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NED UNIVERSITY OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF CIVIL ENGINEERING

Cowasjee Earthquake Study Centre NED NEWSLETTER

Iran continues to suffer from earthquakes.

At 4:47 a.m. (IST) on March 31, 2006 an earthquake occurred in the South of Borujerd with several foreshocks, especially on March 30, 2006 with magnitude of 4.6 and at 23:06 on March 30, 2006 with magnitude 5.1, and also with the aftershock at 5:01 a.m. on March 31, 2006 with magnitude 4.9 (Figure 1). It was a major earthquake after a series of moderate earthquakes in the region in the last six months.

According to the latest news reports, 66 fatalities, about 1280 injuries, and damage to 330 villages in the Darb_e_Astaneh (Silakhor) region (surrounding Borujerd and Dorud) have been reported. The occurrence of this earthquake near the main Zagros fault (section of Dorud fault) shows the probability of further activity from this fault (Figure 1). Earlier an earthquake with magnitude of 4.9 occurred on May 3, 2005 – and caused one fatality and great panic among people of this region. The epicenter of the earthquake on March 31, 2006, was in the southeastern epicentral region of the May 3, 2005 earthquake and with a greater magnitude indicates the continuous activity of the current fault plain in the earthquake stricken region. The occurrence of eight earthquakes between May 3-5, 2005 in the Borujerd region, 17 consecutive earthquakes with a magnitude of 2.5-4 between 21- 27 of November, 2004 in the Poldokhtar region and other similar cases all indicate the high seismic activity of this area of the earth's crust.

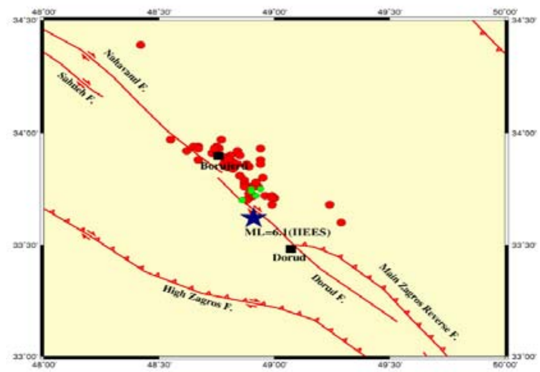

Figure 1: Epicentre of Earthquake

March 25, 2006 Southwest of Bandar Abbas

At 10:58 a.m. local time on March 25, 2006, an earthquake occurred in the region Northwest of Bandar Abbas between Ruydar and Fin having a magnitude of 5.4. Damages to houses and landslides have been reported in the area between Fin and Ruydar.

February 28, 2006, Faryab

At 11:01 (local time) an earthquake with magnitude of 5.9 occurred 85 kilometers southeast of Hajiabad, Hormozgan and 105 km northwest of Kahnooj, Kerman. The village of Ab Bid of Faryab and also the villages of Ahmadi and Bagh Chenar in the epicentral area have been most severely damaged. This earthquake was completely noticeable in the cities of Kerman, Jiroft, Kahnuj, Faryab, Fahraj Soghan, Baft and Manujan.

December 28, 2005 – Hormozghan

At 1:23 (local time) an earthquake with a magnitude of 5.2 on the Richter scale occurred 26 south east of Hajiabad in Hormozghan province. According to the recorded seismograms, this event is located at 28.12 ˚N and 56.07 ˚E.

December 26, 2005- North of Masjed Soleiman

At 2:45 (local time) an earthquake with magnitude of 5.2 on the Richter scale occurred 24 km North of Masjed Soleiman and 28 Km south east of Lali in the province of Khozestan. During the previous month, more than 15 earthquakes have occurred at a radius of 100 km of this earthquake with magnitudes between 2.5 and 4 on the Richter scale.

According to reports from various regions of the town of Lali, there was more than 40 percent damage to 2000 housing, domestic and commercial units of this town.

