



RECONNAISSANCE REPORT OF
PAKISTAN-AFGHANISTAN EARTHQUAKE ON FEBRUARY 1, 1991

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SUMMARY

Pakistan lies in a seismically active zone with northern parts of the country, most of Baluchistan and the Hunza area of Gilgit Agency, being potentially hazardous. During the current century, there have been a number of earthquake disasters in Pakistan but unfortunately they have not been properly documented and studied for damage of buildings and other civil engineering structures. On February 1, 1991, an earthquake of severe intensity struck the northern parts of Pakistan and Afghanistan. The epicenter was located in the Hindukush range, one of the world most active seismic region. The shocks were felt in parts of Russian Turkistan, north of Iran and northern India upto New Dehli. Due to civil war in Afghanistan, exact statistics of damages are not available for that side. The areas in Pakistan close to the Pak-Afghan boarder received severe damage. A three member team from University of Tokyo surveyed the earthquake affected areas in Pakistan for eight days and documented the damage of civil structures. In the region most of the building structures are so-called adobe. Thus damage to them tolled many human lives and property losses.

1. INTRODUCTION

On February 1, 1991, an earthquake with the magnitude 6.8 on the Richter scale had hit northern parts of Pakistan. The epicenter was located in the Hindukush range at 36.2° N and 70.2° E with a focal depth of 125 km. It was severely felt in the North-west Frontier Province (NWFP) of Pakistan, Afghanistan and Soviet Central Asia. It also shook northern Iran, central Pakistan and northern India (Fig. 1).

The shocks came early in the morning, much before dawn at 4:03 PST (January 31, 23:04 GMT) when people were asleep inside their houses. Hence those people became easy victims when their adobe structures collapsed due to the



