	33	Rat Islands, Aleutian Islands, Alaska	
13	2003/11/18	6.5	12.025	125.416	35	Samar, Philippines	1
14	2003/12/01	6.0	42.905	80.515	10	Kazakhstan-Xinjiang Border Region	11
15	2003/12/22	6.5	35.706	121.102	8	Central California	2
16	2003/12/25	6.5	8.416	82.824	33	Panama-Costa Rica Border Region	2
17	2003/12/26	6.6	28.995	58.311	10	Southeastern Iran	43,200
18	2003/12/27	7.3	-22.033	169.65	10	Southeast of the Loyalty Islands	
19	2004/01/01	5.8	8.310	115.78	45	Bali Region, Indonesia	1
20	2004/01/03	7.1	-22.253	169.683	22	Southeast of the Loyalty Islands	
21	2004/02/05	7.0	-3.615	135.538	17	Papua, Indonesia	37
22	2004/02/07	7.3	-4.007	138.998	10	Papua, Indonesia	
23	2004/02/14	5.5	34.77	73.209	11	Pakistan	24
24	2004/02/16	5.3	0.428	100.666	33	Southern Sumatra, Indonesia	5
25	2004/02/24	4.8	3.400	29.572	10	Burundi	3
26	2004/02/24	6.4	35.203	4.008	13	Near North Coast of Morocco	628
27	2004/03/01	3.8	38.058	38.277	5	Eastern Turkey	6
						Total	43,949

Earthquakes Cause Damages ...

(Continued from Page 2)

major calamity to the ancient city Bam. It leveled most of the ancient city, includ-

Aspects of Mitigation

While the main factors that contribute to the initiation and severity of damage were dealt with in Issue 2, Volume 3 of the Newsletter, typical damage and failure mechanism shall further be elaborated in this issue.

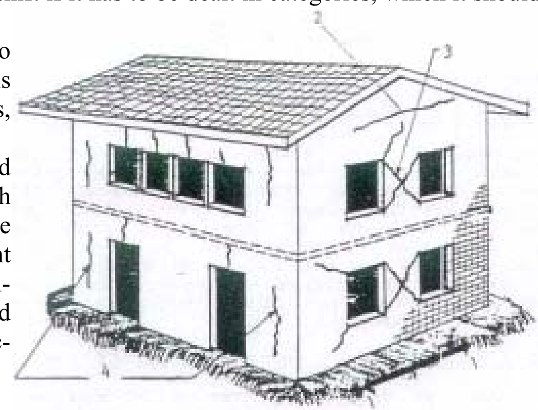
Damage to the building and the possible failure mechanism is dependent on the type of building, material used and the way the building elements are connected with each other. This discussion, therefore, needs a bit of a shift if it has to be dealt in categories, which it should, however, presently it is being treated in rather a general manner.

A typical crack pattern may be observed in shear wall at corners of openings due to unfavourable force distribution and concentration of stresses, Fig.1. This example is sufficient to emphasize upon a need of detailing of openings in rural dwellings, where such systems are prevalent.

Rural construction in most parts of the third world is marked by its large dead weights, both for walls and for roofs. Such construction while may be good enough for gravitational forces, have to pay a heavy toll when it comes to the earthquake forces, as it generates high seismic forces which increases with weight and the height at which they occur. As most of the materials used do not possess the desired ductility, the destruction leads to fatalities. Recent earthquakes in Iran, Turkey, India and Northern areas of Pakistan are a testimony to the vulnerability of such a construction.

The common modes of failure of such load bearing walls may be as follows:

a) For an adobe or stonewall construction as shown in Fig. 2, random rubble masonry walls may completely shatter away and would pile up in a heap of stone. This would happen when the mortar is weak or spaces in between the stones are not completely filled, lack of through stones within the thickness of wall and inadequate connection at corners of the wall. If the above is adequately taken care of, the failure may be initiated by the failure of the roof as shown in Fig. 3 and Fig. 4.



1-1 Earthquake motion 2- Horizontal cracks in gables 3- Diagonal cracks due to shear 4- Cracks due to bending of wall

Fig. 1 Cracking in bearing wall building due to bending and shear (after A Manual of Earthquake Resistant Non-Engineered Construction, published by National Center for Earthquake Engineering (NICEE)).