CESNED holds seminar on Earthquake of October 08, 2005

A seminar was organized in the Department of Civil Engineering in the aftermath of October 08 earthquake on 30th November 2005. Renowned earthquake engineering expert Dr. Tanvir Wasti, Dr. Soofia Ozkan of Middle East Technical University, Turkey and Prof. S.H. Lodi of the Department of Civil Engineering, NED University were the main speakers for the seminar. A large number of leading consultants, engineers, architects, academicians and students participated in the day long interactive seminar.

Inside this issue:

EDITORIAL

The issue in hand of the CESNED newsletter has been published in the aftermath of October 08, 2005 earthquake that struck the northern areas of Pakistan. While the rescue and relief operations seem to be over, still a large number of people are struggling to come to terms with the new scenarios in their lives. The government, international agencies, NGOs and other organizations have done a commendable job, but there is still a lot to be done to rehabilitate the displaced.

CESNED has been doing a bit in its own domain by reaching out to the academicians and experts in the field of earthquake engineering. It organized a seminar immediately after the earthquake, which was addressed by leading experts from Turkey. Since Turkey is one country which has similar geographical and geological features and has been struck by severe earthquakes in the past. An other country that has a wide spread earthquake problem is Japan, where cutting edge research has been done in the area of earthquake engineering and disaster mitigation. In order to learn from their experiences, CESNED has invited leading Professors from Japan for a one day seminar in May 2006.

Editor

Most Destructive Known Earthquakes on Record in the World

Date	Location	Deaths	Magnitude	Comments
1556 01 23	China, Shansi	830000	~8	
2004 12 26	Sumatra	283106	9.0	Deaths from earthquake and tsunami.
1976 07 27	China, Tangshan	255000 (official)	7.5	Estimated death toll as high as 655,000.
1138 08 09	Syria, Aleppo	230000		
856 12 22	Iran, Damghan	200000		
1927 05 22	China, Tsinghai	200000	7.9	Large fractures.
1920 12 16	China, Gansu	200000	7.8	Major fractures, landslides.
893 03 23	Iran, Ardabil	150000		
1923 09 01	Japan, Kanto (Kwanto)	143000	7.9	Great Tokyo fire.
1948 10 05	USSR (Turkmenistan, Ashgabat)	110000	7.3	
1908 12 28	Italy, Messina	70000 to 100000 (estimated)	7.2	Deaths from earthquake and tsunami.
1290 09	China, Chihli	100000		
2005 10 08	Pakistan	80361	7.6	
1667 11	Caucasia, Shemakha	80000		
1727 11 18	Iran, Tabriz	77000		
1932 12 25	China, Gansu	70000	7.6	
1755 11 01	Portugal, Lisbon	70000	8.7	Great tsunami.
1970 05 31	Peru	66000	7.9	$530,000,000 damage, great rock slide, floods.
1935 05 30	Pakistan, Quetta	30000 to 60000	7.5	Quetta almost completely destroyed.
1693 01 11	Italy, Sicily	60000		
1268	Asia Minor, Silicia	60000		
1990 06 20	Western Iran	40000 to 50000	7.7	Landslides.
1783 02 04	Italy, Calabria	50000		

Source: USGS

Earthquake Facts and Statistics

Frequency of Occurrence of Earthquakes

Descriptor	Magnitude	Average Annually
Great	8 and higher	1 [1]
Major	7 - 7.9	17 [2]
Strong	6 - 6.9	134 [2]
Moderate	5 - 5.9	1319 [2]
Light	4 - 4.9	13,000 (estimated)
Minor	3 - 3.9	130,000 (estimated)
Very Minor	2 - 2.9	1,300,000 (estimated)

[1] Based on observations since 1900.
[2] Based on observations since 1990.

