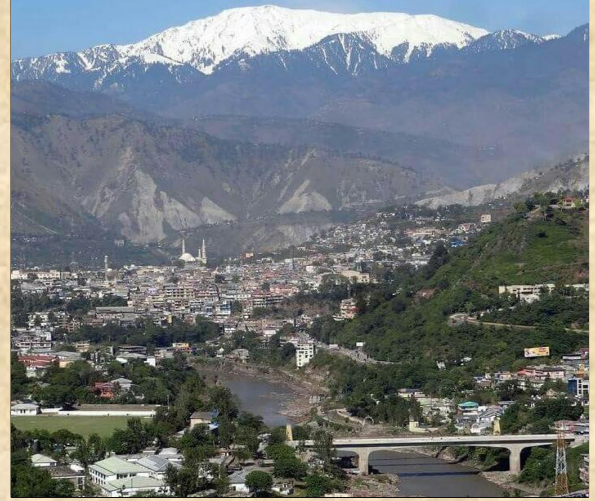
AN INTEGRATED MODEL SIMULATING THE INITIATION AND MOTION OF EARTHQUAKE AND RAIN INDUCED LANDSLIDE IN PAKISTAN

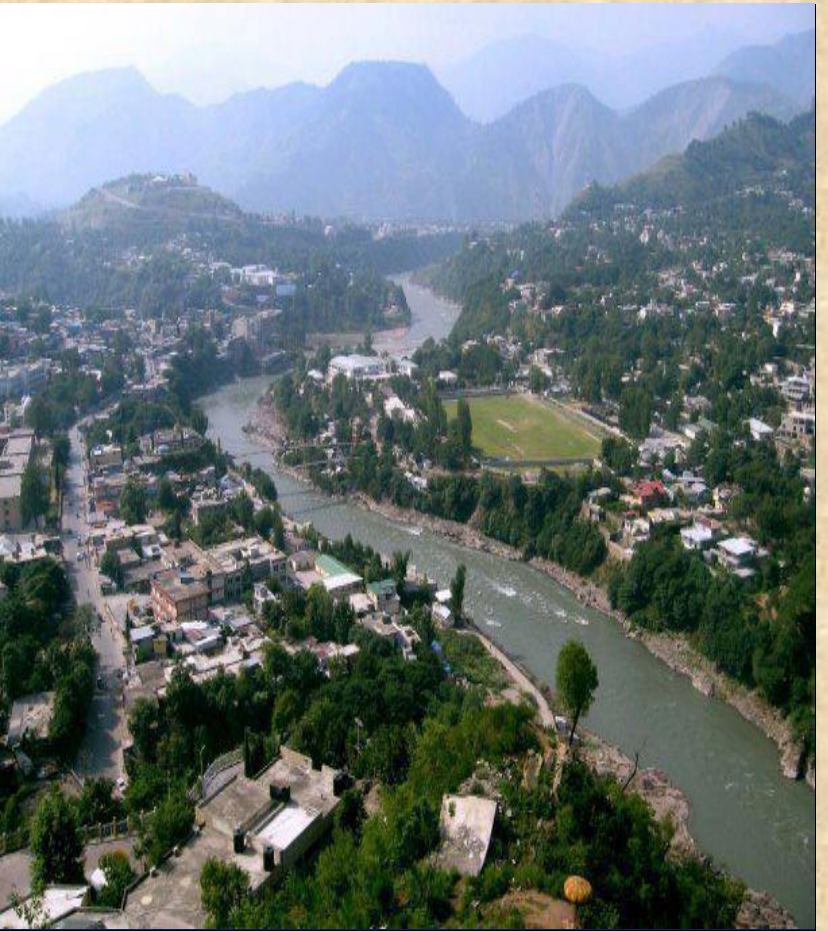
Presented at:

UNESCO-JASTIP Joint Symposium on Intra-Regional Water Security and Disaster Management







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Sequence of Presentation

- Introduction/Background of study
- Objectives
- Site investigation and soil sampling
- Ring shear test’s results
- Integrated computer simulation model (LS-Rapid)
- Conclusions
- Recent works and ongoing research

An integrated model simulating the initiation and motion of earthquake and rain induced landslide in Pakistan

Database inventory and Methodology

Completed

Data collection
- Geological maps
- Topographic maps
- Digital elevation models
- Field investigation
- Soil sampling
- Literature review

Completed

Laboratory tests using the landslide ring shear simulator
- Undrained stress control test
- Rubber edge friction test
- Pore water pressure control test
- Seismic loading test

On going

Landslide simulation
- LS Rapid model

Landslide risk assessment and Data analysis

Failure mechanism

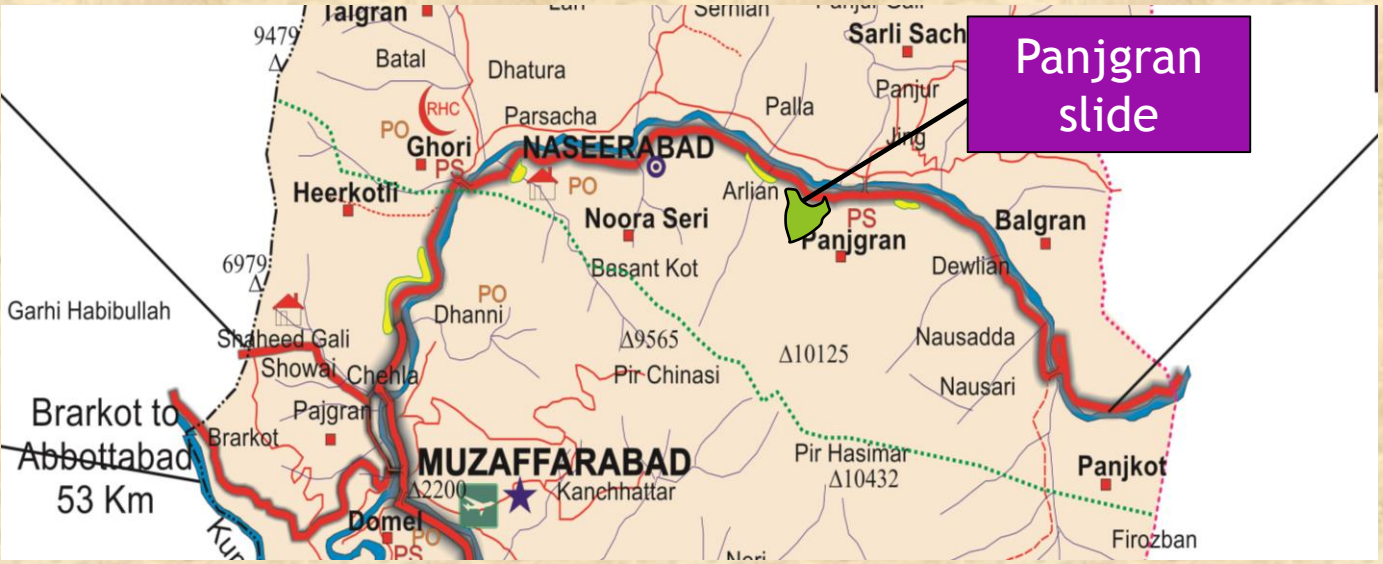
Dynamic analysis

Reproduce the initiation and motion of landslide by LS Rapid software

Conclusions

Introduction

- The study area lies in the NE of Muzaffarabad city, capital of the state of Azad Jammu and Kashmir, between the coordinates 34°21' to 34°28' N and 73°27' to 73°41' E .
- It is the part of "Sub-Himalaya" a morpho-tectonostratigraphic division of Himalaya.
- Himalayan orogeny is the world's youngest active continental to continental collision.



