RECENT SEISMIC ACTIVITY IN MUZAFFARABAD AND ITS SURROUNDING AREAS

***MonaLisa*[♣], *Azam A.Khwaja*[♣] *and Faisal Shehzad*[♦]**

Abstract:

The northern part of Pakistan has been a site of several disastrous earthquakes with moderate to high intensity. The October 8, 2005 Pakistan earthquake with magnitude Mw 7.6 occurred in the northeastern part of NW Himalayan Fold and Thrust Belt at 8:50:38 AM local time. The epicenter of the main shock was located at 34029/35//N and 73037/44//E (USGS) in the Neelum Valley, 19 km northeast of Muzaffarabad, the capital of Pakistani Kashmir. This deadliest of the Himalayan earthquakes took a death toll of more than 80,000 human lives and the estimated damage is of US $ 5 billion. This earthquake caused a widespread destruction in the area surrounding Muzaffarabad, NW Frontier Province (NWFP), and western and southern parts of Kashmir on Indian side. Muzaffarabad, Bagh and Rawalakot in Kashmir, and Mansehra, Balakot, Abbottabad, Batgram and Islamabad in Pakistan are the towns/cities most affected. Based on the information obtained from the print and electronic media (and for some areas from the field studies), the intensity of X (MMI scale) has been assigned at the epicentral location. This intensity zone of X seems to include the localities of Muzaffarabad and Balakot. More than 2000 aftershocks (USGS) have occurred in the area. Epicentral distribution of these aftershocks indicates that more than one tectonic subdivision of the fold belt has experienced instability. Focal depths indicate that most activity is confined to a narrow depth range. Further extension of the Indus Kohistan Seismic Zone (IKSZ) in the Hazara-Kashmir syntaxial area and activation of more than one fault seems to be the cause of this seismic activity, as apparent by the depth distribution of the aftershocks.

Introduction:

The Muzaffarabad Earthquake (also known as the Kashmir earthquake) of 2005 was a major seismological disturbance that occurred at 08:50:38 AM Pakistan standard time on October 8, 2005 with its epicenter 19 km northeast of Muzaffarabad (Fig.1). This earthquake with the magnitude of 7.6 M_w making it the dealiest of the Himalayan earthquakes with a death toll of more than 80,000 peoples.

Seismotectonic Setting:

This 26 km (USGS) deep event lies in the area where the Eurasian and Indo-Pak plates are colliding. Due to this collision, the Himalayas began uplifting about 50 million years

♣ Department of Earth Sciences, Quaid-e-Azam University, Islamabad.

♦ Department of Electrical & Computer Engineering, University of Lahore.

ago, and continue to rise by about 5mm/year. Sella et al., 2002 believe that the Indo-Pak plate is currently penetrating into Asia at a rate of about 45 mm/year and rotating slowly anticlockwise. This rotation and translation results in left-lateral transform slip in Balochistan at about 42 mm/yr (Billham, 2004) and right-lateral slip relative to Eurasian plate in the Indo Burma ranges at 55 mm/year.

Kazmi and Jan, 1997 referred the northwestern portion of Himalayas as the NW Himalayan Fold-and-Thrust Belt. This belt has been the source of several major earthquakes in the past and is seismically very active. The city of Muzaffarabad is situated within the Hazara-Kashmir Syntaxis (HKS). A number of active surface features like Main Boundary Thrust (MBT), Panjal Thrust (PT), Muzaffarabad and the Jhelum Faults (Fig.1) are located in the vicinity of Muzaffarabad. Epicentral distribution of the earthquakes for the period 1904-2002 along with the aftershock distribution of main event (Fig.1) further confirm that overall the area is situated in a very active regime.

Damage/ Destruction and Intensity:

This earthquake caused widespread destruction in northern Pakistan, as well as damage in Afghanistan and northern India. The badly affected areas were Pakistani Kashmir, North-West Frontier Province (NWFP), and western and southern parts of the Indian occupied Kashmir. It also affected some parts of the Punjab, and the city of Karachi experienced an aftershock of magnitude 4.6 (USGS).

In the northwest of the epicenter of main shock, there have been many aftershocks in the area. 147 aftershocks were documented in the first day after the initial shock, one of which had a magnitude of 6.2 (USGS). Twenty-eight occurred with a magnitude greater than five during four days after the main event. Even eleven days after, there were still major shocks, such as on 19 October there were a series of strong aftershocks one with a magnitude of 5.8, which occurred about 65 km north northwest of Muzaffarabad. There have been more than 2000 aftershocks, as of 30 April, 2006 (USGS).

The main event day i.e. Saturday was the normal school day in Pakistan; most students were at schools when the earthquake struck. Many people were also trapped in their homes and, because it was the Holy month of Ramadan, most peoples were taking a nap after their pre-dawn meal and did not have time to escape during the quake. Reports indicate that entire towns and villages were completely wiped out in Northern Pakistan with other surrounding areas also suffering severe damage.

