Volume 3, Issue 2

OCTOBER 2003
BI-ANNUAL

NED UNIVERSITY OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

COWASJEE EARTHQUAKE STUDY CENTRE NED NEWSLETTER

Inside this issue:

EDITORIAL

Since the first issue of Volume 3 of the Newsletter quite a few countries of the world have received repeated blows of earthquake. China specially has been hit almost thrice and eventually has to pay in terms of lives and money. One can arrive only at one conclusion that the mitigating efforts are the only answer to this natural disaster.

CESNED is keeping up tradition of providing its readers not only with latest updates but also article on aspects of mitigation, which are all the more important for countries like Pakistan, where rural construction specially in earthquake prone regions needs special attention. It is hoped that this effort should bring some change in the attitude of builders and planners.

As always it would again be emphasized that CESNED is looking forward for any contribution in terms of articles and/ or news from its valuable readers. We at CESNED are also considering opening up a National Debate in these pages on "Constructional practices and aspects in earthquake prone regions of Pakistan". Your consent in this regard is eagerly awaited.

Editor

Earthquakes hit China, Turkey and Iran.

China, Turkey and Iran remained preoccupied with series of Earthquakes that hit these countries in the last 6 months resulting in deaths, injuries and damage to houses and the economy:

China:

The first of the series hit Qinghai region on April 17, 2003. The magnitude of this earthquake was recorded as 6.4 on Richter scale. The earthquake made extensive damage to about 45 homes and slight damage to 1,000 homes. It was felt at Golmud and Xining as well.

Another earthquake of magnitude 5.6 on Richter scale struck southern Xinjiang on May 04, 2003. At least one person was killed and three were injured. The earthquake also toppled 1,600 homes.

The next earthquake hit Yunnan on July 21, 2003. The magnitude of this earthquake was recorded as 6.0 on Richter scale. The earthquake killed one person, injured eight others and affected nearly 170,000 people. The earthquake destroyed 3,300 rooms, killed 59 animals and seriously damaged local water conservation facilities, transportation, communication and other infrastructure, resulting in more than 300 million Yuan (US$36.14 million) in economic losses.

On August 18, 2003 an earthquake of magnitude 5.6 on Richter scale struck Xizang (Tibet) - India border region. The earthquake injured at least two people and several homes were reported to have been destroyed in Jiashi County.

The most recent earthquake hit southern Xinjiang on September 01, 2003. The magnitude of this earthquake was recorded as 5.7 on Richter scale. The damage assessment of this earthquake is still awaited.

Turkey

An earthquake of magnitude 6.4 on Richter scale hit Bingol area in Turkey on May 01, 2003. Bingol is a city of 250,000 inhabitants. The earthquake lasted 17 seconds killing about 100 to 150 people and injuring 1,000 others. Most of these killings were due to the collapse of a school dormitory. At least 25 buildings and a bridge collapsed in Bingol, while the earthquake damaged several power and telephone lines in the area. More than 100 aftershocks hit the region. The tremor was also felt in the nearby provinces of Erzincan, Tunceli, Erzurum, Kayseri and Sivas.

Turkey is a tectonically active region that experiences frequent destructive earthquakes. At a large scale, the tectonics of the region near the recent earthquake are controlled by the collision of the Arabian Plate and the Eurasian Plate (Fig. 1). At a more detailed level, the tectonics become quite complicated. A large piece of continental crust almost the size of Turkey, called the Anatolian block, is being squeezed to the west. The block is bounded to the north by the North Anatolian

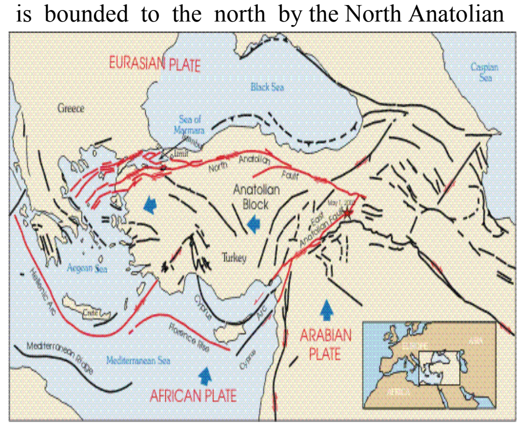

Fig. 1 Plate boundaries of Turkey (Source: ww.usgs.org)