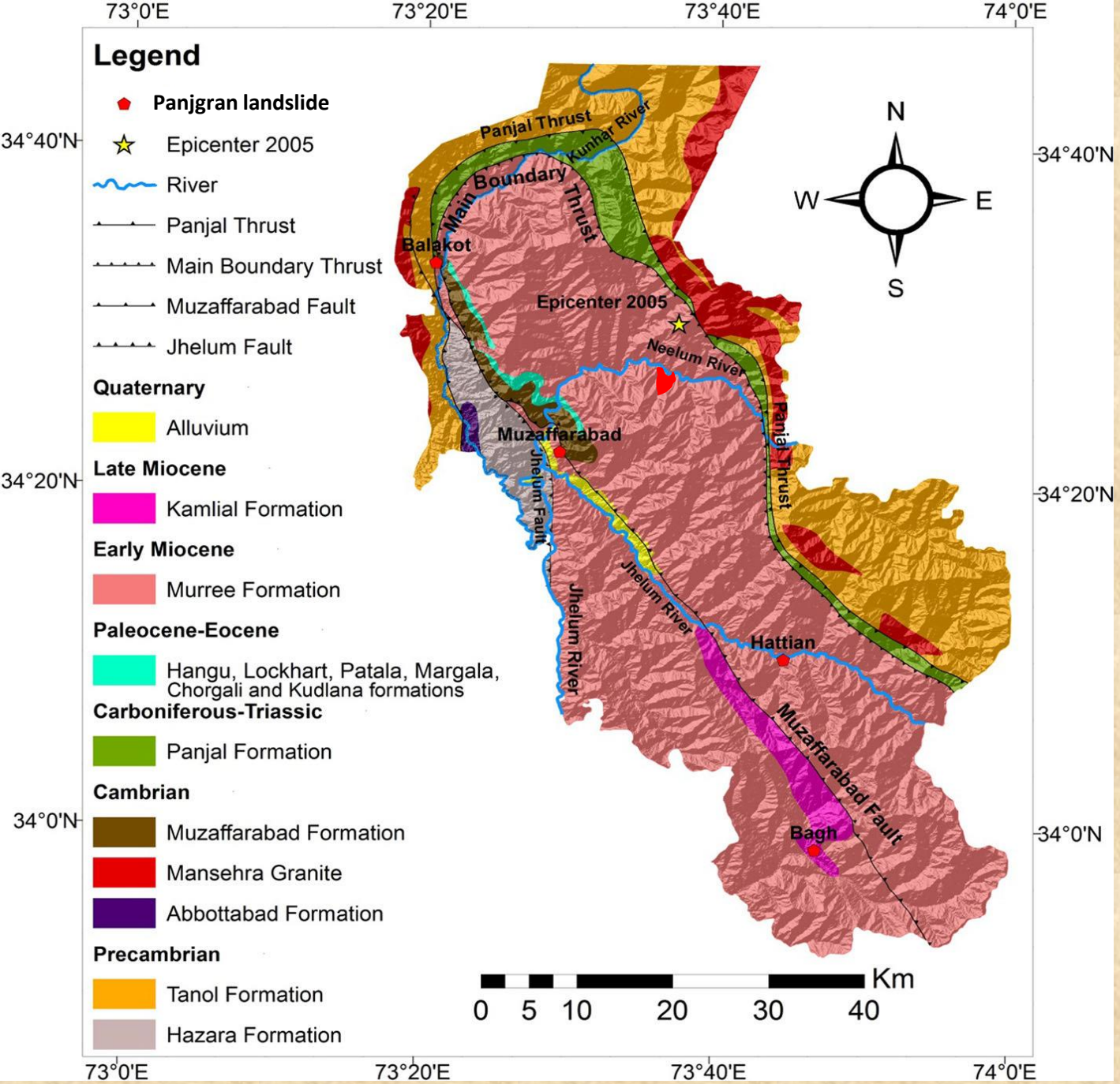


Fig. Geological map of study area

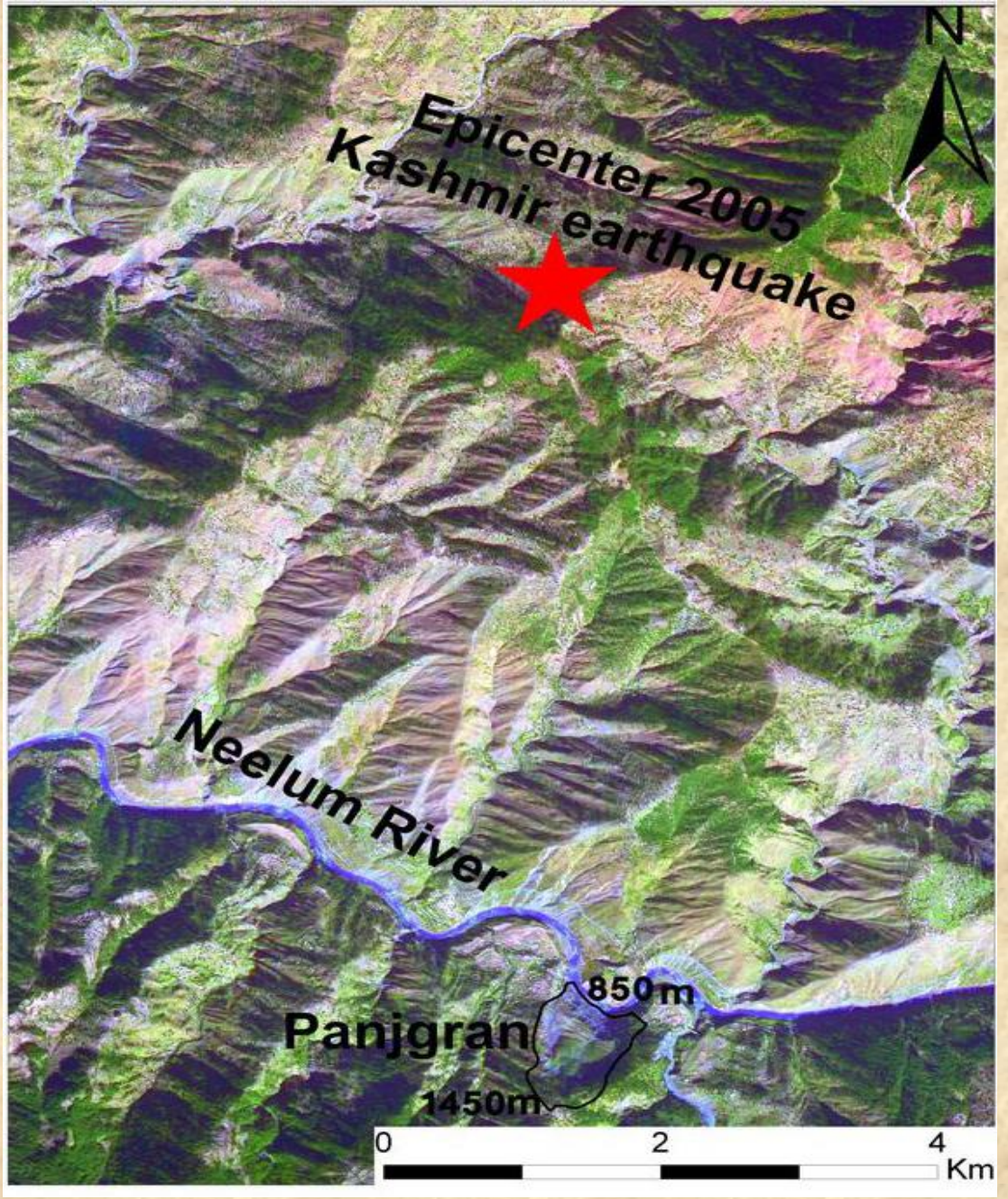
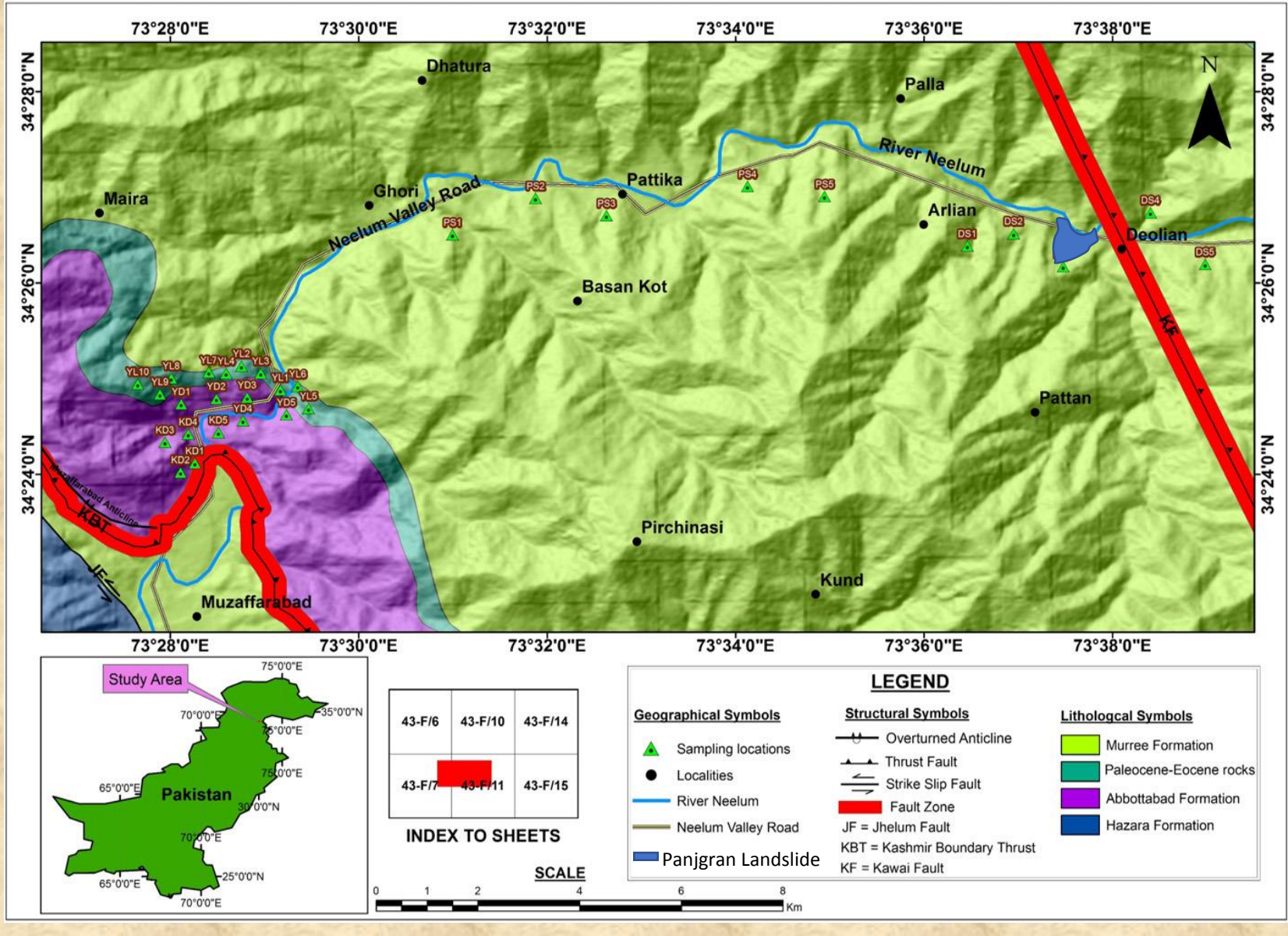