Fig. 1 Epicenter and the surrounding areas

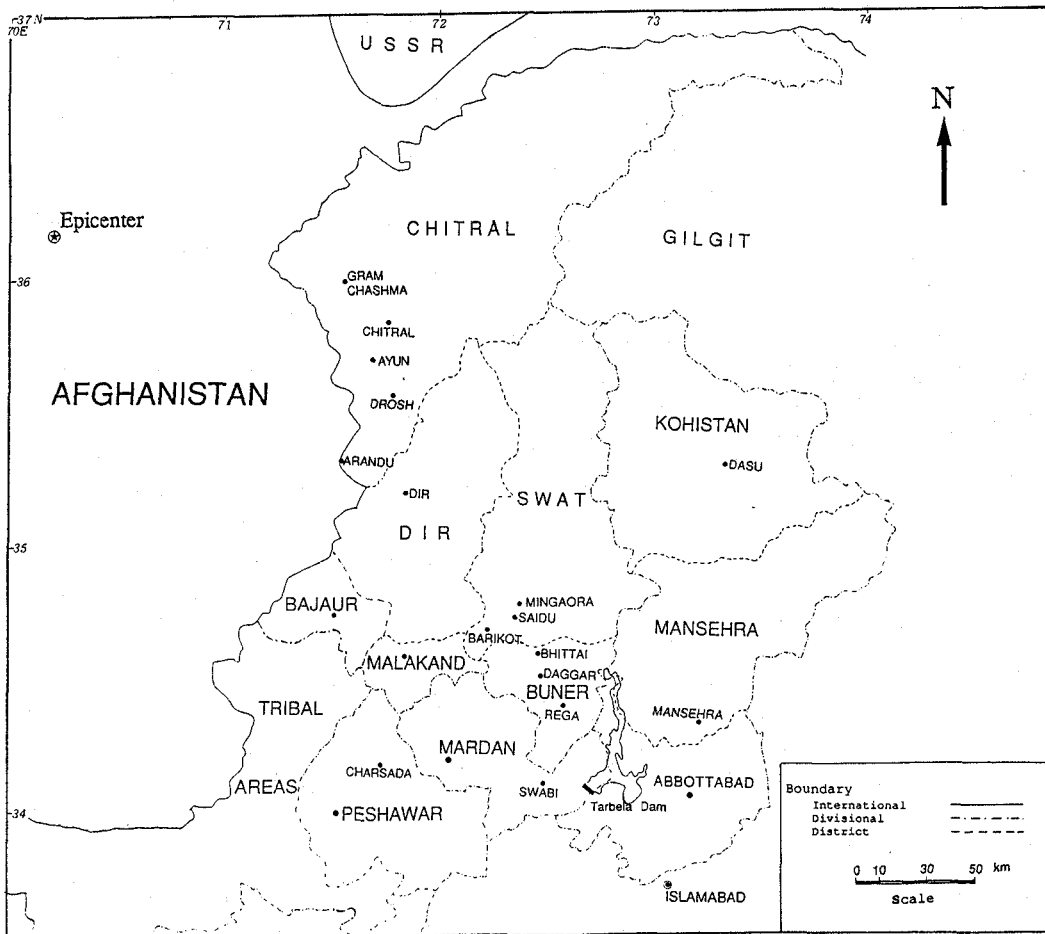


Fig. 2 Damaged areas in Pakistan including surveyed places

severe jolts. At least 181 people were killed and 741 injured, 5187 houses were completely destroyed and 79990 units received non-trivial damage, and 5302 cattle heads perished. In the districts of Dir and Kohistan, major landslides have been reported. The Karakorum Highway was blocked for about ten days.

Pakistan has an area of about 800,000 km² with population of more than 100 million. Administratively, the country is divided into four provinces namely; Baluchistan, Sind, Punjab and NWFP. For this event, NWFP, Punjab and parts of Baluchistan received severe jolting. Among them, NWFP was the worst affected area in Pakistan and 90% of the entire damage was concentrated in its Malakand Division. Malakand Division is further divided into Chitral, Swat, Buner, Malakand, Dir, and Bajaur districts (Fig. 2).

At the time when the earthquake hit the area, the Afghanistan Government issued a press release mentioning unconfirmed 1000 casualties. Afterwards, there was no press coverage of the event so it is difficult to estimate the total damage that occurred in Afghanistan. To observe the adobe structure behavior and damages, a three member team (the authors) left for Pakistan in the end of April, 1991. As the damage is widespread all over the Malakand division and the accessibility is through only good-weather roads, only Chitral, Swat and Buner districts could be surveyed.

2. GENERAL DESCRIPTION OF CONSTRUCTION

The terrain is mountainous with dwellings scattered over the area. In some of the places, the houses were constructed by levelling the hillside. The houses were constructed by the locally available materials. The construction method varies from place to place depending upon the availability of materials, the topography and the economical condition of the area. The building structures can be broadly divided into two categories: Pucca and Kucha buildings.

Pucca building construction includes conventional reinforced concrete and load bearing structures. The walls may be built from stone blocks or klin-burnt bricks set in cement mortar with cement-sand plaster. The thickness of walls vary from 400 to 500mm. They are built with some engineering judgments and are of good standard of construction. Usually such buildings are occupied by government offices, essential facilities and some private residents.

Kucha buildings constitute the majority of private housing in the area. These are made from various locally available materials like wood, sun-baked clay blocks



Photo 1 Collapsed dry masonry wall

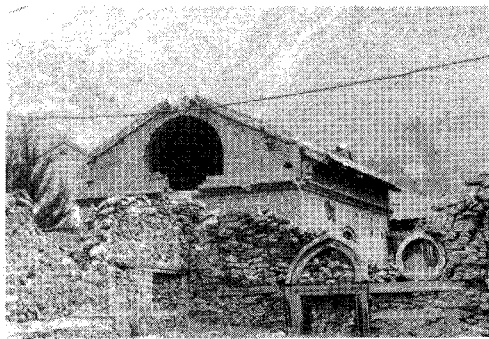


Photo 2 Different types of construction

reinforced with straw, in-place erected clay walls, wall erected by slate like stones without any mortar (Photo 1), round stone wall with or without mortar, block or irregular shaped stones embedded in clay mortar without any plaster (Photo 2), or by constructing the wall partially with stones and partially with clay, etc. The thickness of the walls varies from 400 to 600mm. The survey was conducted after three months of the disaster. Some of the damaged houses were already reconstructed or repaired by that time but still damaged structures can be well speculated.