Fault and to the south-east by the East Anatolian fault. The recent earthquake occurred near the east end of the East Anatolian fault. The faulting in the region is very complicated and extensive, however, this earthquake may have been the result of rupture on the northeast trending East Anatolian Fault or it may have occurred on the northwest trending Bingol Karakocan fault zone.

This earthquake occurred 70 km southeast of the region, which was struck by an earthquake of magnitude 6.1 on January 27, 2003 that killed one person and injured several in the Pulumar area. May 1, 2003 earthquake occurred within or near the source region of the magnitude 6.6 earthquake

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Deaths from Earthquakes in 2003

Date UTC	Region	Magnitude	Number Killed
2003/01/21	Near the Coast of Guatemala	6.5	1
2003/01/22	Colima, Mexico	7.8	29
2003/01/27	Turkey	6.1	1
2003/02/24	China	6.4	257
2003/05/01	Eastern Turkey	6.4	177
2003/05/04	Southern Xinjiang, China	5.8	1
2003/05/21	Northern Algeria	6.8	2266
2003/05/26	Halmahera, Indonesia	7.0	1
2003/05/27	Northern Algeria	5.8	9
2003/06/24	Western Iran	4.6	1
2003/07/10	Southern Iran	5.7	1
2003/07/21	Yunnan, China	6.0	16
2003/07/26	India-Bangladesh Border Region	5.6	2
Total			2762

Source: *www.usgs.org*

A strong earthquake hits Hokkaido, Japan

An earthquake of magnitude 8.3 on Richter scale hit Hokkaido, Japan on September 25,2003. According to initial reports at least 400 people were injured. The earthquake caused extensive damages, landslides and power outages. Many roads were also damaged in southeastern Hokkaido. The earthquake generated a tsunami with an estimated wave height of 1.0 meter along the southeastern coast of Hokkaido. The earthquake was also felt in Tokyo. The strongest recorded earthquake was a magnitude 8.4 that occurred near the coast of Peru on June 23, 2001. Detail report of this earthquake and damages will be included in the next issue of Newsletter.

Earthquake hit China...

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of March 13, 1992, which killed hundreds of people and left thousands homeless in Erzincan.

Iran

An earthquake of magnitude 5.0 on Richter scale hit southern Iran on July 06, 2003. No reports to date, however, is available regarding casualties or damages.

On July 11, 2003 two earthquakes of magnitudes 5.6 and 5.8 on Richter scale hit southern Iran and were followed by 15 aftershocks. The earthquakes struck the villages of Dareh Shur, Deheh No, Debehran, Darva and Shahre Pir, all located around Hajjiabad, a small town in Fars province, located some 200 kilometers southeast of the city of Shiraz and approximately 800 kilometers south of the capital Tehran. One person was killed and 25 others were injured. The earthquakes damaged power and telephone lines, disrupted water supplies and destroyed a police outpost in the village of Deberan.

The next earthquake struck southern Iran on August 4, 2003. The magnitude of earthquake was measured as 5.5 on Richter scale. The earthquake struck the district of Bam, southeast of the city of Kerman. No major damage or casualties were reported as the area was thinly populated.

Another earthquake of magnitude 4.2 struck southern Iran on August 5, 2003. No news of casualties is available.

On August 21, 2003 a strong earthquake of magnitude 5.7 on Richter scale rocked the southeastern Iranian city of Bam. Reports on damage assessment are still awaited.