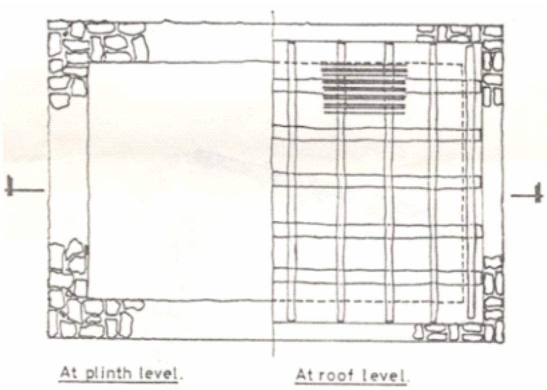


Fig. 2a Plan of adobe or stone wall construction (After Dr. Tariq Rafey)

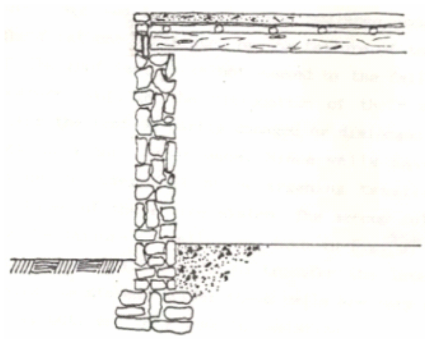


Fig. 2b Section of adobe or stone wall construction (After Dr. Tariq Rafey)

This failure is not caused by the failure of the spanning roof members, but by the dislocation of their connections at support. Once the diaphragm action of the roof after dislocation of the connection is lost, the partly failed, damaged, or dislodged roof, leave the walls to act as isolated cantilevers, and as they possess very small flexural resistance, they fail by enlarging tensile cracks, causing the collapse of the entire system, Fig. 5. This mode of failure is characteristic of massive flat roofs (or floors) supported by joints that in turn are supported by bearing walls, but without proper connection with them. Also if connection

(Continued on Page 4)
Aspects of Mitigation

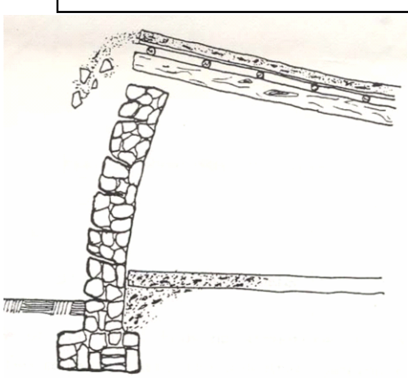
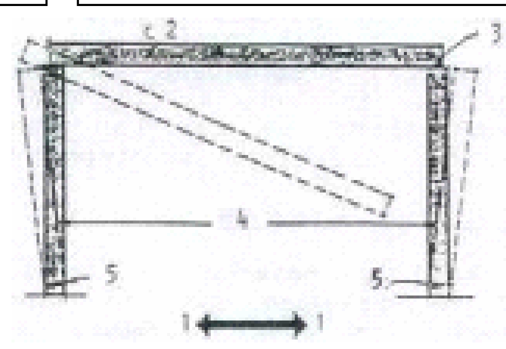


Fig. 3 – Cantilever Wall Collapse Mode (After Dr. Tariq Rafey)



1- Earthquake motion 2- Flat joisted roof 3- Frictional support, no connection 4- Out of phase motion 5- Crack

Fig. 4 – Fall of roof because of Inadequate connection between roof and wall *(after A Manual of Earthquake Resistant Non-Engineered Construction, published by National Center for Earthquake Engineering (NICEE)).*

(Continued from page 3)
with foundation is not adequate, the walls crack there and may slide.

Dr. Syed Tanvir Wasti, Professor, METU Turkey while discussing safety of rural houses in Pakistan, has identified that in Sind, Baluchistan and Punjab, rural housing is basically of two types: adobe buildings or brick masonry construction. Adobe buildings include structures of unburnt brick with mud mortar, rammed earth, and buildings of stone in a mud matrix, i.e. all types of earthen architecture, usually with a mud-plastered roof. A typical rural adobe dwelling is as shown in Fig. 6.

Brick masonry construction uses burnt brick with lime or cement mortar resulting in moderately well designed buildings with flat concrete slab roofs.