Fig. SPOT image of the epicentral area, Outline shows the boundary of the Panjgran landslide

- Two active faults Kashmir Boundary Thrust (KBT) and Kawai Fault(KF) are running through the area.
- KBT was responsible for the devastating 2005 Kashmir Earthquake. KF joins the Indu Kohistan Seismic Zone (IKSZ) which extends up to the Moho (Khan et al., 2012).
- These interformational (KBT) and intraformational (KF) faults have affected the physical and mechanical properties of the rocks present in the immediate vicinity forming a 200 m or sometimes more thick deformed zone.



- The rocks present in these fault zones are highly sheared, folded, weathered and in most parts are badly crushed to fine material

Objective of Study

The main objectives of the study are:

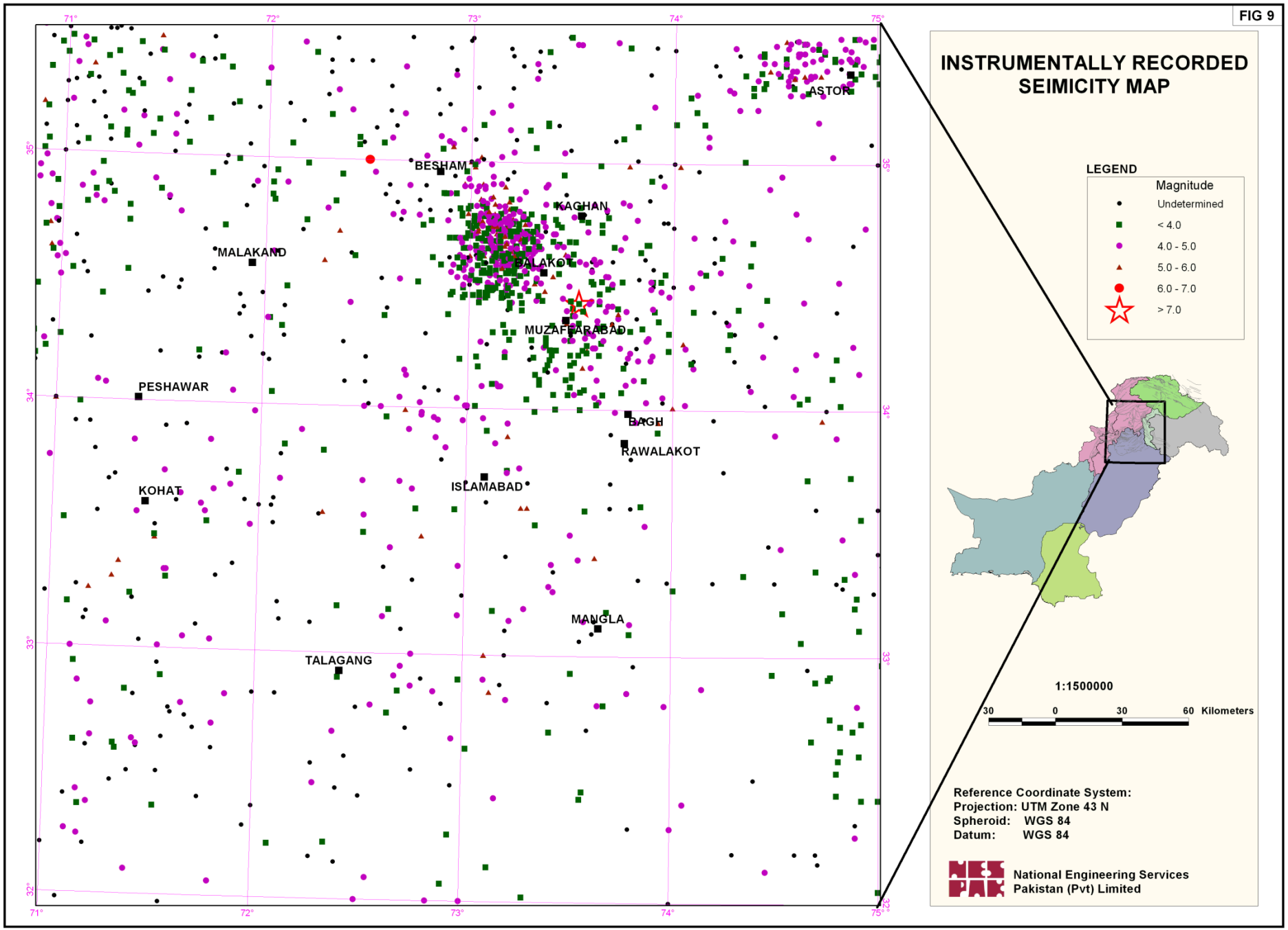
- To identify different causes of land sliding in the study area,
- To interpret the failure characteristics of deep seated Panjgran landslide in Neelum valley, Azad Kashmir, and
- To model and study the initiation mechanism and motion behavior of earthquake and rain induced landslides by reproduction of landslide initiation and develop a failure surface in the laboratory using the Landslide Ring shear simulator.