Recorded Earthquakes of Magnitude 7.0 and Greater in 2003

	Year	Month	Day	Time UTC	Latitude	Longitude	Depth (km)	Magnitude	Region
1	2003	1	20	08:43:06.6	-10.40	160.75	33	7.3	Solomon Islands
2	2003	1	22	02:06:33	18.76	-103.84	24	7.8	Colima, Mexico
3	2003	5	26	09:24:32.9	38.901	141.446	68	7.0	Near the East Coast of Honshu, Japan
4	2003	5	26	19:23:28.2	2.406	128.811	33	7.0	Halmahera, Indonesia
5	2003	6	20	06:19:38.9	-7.606	-71.722	558	7.1	Amazonas, Brazil
6	2003	7	15	20:27:50.2	-2.562	68.300	10.0	7.6	Carlsberg Ridge
7	2003	08	04	04:37:20.0	-60.555	-43.492	10.0	7.5	Scotia Sea
8	2003	08	21	12:12:50	-45.18	167.12	33.0	7.2	South Island of New Zealand

Source: *www.usgs.org*

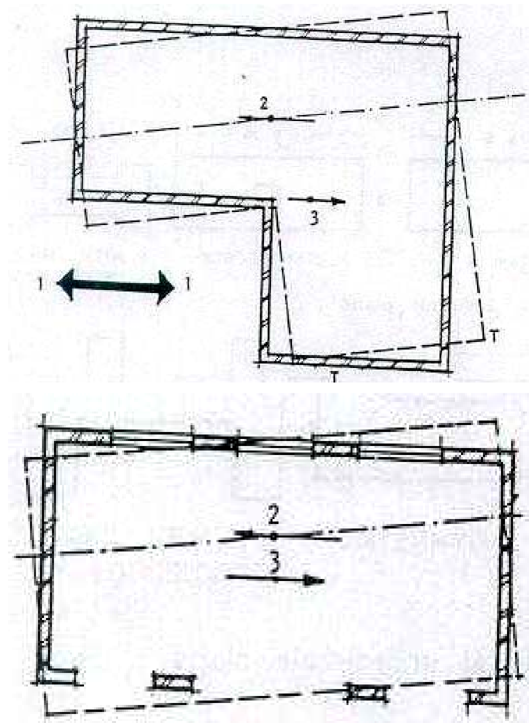
Aspects of Mitigation

The issue 1 of Volume 3 of the Newsletter was left on the note that the categories of damage and factors, which contribute to the initiation and severity of the damage shall be considered.
The damage to the structural elements or to the structure as a whole depends on the magnitude of the horizontal inertia forces, and on mass, local geology and soil conditions, while the resistance available is dependant on the material and cross-sectional properties inclusive of ductility and damping. The structural system redundancies, continuity and symmetry also contribute towards resistance.
The general categories of damage can well be classified as given in Table 1, and seems to be suitable for guidance of post earthquake actions to be undertaken (The contents of the Table are taken from “A Manual of Earthquake Resistant Non-Engineered Construction, published by National Information Center for Earthquake Engineering (NICEE), a very useful guide for non-engineered construction).
The factors, which contribute to the initiation and severity of damage, can be categorized as follows:

Table 1. Categories of Damage

Damage Category	Extent of Damage In General	Suggested Post- Earthquake Actions
0 No damage	No damage	No action required
I Slight Non-Structural Damage	Thin cracks in plaster, falling of plaster bits in limited parts.	Building need not be vacated. Only architectural repairs needed.
II Slight Structural Damage	Small cracks in walls, falling of plaster in large bits over large areas; damage to non-structural parts like chimneys, projecting cornices, etc. *The load carrying capacity of the structure is not reduced appreciably.*	Building need not be vacated. Architectural repairs required to achieve durability.
III Moderate Structural Damage	Large and deep cracks in walls; widespread cracking of walls, columns, piers and tilting or falling of chimneys. *The load carrying capacity of the structure is partially reduced.*	Building needs to be vacated, to be reoccupied after restoration and strengthening. Structural restoration and seismic strengthening are necessary after which architectural treatment may be carried out.
IV Severe Structural Damage	Gaps occur in walls; inner and outer walls collapse; failure of ties to separate parts of buildings. Approx. 50% of the main structural elements fail. The building takes dangerous state.	Building has to be vacated. Either the building has to be demolished or extensive restoration and strengthening work has to be carried out before reoccupation.
V Collapse	A large part or whole of the building collapses.	Clearing the site and reconstruction.

