Landslide Disaster Caused by Inland Earthquake

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1. Overview of North Pakistan Earthquake

The north part of Pakistan, which was hit by the earthquake, is a mountainous area located in a steep alpine region at the west part of the Himalaya Mountains and borders on China and Afghanistan at the Karakoram Range and Hindu Kush Range respectively. North Pakistan Earthquake occurred at 3:50, 8 October 2005 at approx. 100km north-north-east of Islamabad, the capital of Pakistan, and at the depth of 26km, with an estimated magnitude of 7.6 (GSP, 2005). According to the Geological Survey of Pakistan, it was reported that the death toll from this earthquake was 83,000 or more, the victim was 3 million or more, and the complete collapse and half collapse of buildings were 200,000 respectively. It had been pointed out that there were active faults in the area where the earthquake occurred (Nakata, et.al, 1991). North Pakistan Earthquake was supposedly caused by the fault generated at the stress point where the Indian subcontinent hits the Eurasia continent. It is said that many active faults are broadly distributed at the west of the border where the plates come into contact with each other, and the two faults in particular, Muzaffarabad fault and Tanda fault, were closely related to the earthquake.(Nakata, et.al, 2005). It was also reported, based on the analysis of the observation data by a satellite, that 1m or more crustal movement, which extends approx. 90km length, occurred along the aforementioned two active faults and their south east areas, and the movement at the largest part was 6m (Geographical Survey Institute, 2006) . The earthquake fault estimated from these observation and analysis results was verified by a joint field survey between Active Fault Research Center of National Institute of Advanced Industrial Science and Technology and Geological Survey of Pakistan. The joint survey found that the earthquake fault extended approx. 9m and its main part appeared along the existing active faults. (National Institute of Advanced Industrial Science and Technology, 2006)

2. Overview of Landslide Disaster Caused by North Pakistan Earthquake

It is pointed out that the areas which sufferred serious damage from North Pakistan Earthquake were located immediately above or near the aforementioned fault. Among the cities which were damaged by the earthquake, the most afflicted city was Muzaffarabad, which is the capital of the special state of Azad-Kashmir and located at 85km north-north-east of Islamabad, near the seismic center. Geographical Survey Institute analyzed high resolution images taken by US Space Imaging Corp. before and after the earthquake and collected the information on the sediment-related disasters occurring around Muzaffarabad(Sato, et al., 2005). According to the collected information, approx. 100 landslide failures occurred, and many of them concentrated on the north east part of the aforementioned two faults. You should note that the information collected through the analysis of satellite images is limited to relatively large-scale failures, and fur more landslide failures must have occurred if small-scale ones are included.

3. Investigation of Landslide Disaster Caused by North Pakistan Earthquake

We had an opportunity to inspect the landslide disasters and the damaged situation at the local sites with staff members of Geological Survey of Pakistan on January 20 and 21, 2006. Fig.-6 shows the outline locations of the damaged areas, and Fig.-7 shows the inspection itinerary (Fujiwara, 2006). Although the areas that we visited covered only approx. one third of the entire area that suffers frequent occurrence of landslide disasters, we were able to visit Hathian, which was hit by a massive landslide. Firstly, we went through the settlement called Murree in a pass at approx. 50km north west of Islamabad and at the evaluation of approx. 2000m. Then we went down a valley and went north along the Jhelum River, and reached Muzaffarabad, which was the center of the afflicted areas. It took us approx. 4 hours to travel approx. 135km distance as we passed large landslide areas and some roads with one side closed. Photo-16 shows an example of a road collapse caused by a landslide. The state of Azad-Kashmir, which was the investigation site, was under territorial dispute with India. As we approached Muzaffarabad, tents for the victims were increased. In the city, collapsed middle-rise buildings and low-rise houses were found here and there. The mountain slope at the north of the city was totally

collapsed, resulting in a bare mountain. The road to Chikkar from the left bank of the Jhelum River runs through the slope in close proximity to the seismic center fault, and significant deformation was seen in the slope.

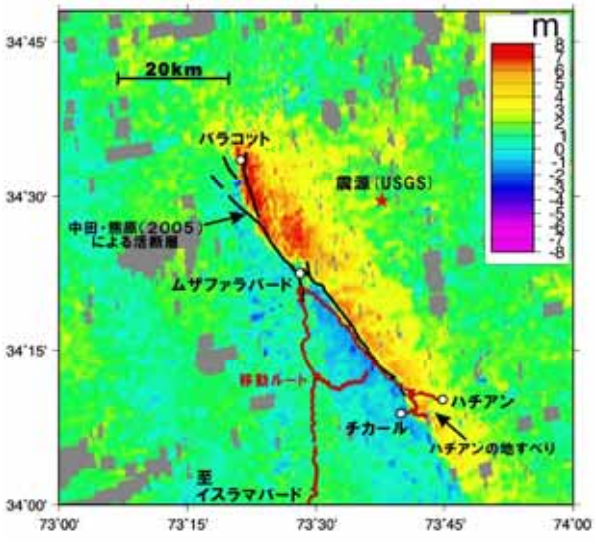

Fig.-1 Outline locations of damaged areas

(Excerpted from the web site of National Institute of Advanced Industrial Science and Technology)

Fig.-2 Investigation team travel route

(Created by Mr. Fujiwara, Geographical Survey Institute)

In the Hathian landslide area, the mountainside collapsed from north to south and created a debris avalanche deposit, of which width is 500m, slope length is 2km, and depth at the deepest part is more than 100m(Photo-17). The debris of more than $10^7 m^3$ blocked the confluence of the two branch valleys, forming two landslide dams. It is presumed that this mountainside collapse was not first time occurrence, but an existing landslide was expanded to the upper side, resulting in the collapse (Schneider, 2006). The debris from the landslide is composed of red sandstones, siltstones, and mudstones of the Murree layer of early Miocene. The cross section of the debris is a wedge shape of a right triangle of which the base is the ground surface, long oblique line is the slope, and the short oblique line is the east side of the collapsed cliff. The slope is parallel to the bedding plane of the bed rock. Along with the collapsed cliff side, many cracks and multilevel terrain were formed, and remaining large debris was found right under the top of the mountain.

Photo-1 Collapsed roads due to landslide

Photo-2 Hathian landslide (Seeing the landslide area from the side cliff at the upper side)

12. Challenge to Restore Areas Damaged by North Pakistan Earthquake

North Pakistan Earthquake caused many serious and high density landslide disasters in the earthquake fault areas along the existing active faults close to the earthquake center and its proximity areas. Many houses have been built on the steep slopes, of which

difference in elevation is as large as 1000m, and people have created terraced fields and engaged in agricultural work as they have been living with landslides for many years. This situation is quite similar to that of Yamakoshi village in the Chuetsu region, and their problems are common to the areas which suffer frequent occurrence of landslides.

In many damaged areas, cracks and multilevel terrain are formed on the slope, and it is expected that they are quite likely to cause secondary disasters. The monsoon season is approaching, and we need to grasp the current situation of the possibility of landslides and hillside collapse in the damaged areas and assess the risk. Also, there is a need to immediately take a measure for discharging the dams which were created by the Hathian landslide. We believe that the knowledge and technique that we obtained through the experience of the Niigata Chuetsu Earthquake will help alleviate future landslide-related disasters in the areas damaged by North Pakistan Earthquake.

Acknowledgement:

Regarding the occurrence mechanism of North Pakistan Earthquake, we referenced the websites of Geographical Survey Institute and National Industrial Research Institute. We herein express our appreciation to the aforementioned organizations and individuals.

Reference Documents:

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