Causes

Natural causes

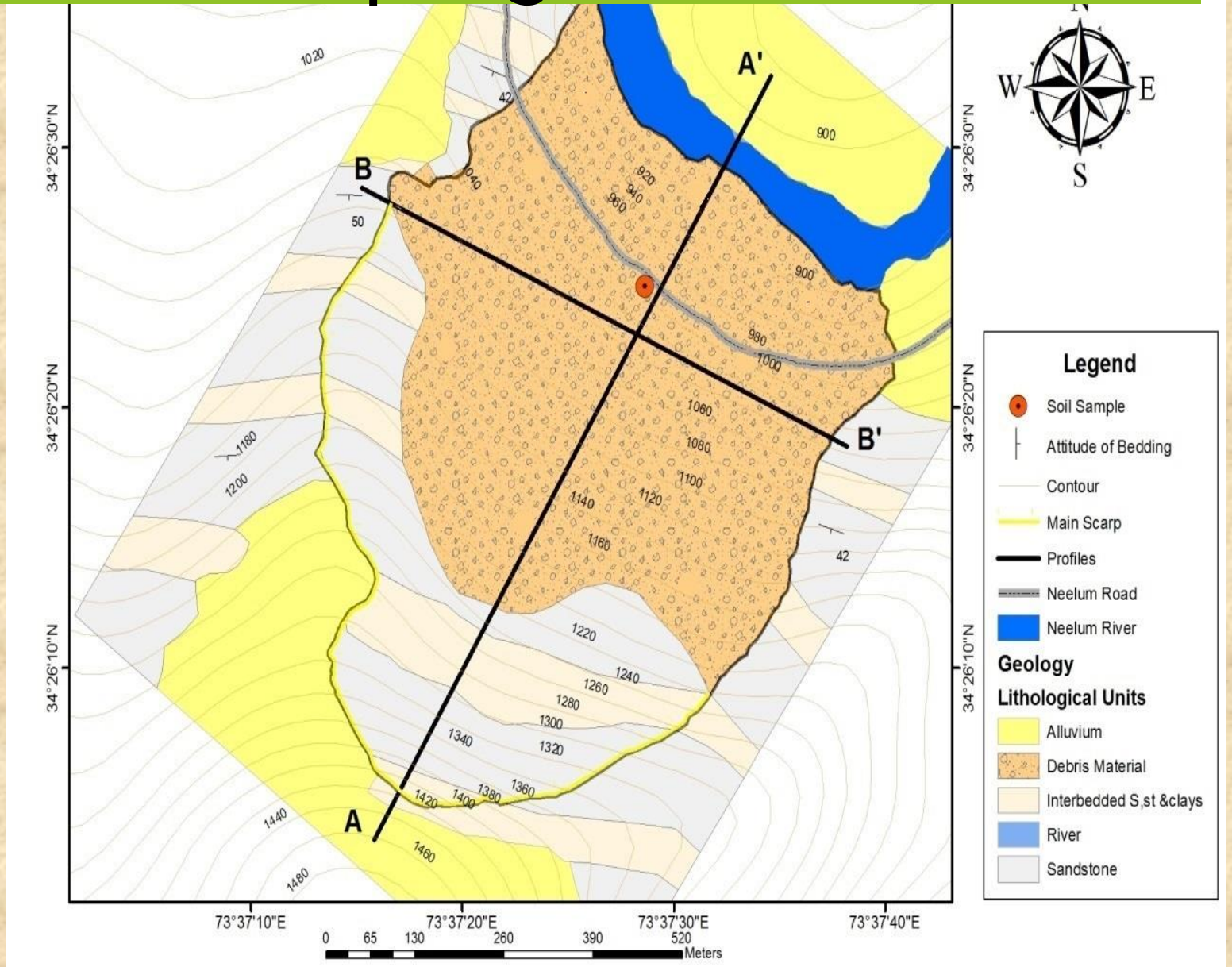
- Heavy Rainfall
  - Average annual precipitation 1511 millimeters.
  - Heavy rainfall events especially in July and August
- Seismic Activities
  - Collapse of steep rock walls
  - Coseismal mass movements
- Steep topography and Soil Erosion
  - Original slopes of area are steep and prone to mass movement