2.1 Characteristics of Damage

The Pucca buildings resisted the earthquake for us in a better way. No major damage had been reported for these buildings except for some old ones. The damage varies from wide cracks, spalling of plaster, partial damage of internal walls, collapse of boundary walls, etc.

The Kucha type of construction received the majority of damage from complete collapse to minor damage. In most cases, the houses collapsed when the earthquake struck. However, in some cases they received major damage and came down afterwards when the rains had started. The main causes for the damage were the heavy weight, very low tensile and shearing stresses, weak connection between the walls and roof and wall.

One of the failure patterns of walls seems to be shear failure (Photo 3).

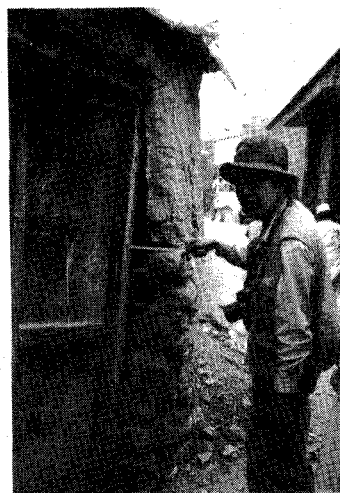


Photo 3 A wall failure mode

3. SURVEY OF DAMAGED PLACES

During the course of survey, we focused on the Malakand Division, the worst affected region in Pakistan. The area of this division is about 30,000 km². and the present population is estimated around 3.1 million including 0.4 million Afghan refugees. Due to limited time and inaccessibility of some areas, we visited only three districts (Chitral, Swat and Buner). Most of the journey was done on good-weather mountain jeepable trails. Interviews were made with administrative officials in each district for the structural damage and the relief activities. Damage data was collected by visiting the Relief Commissioner Office, Peshawar (Table 1). The damage statistics do not include the damage to Afghan refugees as their affairs are looked after by international agencies.

3.1 Chitral District

Chitral is, areawise, the biggest district in the Malakand Division. It runs along the Pak-Afghan border and had sustained the maximum damage. The altitude of the area changes widely from 500m to 7,692m, the peak of Trich Mir. The population of Chitral District is 277,000 with an area of 14,850 km². It took about one hour from Peshawar flying between the mountains of over 3,000m in height. The district can be divided into main, lower and upper Chitral.

Table 1 Damage Statistics in Pakistan for February 1, 1991 Earthquake

| S. No | Name of District | Casualties | | Houses Damage | | Cattle perished |
|-------|------------------|------------|---------|---------------|-----------|-----------------|
| | | Dead | Injured | Completely | Partially | |
| 1 | Swat | 10 | 86 | 632 | 8498 | 359 |
| 2 | Malakand | 15 | 27 | 234 | 7352 | 70 |
| 3 | Dir | 26 | 164 | 901 | 9432 | 945 |
| 4 | Chitral | 24 | 155 | 1103 | 18035 | 2537 |
| 5 | Bajaur | 38 | 120 | 491 | 12076 | 363 |
| 6 | Buner | 36 | 108 | 833 | 9695 | 593 |
| 7 | Mansehra | 23 | 69 | 633 | 3088 | 159 |
| 8 | Abbottabad | - | - | 206 | 2432 | 34 |
| 9 | Kohistan | 02 | 05 | 117 | 362 | 136 |
| 10 | Mardan | 05 | - | 17 | 6708 | 72 |
| 11 | Swabi | 01 | 05 | - | 1881 | 34 |
| 12 | Others | 01 | 02 | 20 | 431 | - |
| | TOTAL | 181 | 741 | 5187 | 79990 | 5302 |