Number of Earthquakes Worldwide for 2000 - 2006

Magnitude	2000	2001	2002	2003	2004	2005	2006
8.0 to 9.9	1	1	0	1	2	1	0
7.0 to 7.9	14	15	13	14	14	10	4
6.0 to 6.9	158	126	130	140	141	148	30
5.0 to 5.9	1345	1243	1218	1203	1515	1709	356
4.0 to 4.9	8045	8084	8584	8462	10888	13909	2902
3.0 to 3.9	4784	6151	7005	7624	7932	9153	1928
2.0 to 2.9	3758	4162	6419	7727	6316	4636	761
1.0 to 1.9	1026	944	1137	2506	1344	26	6
0.1 to 0.9	5	1	10	134	103	0	1
No Magnitude	3120	2938	2937	3608	2939	866	177
Total	22256	23534	27454	31419	31194	30458	6165
Estimated Deaths	231	21357	1685	33819	284010	89354	85

Source: USGS

GPS STRATEGY TO MONITOR PLATE MOTIONS NEAR KARACHI

Tectonic Setting

The Karachi region of Pakistan is close to the triple junction that separates the Arabian, Indian and Asian plates. The corresponding plate boundaries are the east-west Makran Subduction Zone (convergence 2-4 cm/yr), the north-south Chaman fault system, a left-lateral transform plate boundary that separates the Indian and Eurasian plates (2-4 cm/year), and the offshore SW trending Owens Fracture Zone (3-9 mm/yr). The width of the region of deformation across the plate boundaries varies from 150 km at their narrowest to more than 500 km elsewhere. The surface geology obscures any simple definition of the triple junction: fold and thrust systems thrust southwards over the Arabian Plate and eastwards over the Indian Plate. The western edge of the Chaman fault system is terminated abruptly by the Chaman fault, whose strike varies from approximately parallel to the NUVEL-1 inferred India/Eurasia slip velocity, to an oblique strike of 20° in a transpressional sense north of Quetta. The fold and thrust belt is most prominently developed where transpression attains its maximum obliquity.

Relative plate motions between India and Eurasia in the past decade show a wide region of distributed deformation north of an apparently rigid Indian Plate moving NE at roughly 47 mm/year (Wang et al., 2001). In contrast to well-determined velocity fields in parts of the Himalaya, there is currently no GPS geodetic control across the Chaman Transform boundary and important questions remain concerning the slip rate between Baluchistan and the Indian plate. If central Baluchistan is part of the Euroasian Plate it is possible that the slip velocity along the Chaman system may be as high as 41 mm/year, yet seismicity in the mountains of northern Afghanistan suggests that some convergence may be occurring there, which would reduce this velocity. It has been suggested (Stein et al. 2001) that the western margin of the Indian plate may be deforming, and may be responsible for historic seismicity in the Rann of Kachchh. This also, were it occurring would reduce the slip rate on the transform boundary. The resulting "flake" could have fragmented the western corner of the Indian plate resulting in seismicity extending eastward from the 1819 rupture toward Karachi.

Quittmeyer and Jacob (1978) estimated plate closure velocities in the region and their estimates, despite being made with early plate motion models cannot be much improved on today. NUVEL-1 estimated relative motions between the Eurasian plate and the Arabian plate south of Baluchistan (27° N, 66°E) are 42.1 mm/yr at 9°E, and between the Indian plate and the Eurasian plate (30°N, 66°E) are 40.2 mm/yr at N5°E. The inferred relative velocity between India and Arabia on the Owens Fracture Zone south of the triple junction near Karachi is less than 2 mm/year at approximately N40°E. Allowing for minor convergence in the Afghan mountains would suggest that the relative velocity between E. Baluchistan and W. India is less than the Eurasia/Indian plate velocity, and more than that estimated from geological offsets on faults with recent surface expression.

Slip rates within the Chaman fault system estimated from geological offsets are 19-24 mm/yr for the past 20-25 Myr (Lawrence et al. 1992) and 25-35 mm/yr for the past 2 Myr (Beun et al., 1979), but these do not sample distributed shear, and underestimate the contribution from block rotation should this be occurring.