FIG 9

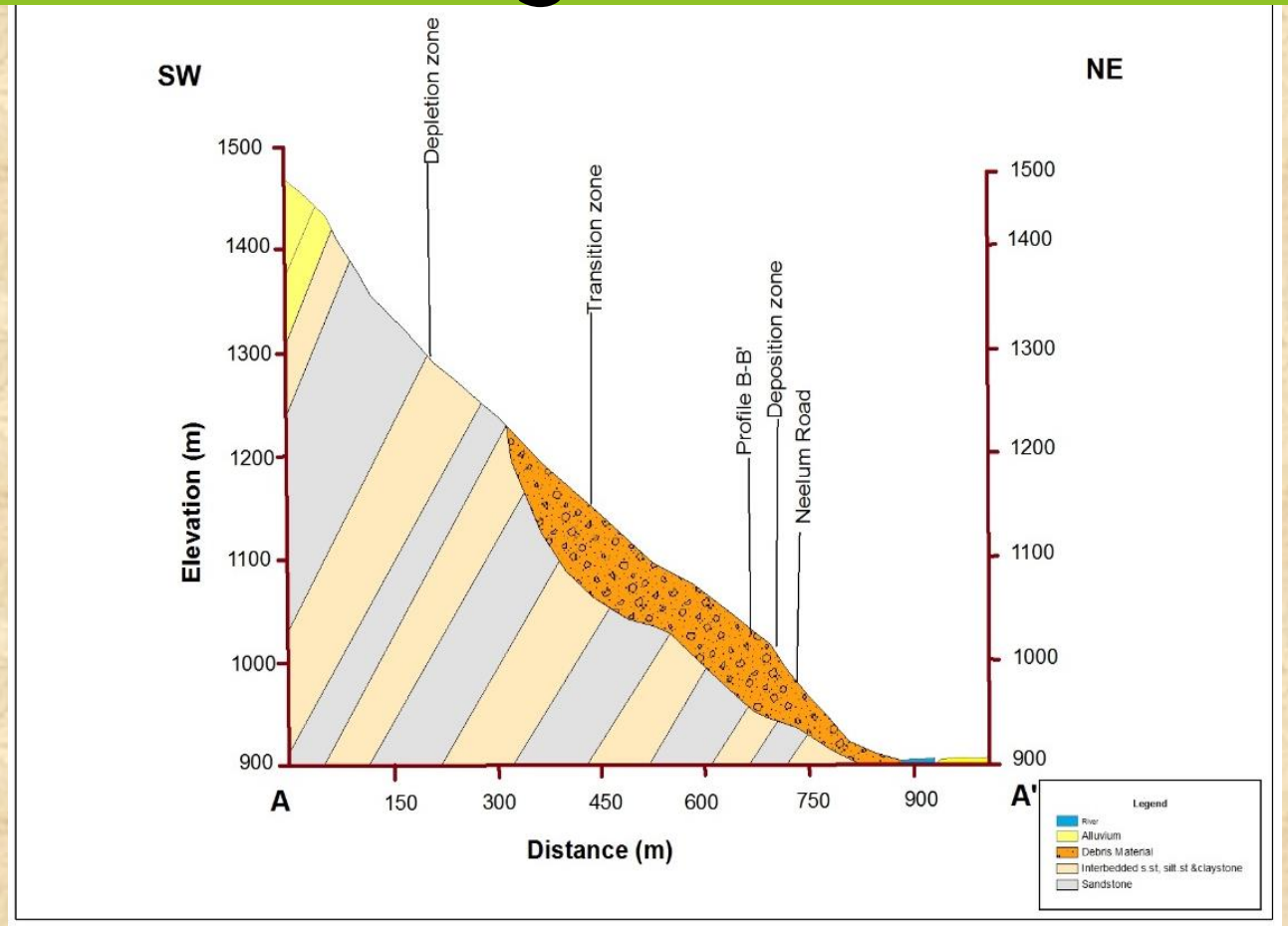

INSTRUMENTALLY RECORDED SEIMICITY MAP
LEGEND
Magnitude
Undetermined
< 4.0
4.0 - 5.0
5.0 - 6.0
6.0 - 7.0
> 7.0
ASTOR
BESHAM
KAGHAN
MALAKAND
BALAKOT
MUZAFFARABAD
PESHAWAR
BAGH
RAWALAKOT
ISLAMABAD
KOHAT
MANGLA
TALAGANG
71°
72°
73°
74°
75°
35°
34°
33°
32°
1:1500000
30 0 30 60 Kilometers
Reference Coordinate System:
Projection: UTM Zone 43 N
Spheroid: WGS 84
Datum: WGS 84
National Engineering Services
Pakistan (Pvt) Limited

Site investigation and soil sampling

- The Panjgran landslide is located in the Neelum Valley area 35 km away from the Muzaffarabad city. It is anold mass movement of the area which was reactivated in the 2005 Kashmir earthquake.
- Panjkot ridge (34° 25′ 47″ N; 73° 37′ 12″ E, altitude 1,450m asl) was the initiated point of this landslide.
- The landslide moved towards northeast of the Neelum river. The Neelum river had frequent undercut and oversteepened the slope in the area. This was one of the reasons to reduce the overall stability of the slope.
- Lithology of Formation at landslide site may be described as a series of alternate beds of sandstone, mudstone, clay stone and shale (cyclic deposition).



Site investigation and soil sampling



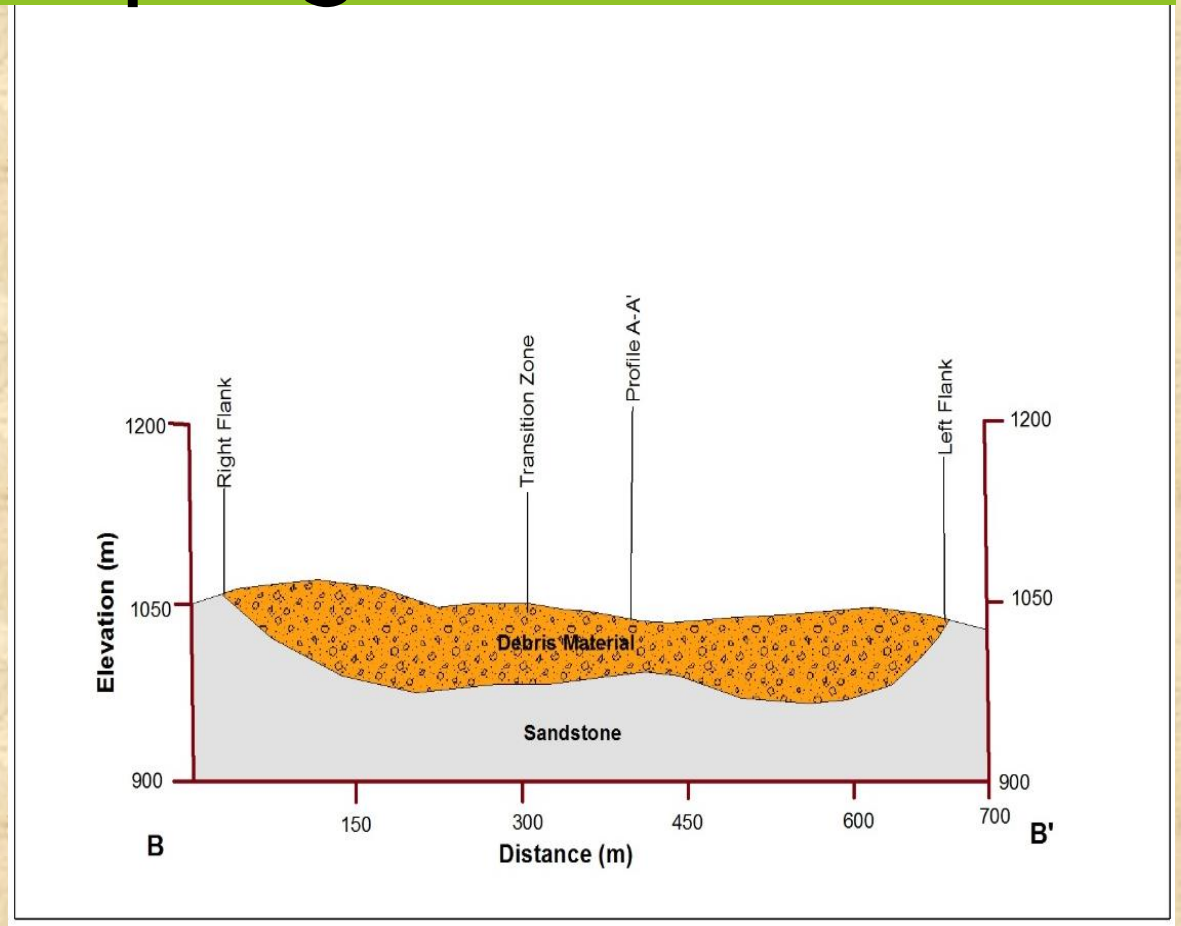


Fig.(a,b) Geological Cross sections of Panjgran landslide

- The shale/clay and mudstone is exposed at scarp along the road which has swelling potential. In rainy season, the argillaceous material, absorbs water and accelerate the movement.
- The landslide started at an elevation of 1450m asl from the Panjkot ridge. The length and width of landslide is about 950m and 650m. The rough estimated average depth of landslide is about 80m. The volume of the landslide is calculated approximately 6.75 x106 m^3.