3.1.1 Chitral and Surroundings

Chitral City is the districtquarters of the Chitral District. It lies at an altitude of 1500m and the epicentral distance is 145 to 150 km. The intensity was estimated in Modified Mercalli (MM) scale at IX. The city's airport is the only one for the area which serves in good weather conditions only. At the time of the earthquake, the city and surroundings were covered by 0.3 to 0.4m thick snow. The water channel feeding to the hydro-power station was hit by rolling boulders. The repair works took two months before it was able to supply water and power normally. The telephone lines performed well.

The standard of construction around the city is comparatively good with 30% by Pucca. About 20% of Pucca buildings have received non-structural damage like wide diagonal cracks in the masonry (Photo 4), falling down of parapet wall, spalling of plaster, damage to roof chimneys, collapse of boundary walls, etc. Some of the old constructed houses had been rather severely damaged.

The Kucha buildings in this vicinity are made mainly from clay blocks or stones embedded in mud mortar with horizontal timber reinforcement at regular intervals. About 90% of such type of construction had received some damage with 20% totally collapsed. In a village near to the city area, houses were built on a man-made terrace. Out of 260 dwellings, 26 were completely destroyed and 160 had received major damage (Photo 5,6).



Photo 4 Old Fort, Chitral

3.1.2 Ayun and Vicinity

Ayun is a village located about 20 km southwest of main Chitral. The intensity felt was IX in MM scale, with 90% damage to the Kucha and 20% damage to the Pucca buildings. Excessive rockslides took place around Ayun and in the Kalash valley (Photo 7,8). Afghan refugees' dwellings also received considerable damage in this area.



Photo 5 Village built on hillside, Chitral

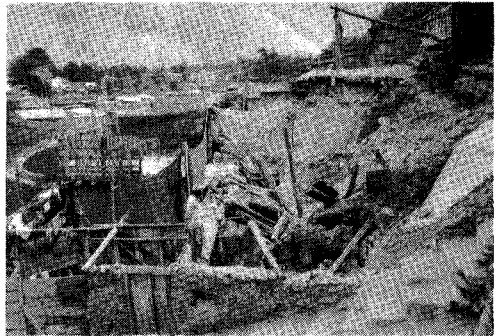


Photo 6 26 houses collapsed in this village

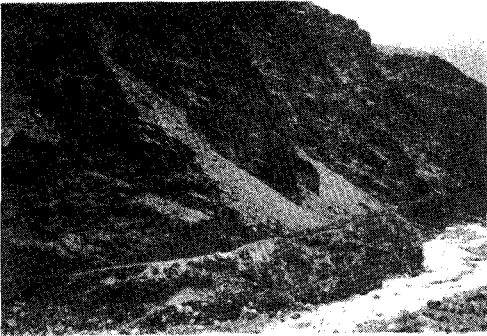


Photo 7 Rockslide in the Kalash valley

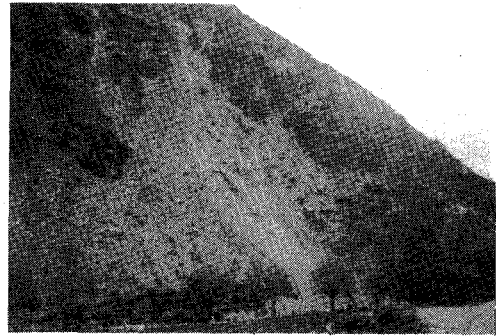


Photo 8 Rockslide near Ayun

3.1.3 Drosh

Drosh is located 30 km south of Chitral. The intensity was IX in the MM scale, 90% of Kucha buildings and 15% of Pucca buildings were damaged. Most of the Kucha buildings are made from irregular shaped stones with or without mud mortar (Photo 9). Among the Pucca buildings, the Meteorological observatory building was partly damaged with the retaining wall totally destroyed. The Civil hospital also received non-structural damages like spalling of plaster, wide cracking in the masonry and collapse of internal walls.