An assessment of damaged buildings in Muzaffarabad and the surrounding area showed that about 60% of the buildings in urban areas were unreinforced solid concrete block masonry buildings and it was the collapse of more than 60% of these buildings that was responsible for the majority of deaths and injuries. Pakistan television reports widespread damage to Balakot (almost completely wiped out), Garhi Habibullah, Rawalakot and Muzaffarabad (near the epicenter) where 30,000 are thought to have died.

The quake triggered landslides (Fig.2), burying entire villages and roads in many areas of NW Frontier Province and Pakistani Kashmir. Hundreds of thousands of buildings are thought to have collapsed. One of two residential towers (Margalla Towers in F-10

sector, Islamabad), believed to contain up to sixty apartments each, collapsed in the earthquake in Islamabad. The Karakoram highway is blocked at several points, hindering relief efforts. Damage to buildings and several casualties have been reported in surrounding provinces of Punjab and Balochistan. Relief efforts in many remote villages were hampered, as roads were buried in rubble and many affected areas remained inaccessible.

The intensity of X (MMI scale) has been assigned at the epicentral location (Fig.3) based upon the print and electronic media. This intensity zone of X seems to include the localities of Muzaffarabad and Balakot. An intensity map is presented, which has been prepared using the damage/destruction reports from different parts of the country.

Focal depths (USGS) of aftershocks indicate that most activity is confined to a narrow depth range. Further extension of the Indus Kohistan Seismic Zone (IKSZ) in the Hazara-Kashmir Syntaxial area and activation of more than one fault seems to be the cause of this seismic activity, as apparent by the depth distribution of the aftershocks (Fig.4).

Preliminary Conclusions/Recommendations:

The significant damage was observed in the prevailing stone masonry residential, community, and government buildings, particularly those of random-rubble, a type which is well-known for poor seismic resistance. Buildings should not only meet the functional needs of their occupants but also the essential requirement of safety, based on sound earthquake resistant design and construction. Most of the residential units in the affected area relied on load-bearing masonry walls for seismic resistance. Much of the damage could be attributed to inferior construction material, inadequate roof support, poor wall-to-wall connections, poor detailing work, weak in-plane wall due to large openings, out-of plane instability of the walls, asymmetric floor plans, and aging.

There is an urgent need to revive these traditional masonry practices which have proven their ability to resist earthquake loads. Modern bridges, roads, water tanks, etc., which have been constructed without due consideration of the potential high seismic forces associated with the Himalayan region make such civil infrastructure extremely vulnerable to future earthquakes. At the same time a well comprehensive seismotectonic and seismic hazard map of the area is needed, in order to prevent/mitigate any future disaster in the form of an earthquake.

References:

Billham, R. 2004. Earthquakes in India and the Himalaya: tectonics, geodesy and history. Annals of Geophysics, Vol.47. No. 2. Pp. 839-858.

Kazmi, A.H. and Jan, M.Q. 1997. Geology and tectonics of Pakistan Graphic Publishers. Karachi. Pakistan.

MonaLisa, Khwaja, A.A., Javed, M., Ansari, Y.S and Jan, M.Q. 2005. Seismic Hazard Assessment of NW Himalayan Fold and Thrust Belt using Probabilistic Approach. Proceedings of the Pakistan Academy of Sciences. Vol. 42. No. 4. Pp. 287-296.

United States Geological Survey (USGS). Open File Report on October 8, 2005 Earthquake.