Existing condition at Panjgran slide

Existing condition at Panjgran slide

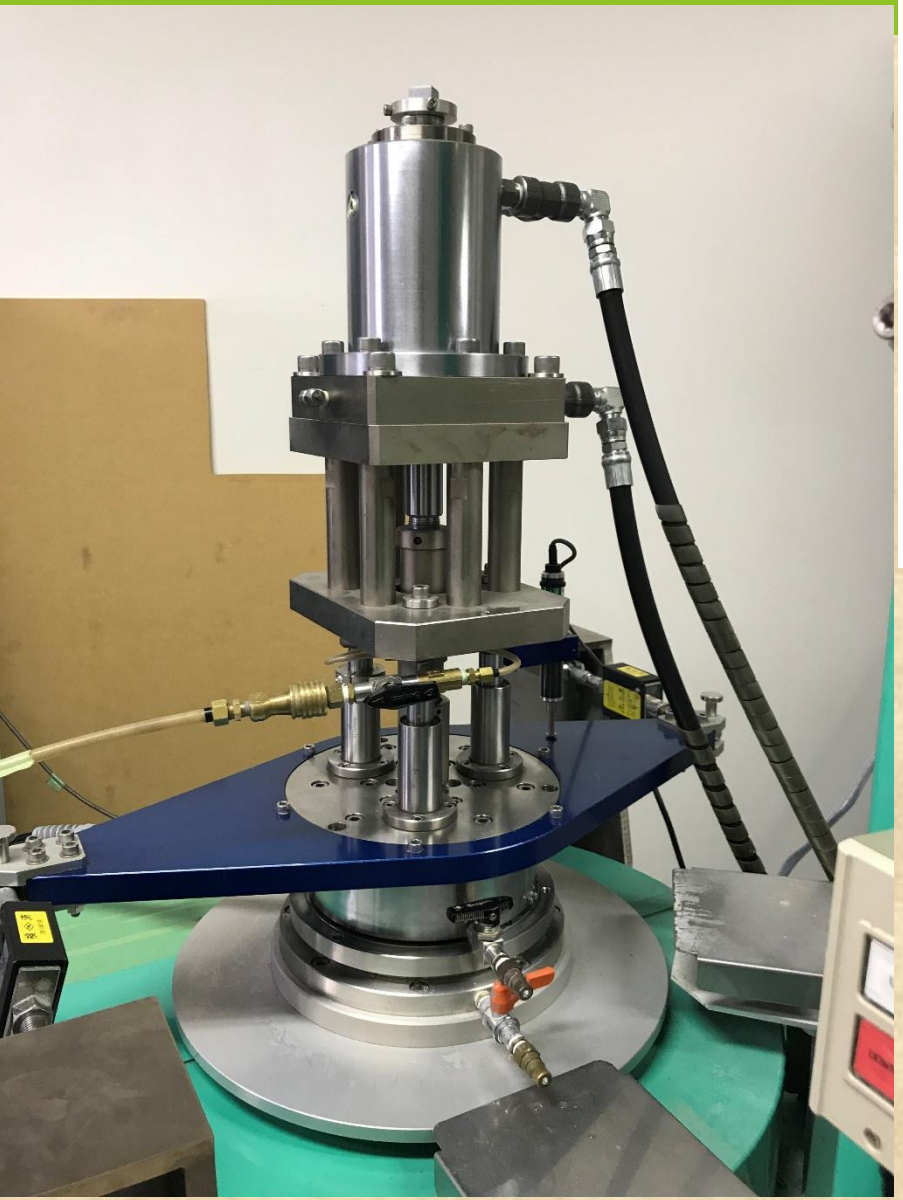
Some Landslides related Issues

- Blockage & Damage of Muzaffarabad-Neelum Valley & Muzaffarabad-Islamabad main roads.
- Scarcity of medical facilities in Neelum Valley due to blockage of roads.
- Human live losses.
- Damage to houses.
- Damage to infrastructure(bridges, electricity poles, telephone lines etc).
- Damage to Public & Private vehicles.
- Deforestation due to slope failure.

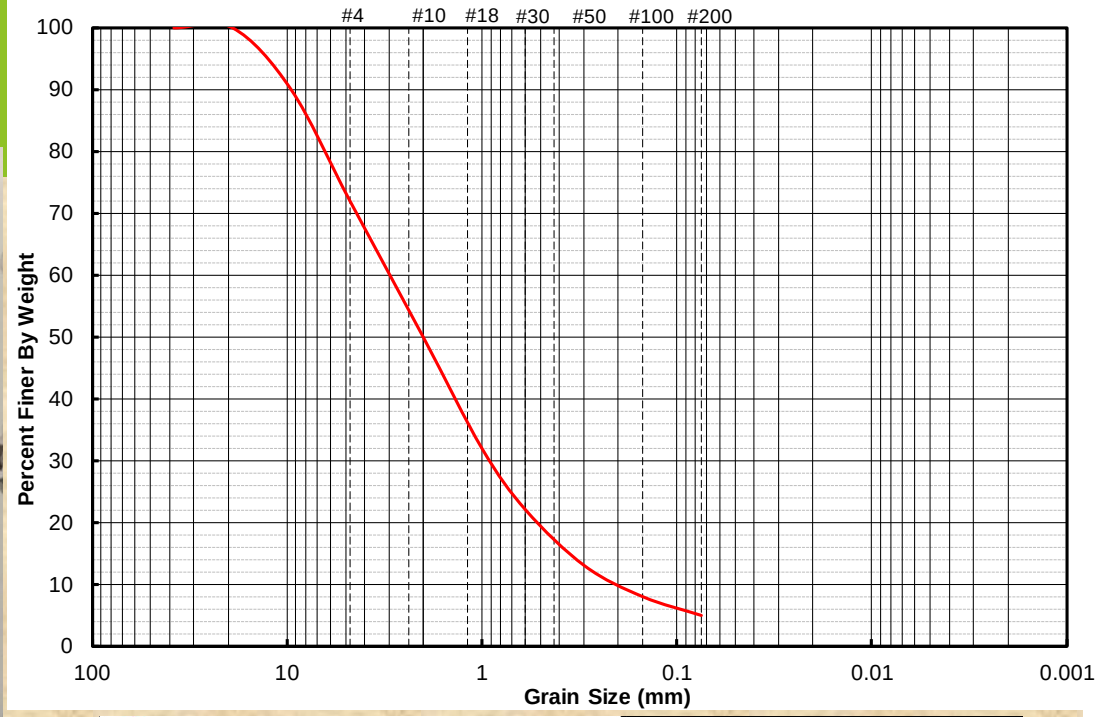
Landslides related Issues

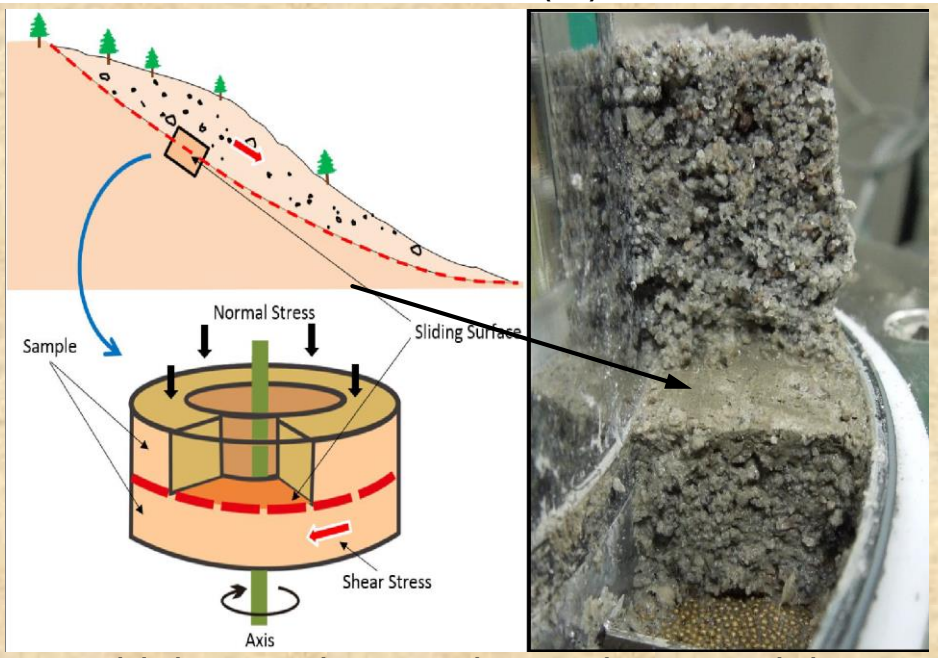
- Water and Air pollution.
- degradation of these natural resources (The debris flowing due to landslides not only caused human causalities but also polluting the water of Neelum River, which is the only available drinking source to the valley. The water pollution is posing a serious threat to the local community's health and life by spreading of various diseases to the population and environmental degradation to the aquatic fauna (water species i.e. fish, crab, fresh water mussels etc.).
- Debris produced by slopes failure may also increase the sediment load in the river. As entire AJK is a catchment area of the major reservoir e.g. Mangla, high sediment load can enhance the silting up of the dams and ultimately can reduce the life of the reservoirs as a long term hazard.