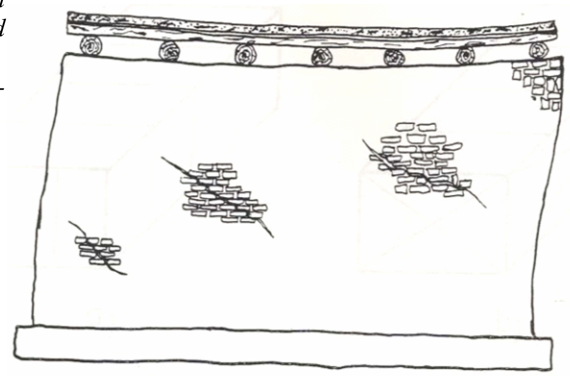


Fig. 5 – Shear Wall Collapse Mode (After Dr. Tariq Rafey)

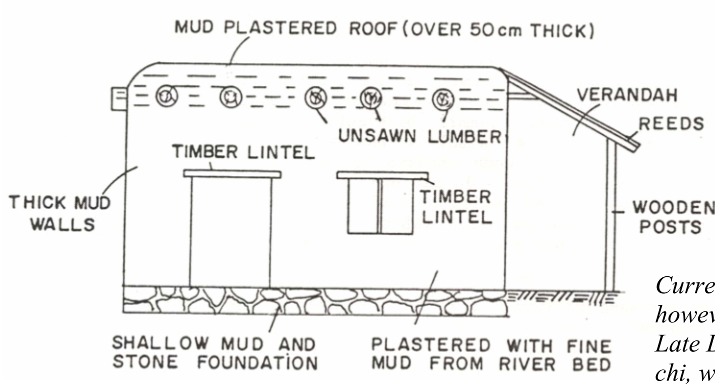


Fig. 6 – Rural Adobe Dwelling (After Dr. Tanvir Wasti)

Current methods of construction for both types of rural construction, however, is said to incorporate few if any features for seismic safety.

Late Dr. Tariq Rafay, former Chief Structure Division, NESPAK, Karachi, while elaborating the construction techniques in rural housing to improve resistance to seismic forces, reported that materials used for rural housing in northern areas of Pakistan consists primarily of stone, wood and mud plaster. These materials are locally available while the manufactured building materials such as cement and steel, which have to be transported from outside, over long distances, and, over tortuous routes, become too expensive. The construction techniques presently employed are quite adequate for gravity loads, but are poor for lateral forces. The walls and the roofs are thick and heavy, thereby leading to generation of large lateral forces even during moderate earthquake, to be resisted by structures lacking seismic resistance.

K. Mahmood, Z. Mian and S. T. Wasti, while discussing the design and construction needs for rural structures, emphasized that the prevalent methods of rural construction in Pakistan results in houses and farm structures that are often primitive and afford little protection from natural hazards. Because of poor construction methods and absence of planning, the whole pattern of rural settlement in Pakistan is unsatisfactory. All dwellings need frequent repairs because of crack formation and other damages. Very few rural dwellings can resist earthquakes, floods or other natural disasters and are usually build afresh by the villagers in the same traditional manner. This often results in a dwelling that is structurally even more unsound than the one destroyed.

The above references have been made part of this regular feature of the Newsletter, just to emphasize the need of identifying the responsibility that the engineers and planners have to play regarding mitigating efforts. It is not only the basic understanding of the phenomenon of earthquake, its resistance offered by the designed structure, but also the understanding of the socio-economic factors, engineering prop-

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ing the Arg-e-Bam, or Citadel of Bam, the world's largest mud-brick fortress. According to an estimate

Fig 2. The historic site of Arg-e Bam before and after earthquake (Source: International Institute of Earthquake Engineering and Seismology, Iran)

by the Government of Iran, 85 per cent of buildings have been destroyed in Bam and the surrounding area. This has left about 45,000 to 75,000 people homeless in Bam. The earthquake also killed more than 43,000 people and injured 30,000.

RESOURCE PERSONS:

- Prof. Dr. S. F. A. Rafeeqi
- Prof. S. H. Lodi

Mail: Cowasjee Earthquake Study Centre NED
Department of Civil Engineering,
NED University of Engg. and Tech.,
Karachi-75270,
Pakistan.
Phone: 92-21-924 3262-68 Ext. 2205 & 2223
Fax: 92-21-924 3255
Email: cesned@neduet.edu.pk
Web page: www.neduet.edu.pk

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