Oldham (1883) speculated that the town of Debal (Dewal, Debil, Diul Sind or Sindi) near the current site of Karachi was destroyed by an earthquake in 893 AD, but Ambraseys (2003) notes that the sources of Oldham's account refer to Daibul (Dvin) in Armenia. Yule et al. (1903) describe Debil's 1000-year-long history, prior to its effective disappearance from accounts within a century of an earthquake in its vicinity in 1668 (Oldham, 1883). The archaeological town of Bhanbore has been suggested as ancient Debil and it is likely that the sudden change in the course of the distributary of the Indus responsible for its abandonment was caused by tectonic uplift. This would place Bhanbore on the hanging wall of a hypothetical reverse fault. Ongoing earthquakes near Karachi (Ahmed, 1954) suggest that the town must be considered close to a quadruple junction.

GPS Technology to Monitor Tectonic Activities

The Global Positioning System (GPS) is a space based navigation system, consisting of a constellation of 24 satellites, in six orbital planes with 55° inclination to the equator. The satellites are placed at a height of about

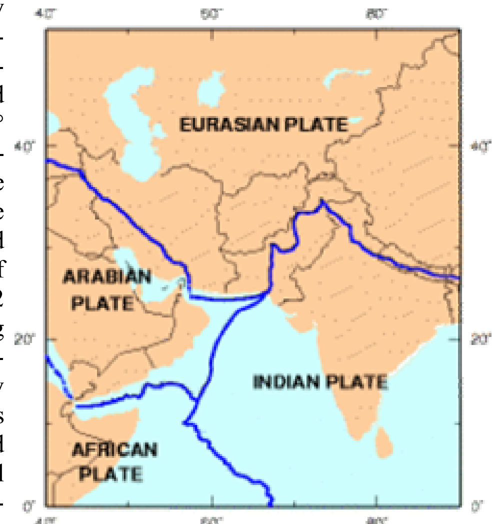

Figure 1: Political map of South Asia with tectonic plate boundaries.

20,200 km with 12 hours orbital period and operated by the United States Department of Defense (DOD) for accurate determination of position, velocity and time. All the GPS satellites are controlled by system tracking stations, ground antennae and the master control station. The distance to GPS satellite is estimated by measuring the time a radio signal takes to reach us from the satellite.

While the use of the GPS is extensive in defense, navigation and surveying applications, it is being used in geo-science, ionospheric and atmospheric studies, global climate changes, observing polar motion & earth rotation rate, mapping the gravity field, detecting seismo ionospheirc effects, transport and communications, environment management, for accurate time and frequency etc.

Better accuracies have been achieved in processing techniques which circumvent the purposeful degradation of the GPS signals. This resulted in using GPS for monitoring the slow and relentless crustal deformation by employing a technique called carrier tracking which allows determining baseline length within a few millimeters. The methodology is that the changes in position coordinates and baseline lengths in three orthogonal directions computed with GPS data during successive visits will enable us to assess the crustal deformation. Changes in

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Aftermath of Kashmir Earthquake of 08th October 2005

There have been many earthquakes triggered in the intraplate region of Pakistan and neighbouring countries due to the major event of Kashmir earthquake of 08th October, 2005. At least 288 earthquakes of varying magnitude were reported by USGS in the Pakistan and its vicinity; over 78 earthquakes were recorded to be greater than 4.5. Most of the earthquake epicentres were located in the South Eastern Pakistan i.e. Rann of Kutch, Central Pakistan and Southern Coastal belt of Iran. Although no any causalities were reported in South Western Border of India and Pakistan and Southern Iran where earthquake magnitude was 6.0 followed by many aftershocks; yet this continuously alarms the ongoing seismic activity in the region with movement of Indian Plate northwards to the Eurasian plate.