1. <u>Structural Configuration</u>
In seismic areas special consideration should be given to the structural configuration and ideally it should be simple and symmetrical in plan and elevation. Structures with relatively simple form and symmetry usually have the lowest requirements for elaborate and extensive bracing and/or for complex connections for lateral loads. Unsymmetrial buildings develop additional shearing forces due to twisting and warping as shown in Fig. 1.



1. Earthquake force 2. Centre of stiffness or resisting force 3. Centre of gravity or the applied inertia forces 4. Twisted building

Fig. 1. Torsion of unsymmetrical plans (After A Manual of Earthquake Resistant Non-Engineered Construction, published by National Information Center for Earthquake Engineering (NICEE)).

The unsymmetry produces an eccentricity between centre of mass (where applied forces act) and centre of stiffness (where resistive forces act). On the same principle, a sudden change in mass and/ or stiffness tends to develop unfavourable distribution and concentration of stresses, which may be difficult not only to calculate but also to provide required resistance. Unsymmetricallly placed openings also pose the same difficulty. The discontinuity of any form i.e either of stiffness arising from changed cross sections or materials also lead to stress concentration and difficulty in transmitting the horizontal forces to be resisted by stronger elements of the structural system. It is vital, therefore, that the structural system should be devoid of such defects and the structural engineers should, from the very beginning, emphasize on the architects to plan the building such that the structural

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system that is arrived at, should have **Uniformity and Continuous Distribution of Strength and Stiffness.** A structure will have the maximum chance of surviving an earthquake, if a) the load bearing members are uniformly distributed; b) all columns and walls are continuous and without offsets from roof to foundation; c) all beams are free of offsets; d) columns and beams are co-axial; e) columns and beams are nearly the same width; f) no principal members change section suddenly; g) the structure is as continuous and monolithic as possible. Some simple rules for vertical frames in aseismic buildings as shown in Fig 2 may well be utilized for rural buildings. If at all unsymmetry is unavoidable, then seismic joints should be provided between them. Seismic joints are special joints designed to prevent hammering of adjacent dissimilar structures, and depends on the relative displacement of floors known as "Drift".

2. Lack of Ductility

Ductility is an ability of the structure to bend, sway and deform by large amounts before failure. As earthquakes produce lateral forces, which induce such actions, a non-ductile frame would tend to fail suddenly and without offering much resistance due to non availability of ability to deform by large amount. Ductility of structure is primarily achieved by using materials, which themselves are ductile such as steel and wood or by detailing the structural joints by utilizing ductile materials to enhance the ductile performance of structures made from brittle material. Concrete is one such material, which can be made to behave in a ductile manner by properly detailing the sections and joints when reinforcing bars are utilized to transform it into reinforced concrete. Materials weak in tension are bound to be weak in shear, and therefore unreinforced masonry walls commonly used in buildings are highly susceptible to

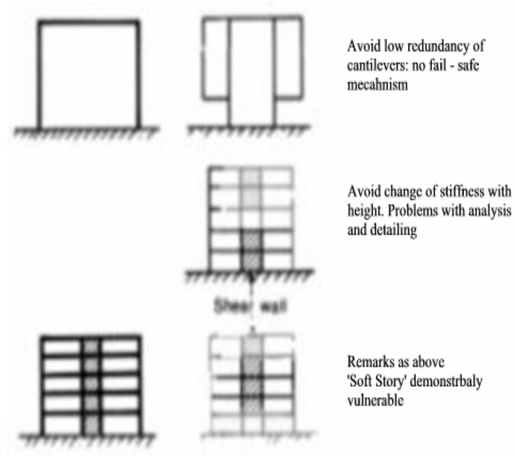

Fig. 2 Simple Rules for Vertical Frames in aseismic Buildings (after Earthquake Resistant Design A Manual for Engineers and Architects by D. J. Dowrick)

damage because of not only being low in tensile and shear resisting capacity but also due to being made of brittle material.