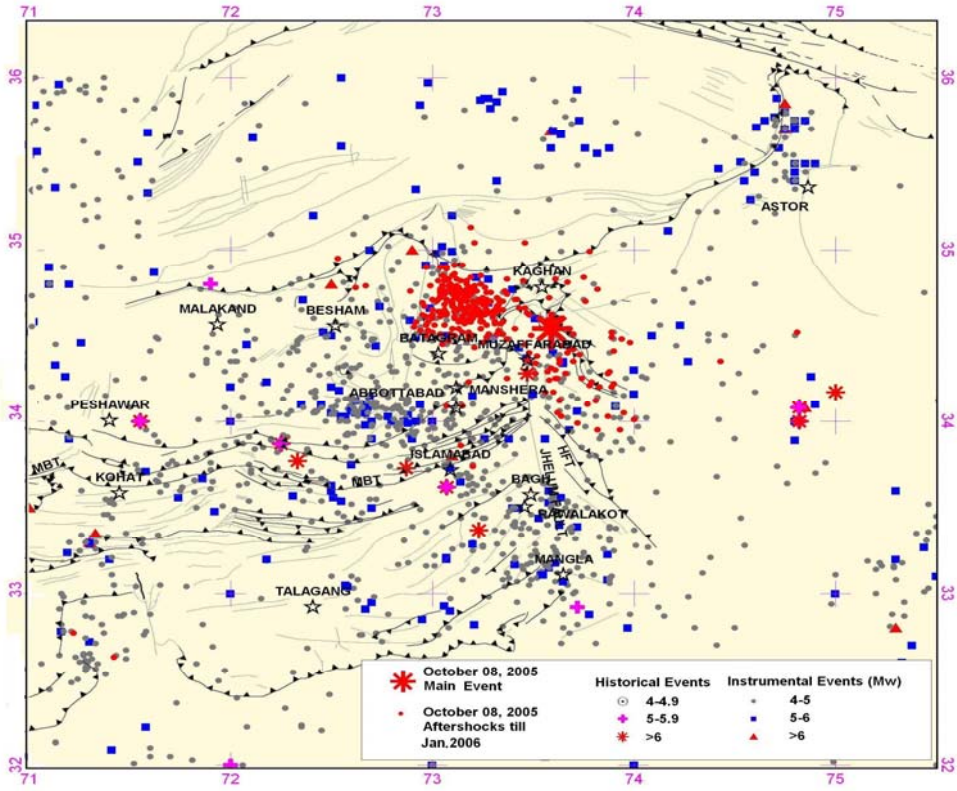

Figure 1: **Seismotectonic setting of the area with October 8, 2005 Earthquake and its aftershocks (adopted from MonaLisa et al., 2005).**

Figure 2: **Landsliding in Muzaffarabad.**

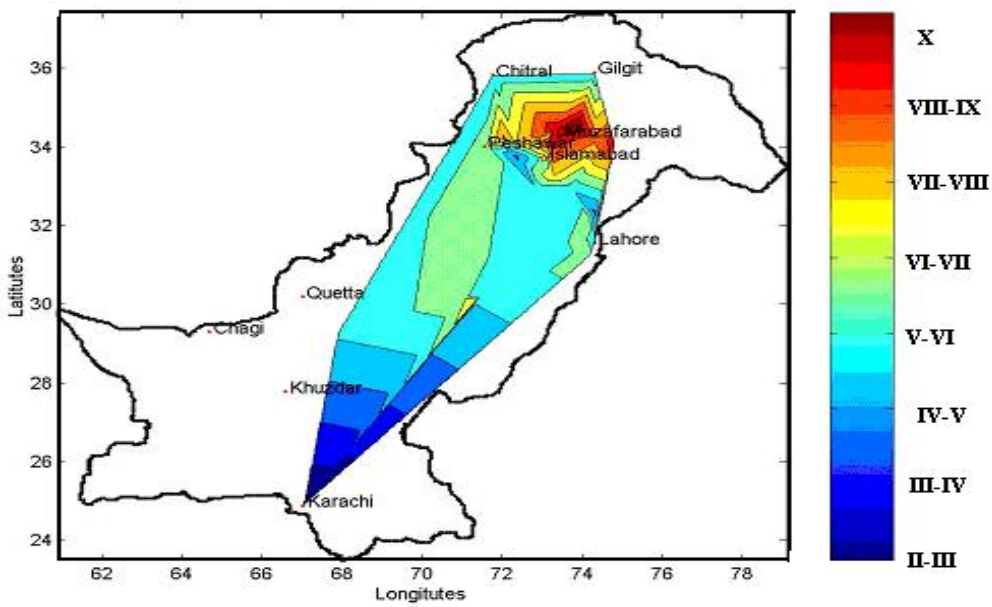

Figure 3: **Intensity map of the area**

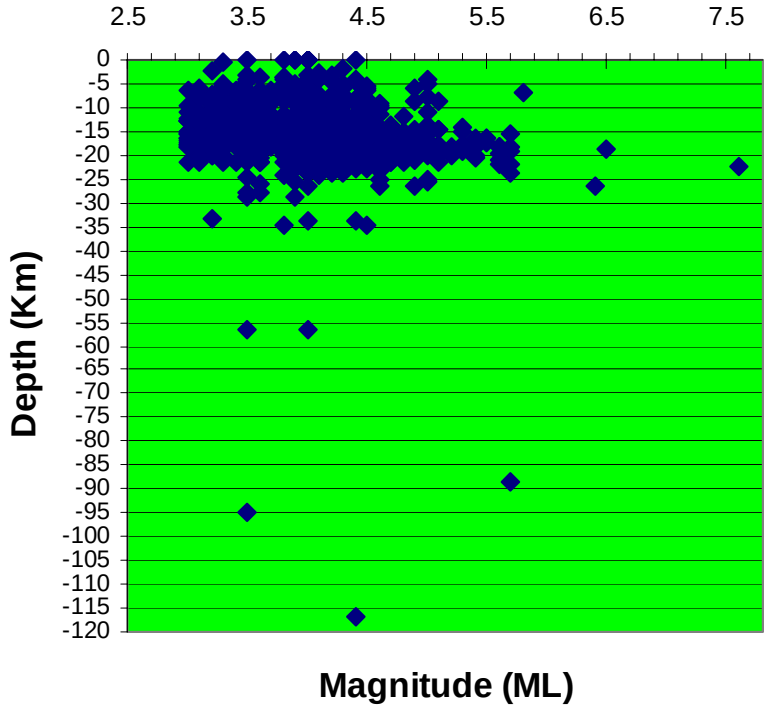

Figure 4: **Depth-Magnitude comparison for October 8, 2005 Earthquake and its aftershocks.**