List of Earthquakes Greater than 5.5

Year	Month	Day	Latitude	Longitude	Magnitude	Depth
2005	11	27	26.77	55.86	6.1	10
2005	11	27	26.84	55.81	5.5	10
2006	02	28	28.12	56.87	6.2	18
2006	03	07	23.73	70.87	5.5	10
2006	03	20	34.81	73.76	5.5	10
2006	03	25	27.61	55.68	5.9	18
2006	03	25	27.58	55.80	5.5	11
2006	04	06	23.29	70.42	5.5	10

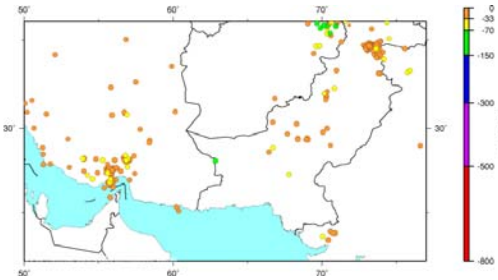

Fig. 1: Earthquakes in Pakistan and neighbouring region after 08th October 2005

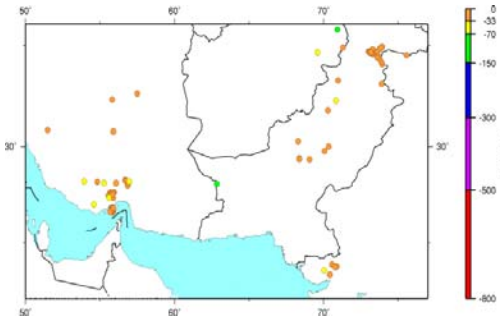

Fig. 1: Earthquakes of magnitude greater than 5in Pakistan and neighbouring region after 08th October 2005

GPS STRATEGY TO MONITOR...

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deformational rates have intrinsic value in understanding the physics of the earthquake processes.

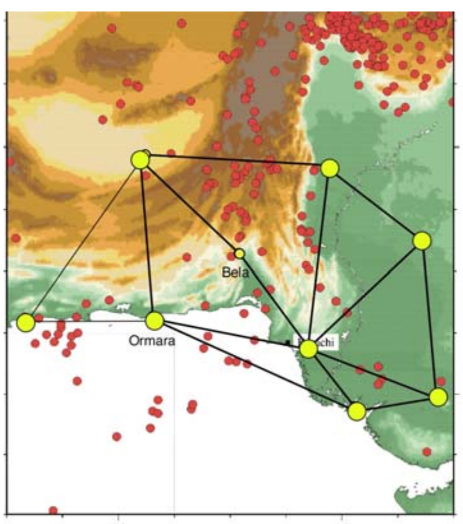

Figure 2: Shows the primary network designed to quantify the gross motions that determine seismic hazard in the Karachi region. A continuous station at Karachi operates at NED University. Other points are occupied for periods of 3 days or more.

Crustal deformation studies have received new impetus all over the world with the full complement of satellites for adequate coverage, availability of comparatively low-cost receivers, sophisticated post processing software and international cooperation through International GPS Services for Geodynamics (IGS). In many countries the receivers are used permanently in a network mode with data telemetered and processed continuously to have upgraded baseline vectors regularly. For the past few years, regional GPS networks designed mainly to monitor strain for earthquake research and forecasting have been operated in many countries all over the world and have proved useful in detecting the crustal displacements.

Strategy

1. Monitor the gross motions of the Indian and Asian plates.
2. Place dense arrays (20 km spacing) to identify regions of enhanced shear across the Chaman system (India/Asia), and the locking depth of Makran convergence (Asia/Arabia).
3. Densify spacing (10 km) to determine depth of locked zones, and extent of creep if present on both plate boundaries.

It is planned to install trimble 5700 GPS receivers with zephyr antennas at locations indicated in Figure 2 for a certain duration over a period of time. This will be repeated several times in a year. This will give positions of this point at different time intervals. After processing the data obtained displacements and deformations of these locations can be estimated with an accuracy of 1 mm and further processing will enable to estimate relative velocities at inter-plate and intra-plate boundaries.

It is envisaged that after a year's work some reliable data (recorded for the first time) of this region will provide a better insight of the potential earthquake hazard in and around Karachi and around coastal belts of Sindh and Balochistan.

It is essential to expend this project for a larger duration and by densifying the array of GPS receivers. This will provide a reliable estimate of ground motion enabling planner and engineers to plan and design reliable and safe human settlements and securing safe future.

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