Test results

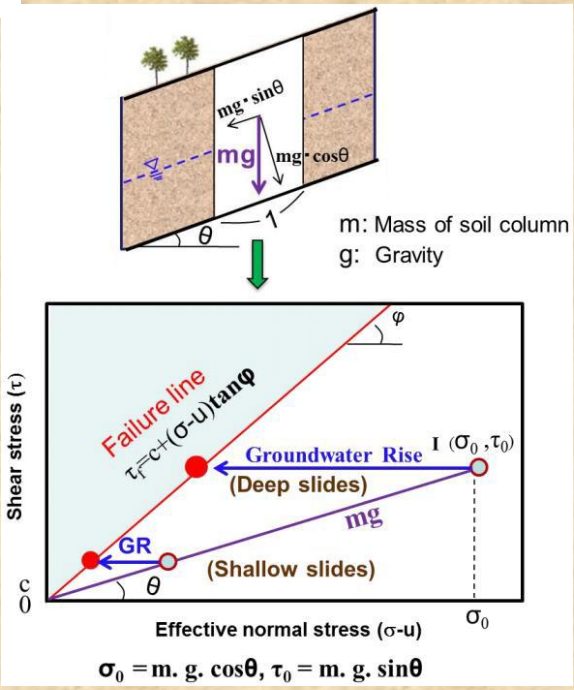


Landslide Ring shear apparatus ICL-2

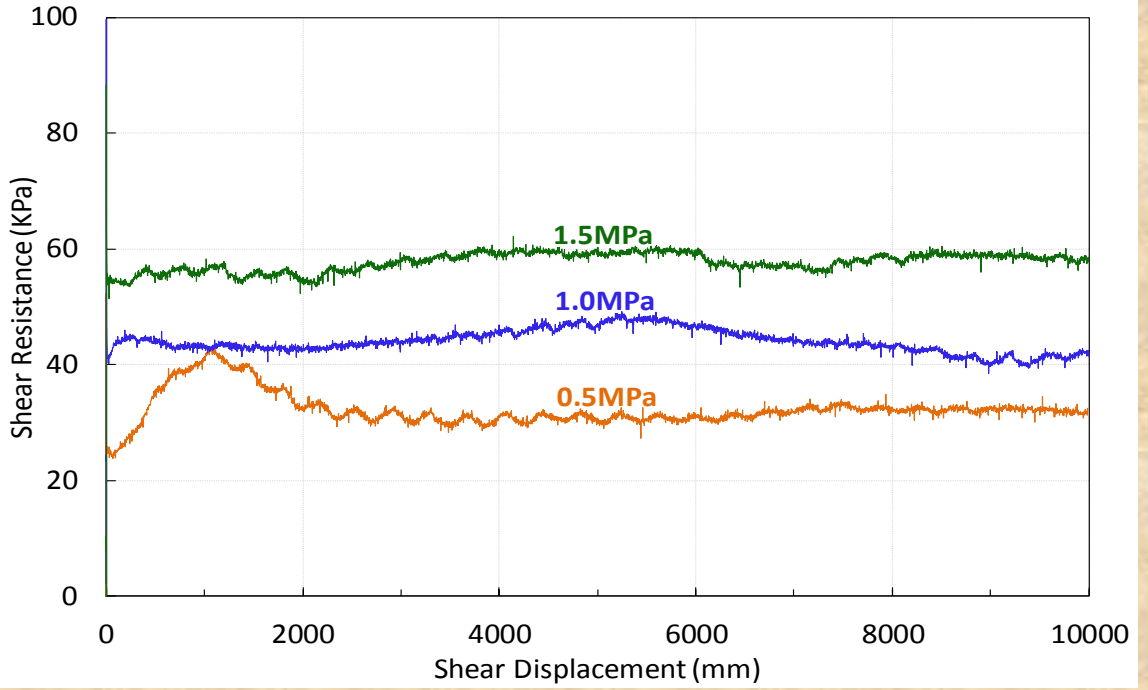


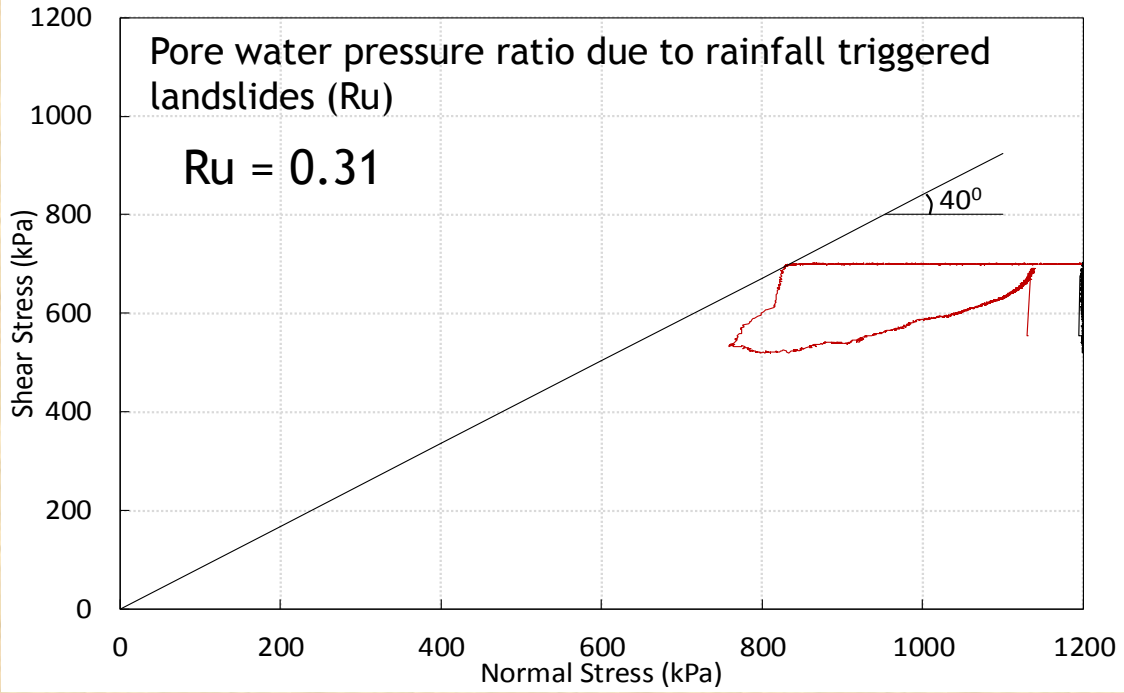


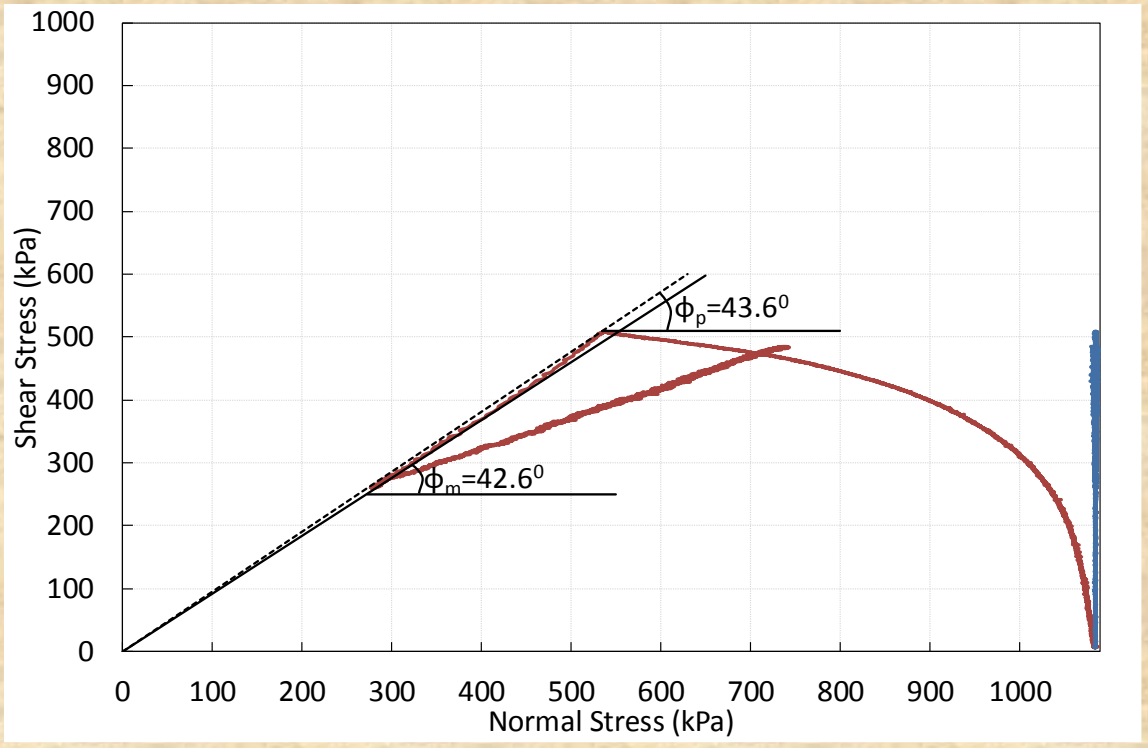
Landslide simulator (photo showing sliding surface after testing)