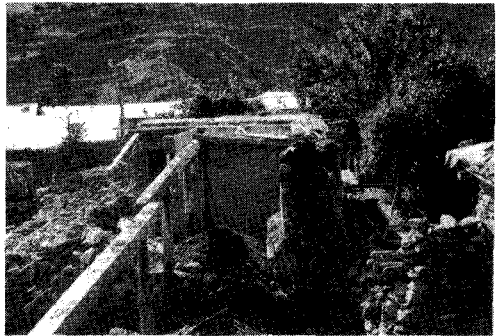


Photo 9 Collapsed house in Drosh

3.1.4 Arandu

Arandu is located at an altitude of 500m in lower Chitral valley. The epicentral distance is about 155 to 160 km. It is situated at a distance of 98km in southwest of main Chitral, on the Pak-Afghan border. The intensity felt was estimated as X in MM scale, 25% of the Pucca and 100% of Kucha houses were damaged. Most of the Kucha structures were either collapsed by ground shaking or demolished

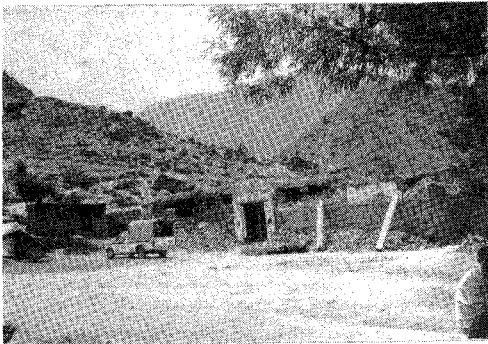


Photo 10 Damaged police station, Arandu



Photo 11 Blocked stone boundary wall, Arandu



Photo 12 Aradu, reconstructed village

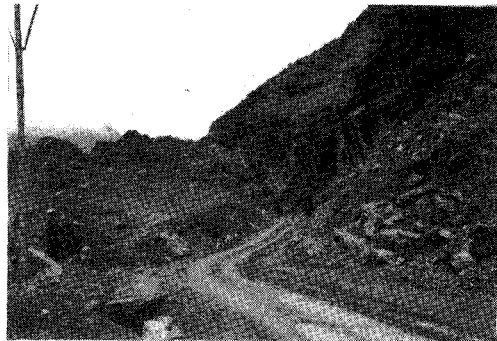


Photo 13 Rockslide on way to Aradu

afterwards due to major damages. The police station building also collapsed (Photo 10). The boundary wall of a hospital, which was built from rectangular shaped stone blocks embedded in cement mortar fall down (Photo 11). A village having 300 dwellings was completely razed to the ground (Photo 12). A number of slides were found on the mountain jeepable trail leading to the place (Photo 13).

3.1.5 Gram Chashma

Gram Chashma is located in upper Chitral valley at an altitude of about 3000m. The epicentral distance is approximately 135 km. It is situated 47 km northwest of Chitral. Unusually heavy snowfall was reported this year. At the time when the earthquake hit, the area was covered by more than 1.5m thick snow. Due to the heavy snowfall, the telephone lines to Gram Chashma were already disconnected. The jeepable trail leading towards Gram Chashma was also unaccessible because of the heavy snow together with rolled down boulders and glaciers. The way was opened to vehicular traffic in the last week of April.