3. Lack of Connections

This aspect has partially been discussed above; however, more discussion is needed for this aspect.

The distribution of seismic forces is shown in Fig. 3. As evident large seismic forces develop at the top levels not only due to heavy concentration of weight there but more due to amplification of ground acceleration at higher levels. If the elements used in the roof or floors are not properly interconnected together and if the large seismic forces are not properly transmitted to the supporting frames or vertical load carrying elements through suitable connections between them, the roof and floors may be damaged severely or collapse completely. The complete collapse or severe damage of frames may be caused by excessive column bending or failure of rigid joints of frame elements i.e insufficient strength of structural elements, lack of connections and inadequate ductility. Similarly, collapse of bearing walls may also be due to failure of connections between wall and wall, wall and roof and walls and foundation. Thus lack of structural integrity is the greatest source of weakness, which should be avoided at all cost.

4. Local geology and Soil Condition

In many earthquakes the local geology and soil conditions have had a profound influence on the structure response. Buildings sometimes fail due to inadequate foundations, which may have otherwise resisted an earthquake. Tilting, cracking and failure of superstructure may result from soil liquefaction, and differential settlement of footing.

Certain types of foundation are more susceptible to damage than others. For example, isolated footings are likely to be subjected to differential settlement. They should, therefore, be connected so as to achieve an integral action. Also, sites with large variations in the subsoil condition should be avoided, where possible. Mixed type of foundations within the same building may also lead to the differential settlement and the resulting damages.

Very shallow foundations may deteriorate because of weathering, particularly when they are exposed to freezing and thawing in the regions of cold climate.

5. Construction Quality

Poor quality of construction, substandard materials and poor workmanship has often been found reasons of most damages in many earthquakes. These may include inadequate skill in understanding and detailing and lack of supervision etc, and which is the prime concern in non-engineered rural construction.

Further elaboration on the failure and damages due to earthquakes shall be made in the next issue of the Newsletter.

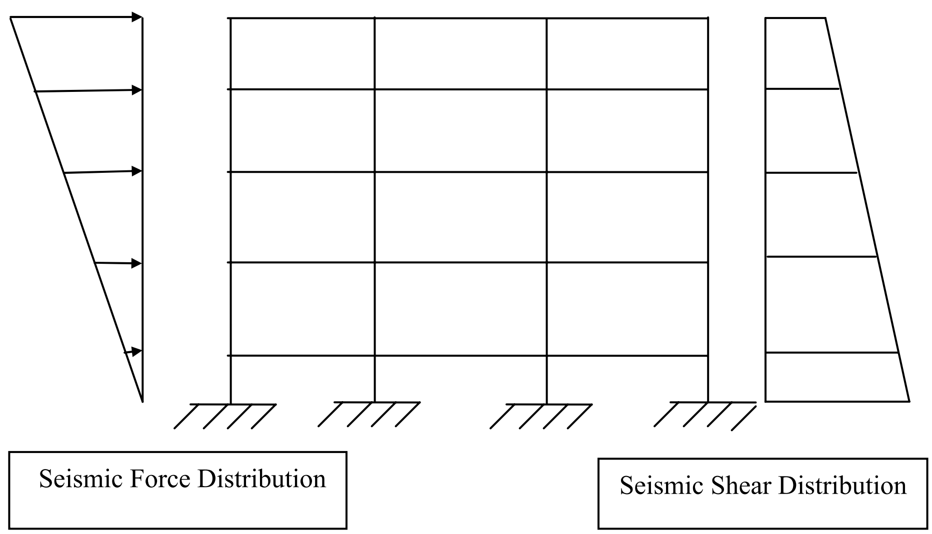

Fig. 3. Distribution of Seismic Forces

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