In the walls of the Governor House by Pucca, cracks developed with spalling of the plaster (Photo 14). Most of the damage in upper Chitral were due

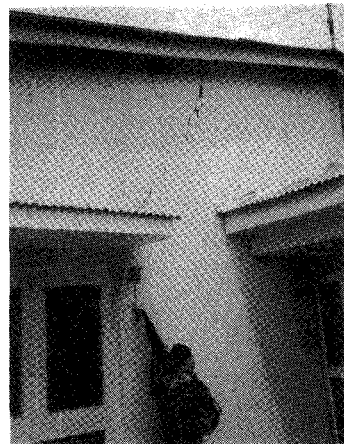


Photo 14 Governor House, Gram Chashma

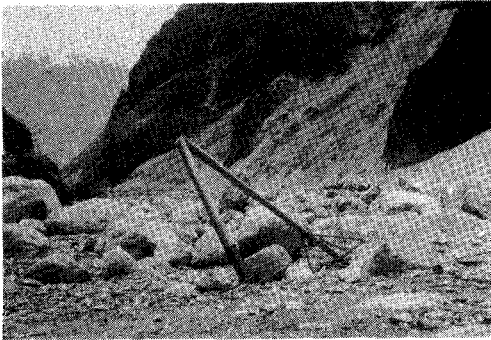


Photo 15 Fallen pole hit by boulder



Photo 16 Wall breached by boulder which is still inside this building

to rockfalls from the steep valley. In many instances, large boulders fell on the roofs of the houses which had suffered no structural damage by ground shaking (Photo 15,16). The structures destroyed by shaking were mostly built of dry masonry with walls more than half meter thick, often of balanced round stones. Very few of such walls fall sideway as a unit, but most of them collapsed due to crumbling.

3.2 Swat District

Swat district is the eastern part of Malakand division. Saidu, the divisional center is about 250 km from the epicenter. The construction quality is better compared to other places. Mingaora was the worst damaged place of the district, with about 300 collapsed houses. In Saidu, most of the Pucca buildings had suffered non-structural damages (Photo 17). In Nawagai village in Barikot, a place south of Swat, ground had started to settle down after the earthquake. One month after the earthquake, rain had started which triggered the ground settlements. The progressive settlement, which is still continuing, results in structural failures (Photo 18,19). Some landslides had been reported in upper Swat which damaged the Karakorum Highway.

3.3 Buner District

Buner district is situated in the south of Swat. Daggar, the district quarters is located at a distance of about 280 km from the epicenter. The shaking was of



Photo 17 A damaged Pucca hotel in Saidu



Photo 18 Uneven ground settlement, Barikot

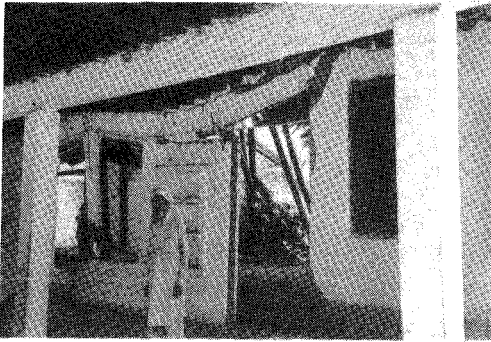


Photo 19 Structural damage due to ground settlement in Barikot

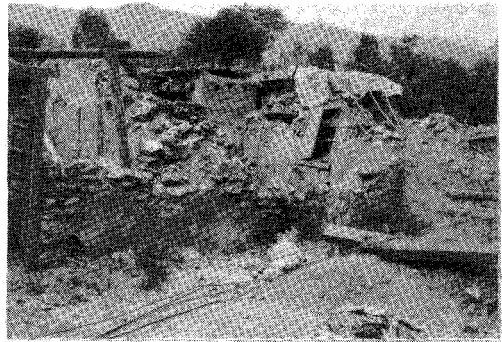


Photo 20 Damaged houses in Bhattai, Buner

severe intensity throughout the district. However, the northern parts were more damaged by the ground shaking (Photo 20). Some of the collapsed houses fell down after the earthquake because of rain which started one month after the earthquake and continued for about two months. In the south of Buner, water had come out of the ground which experienced excessive settlement. At such places like Rega, Karappa and surrounding areas, collapse of houses and continuous settlement of roads have been reported.

4. OTHER AFFECTED AREAS

Due to limited time and difficult accessibility, only three districts had been visited by the survey team. In Malakand division, Dir, Malakand and Bajaur had also suffered considerable damages. In Bajaur, the intensity was IX in MM scale and about 80% of the houses were damaged. Three villages were completely razed to the ground due to severe jolting which lasted for about three minutes. In Dir, intensity was also reported as IX in MM scale. Here excessive rockslides had occurred, and most of the houses were hit by rolling boulders. The road access to Dir was snow blocked when the team was in that area. The Malakand agency is situated about 240km away from the epicenter. About 50% of the Kucha houses collapsed.

In Hazara division, three districts, namely, Kohistan, Mansehra and Abbottabad were affected. In Kohistan, the Karakorum Highway had been blocked at various sections due to major landslides. It took about ten days before the road opened. Mardan division also suffered building damages. The intensity in these areas ranged from of VII to VIII in MM scale. In Peshawar, D. I. Khan, and Kohat divisions, the intensity ranged from VI to VII in the MM scale. Damage to structures, from minor to collapse had been reported in these areas.

Besides the NWFP region, the earthquake was strongly felt in central Pakistan. In Islamabad, Lahore and their vicinity areas, the intensity was estimated in the range of V to VI in MM scale. The earthquake intensity was about IV in MM scale in Multan, a city about 700km in southeast of epicenter.

According to Press Trust of India, the tremors were felt in northern India including New Dehli, which lies 800km away in the southeast direction of the epicenter. Panic was reported as hundreds of people rushed out of their houses after the beginning of shaking. Details were not available for Afghanistan, Russian Turkistan or northern Iran.

5. RELIEF ACTIVITIES OPERATION

The stricken region is seismically active and frequently jolted by earthquakes. No relief funds or goods were available from the local authorities to respond to such an emergency. The event took place in the early hours of Friday, which is a weekend in Pakistan. Being a bank holiday, no governmental funds could be activated immediately for relief works. In the meantime, the local authorities at divisional and district levels started their activities and tried to be in contact with each other. At that time, all the Malakand division was snowclad with no accessibility to upper Chitral, Dir and Kohistan areas. The situation created uncertainty and led to higher casualty estimates in the beginning.

The immediate rescue operation was done by neighboring people. They pooled the money they had in their pockets, purchased blankets and edibles and distributed them among the homeless people. Shelters were opened in the school Pucca buildings. The first relief items were received by local welfare organization after 24 hours in Swat and Buner districts. Due to the weather conditions the relief operation in far areas was delayed. Relief supplies were air dropped in some places. However there were areas which still had not received any aid at the time of this survey.

The prime minister, Mr. Nawaz Sharif visited Arandu in Chitral and Chawatra in Bajaur on February 2 and shared the grief of the affected people. He announced cash compensation of Rs. 20,000 for a dead person, Rs. 4,000 for an injured person, Rs. 25,000 for a collapsed house, Rs. 2,000 for a partially damaged house and Rs. 600 for a perished cattle head. An emergency cell was created in the provincial capital, Peshawar, to coordinate the divisional and district administrations to expedite the relief and rescue operations and for distribution of essential goods among the victims.

6. CONCLUDING REMARKS

The northern part of Pakistan is highly vulnerable to seismic activities. At this time as well as in the past, the huge loss of human lives and properties were mainly due to the collapse of adobe structures. It is not practically possible to replace the existing structures by earthquake resistant ones. Comprehensive studies should be conducted to understand the behavior of local available materials during ground shaking and to improve the performance of Kucha houses.

This is not the first calamity of its kind to have struck Pakistan and there is no knowing when and where a similar disaster may strike again. There should be effective disaster mitigation settings to cope with such emergencies. Local residents should be trained as rescue workers and paramedics. Necessary supplies should be maintained as a permanent stock. Existing roadways should be improved and expanded to all-weather roads.

Interesting observations can be made by studying the seismic activities in the Hindukush seismic zone. Seismic observatory equipped with latest technology should be established in the Chitral area.

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