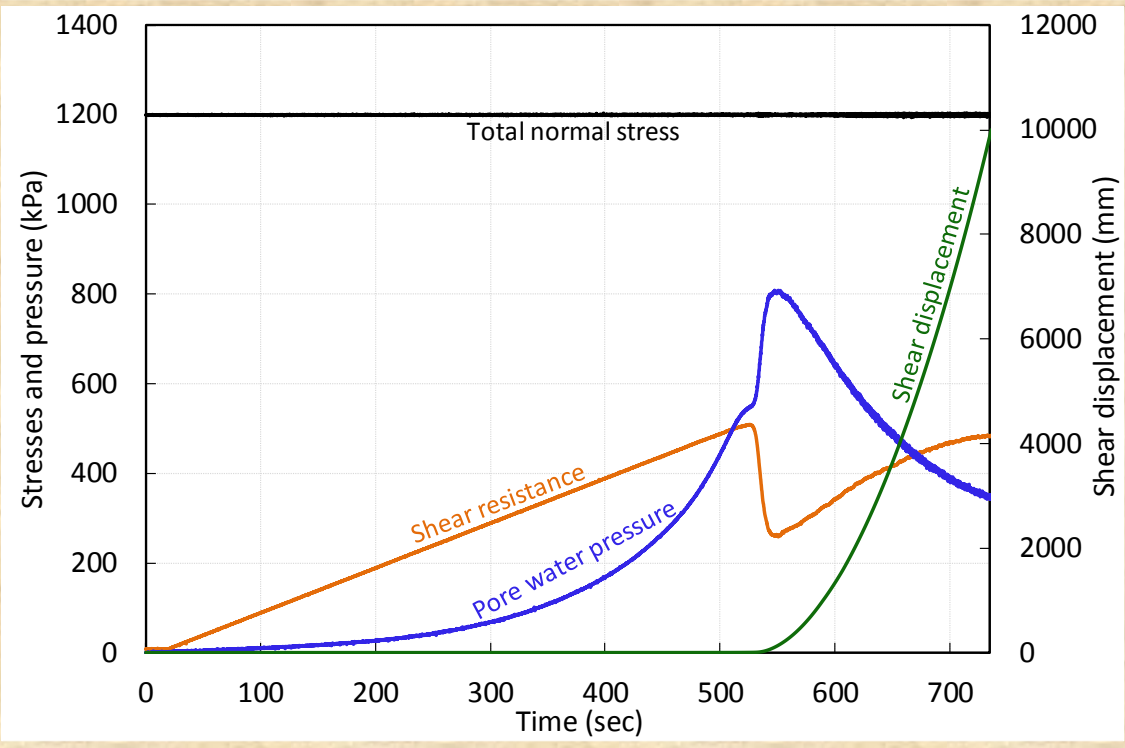


Stress conditions of slopes

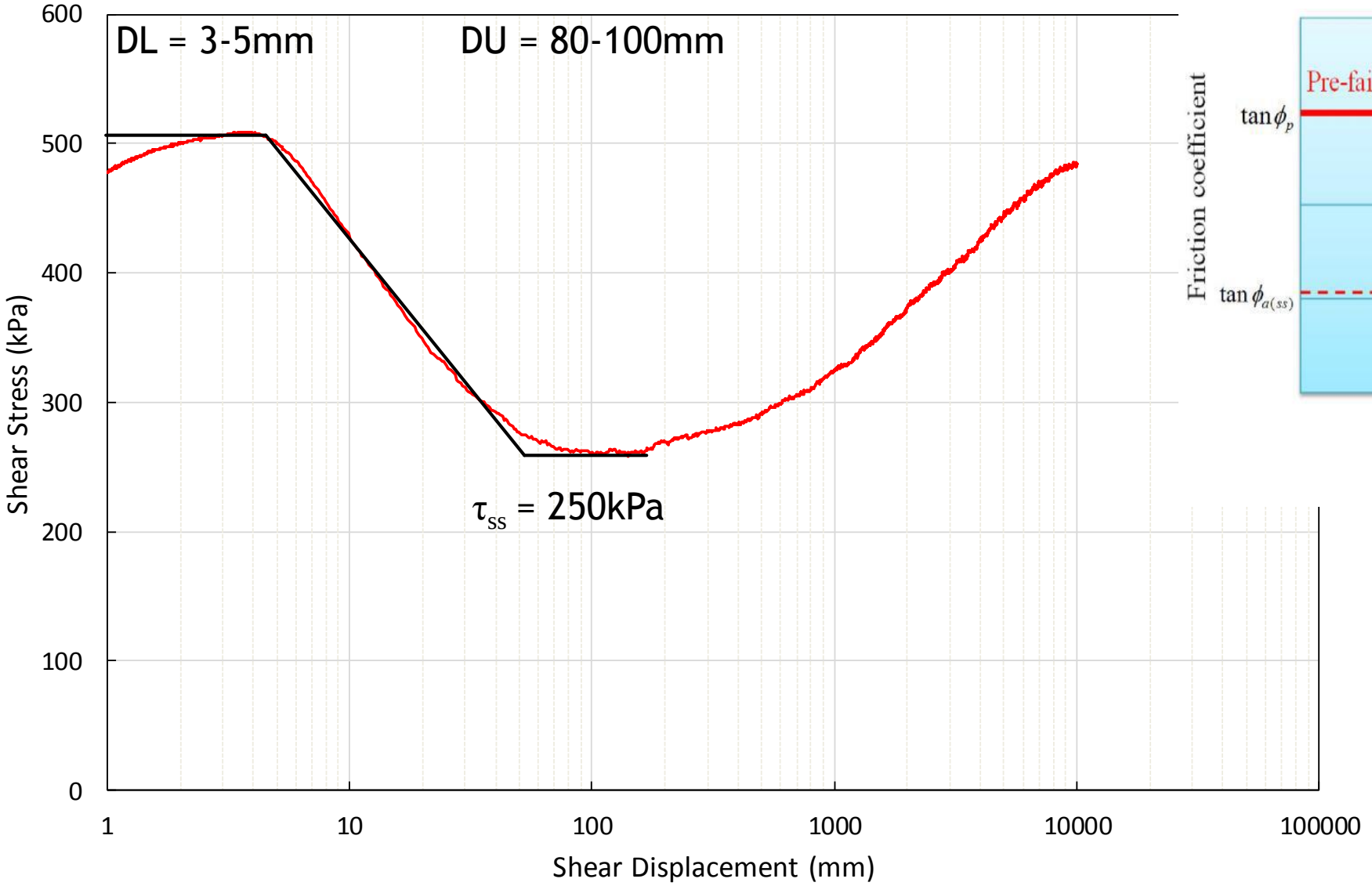

Shear Resistance (KPa)
Shear Displacement (mm)
1.5MPa
1.0MPa
0.5MPa

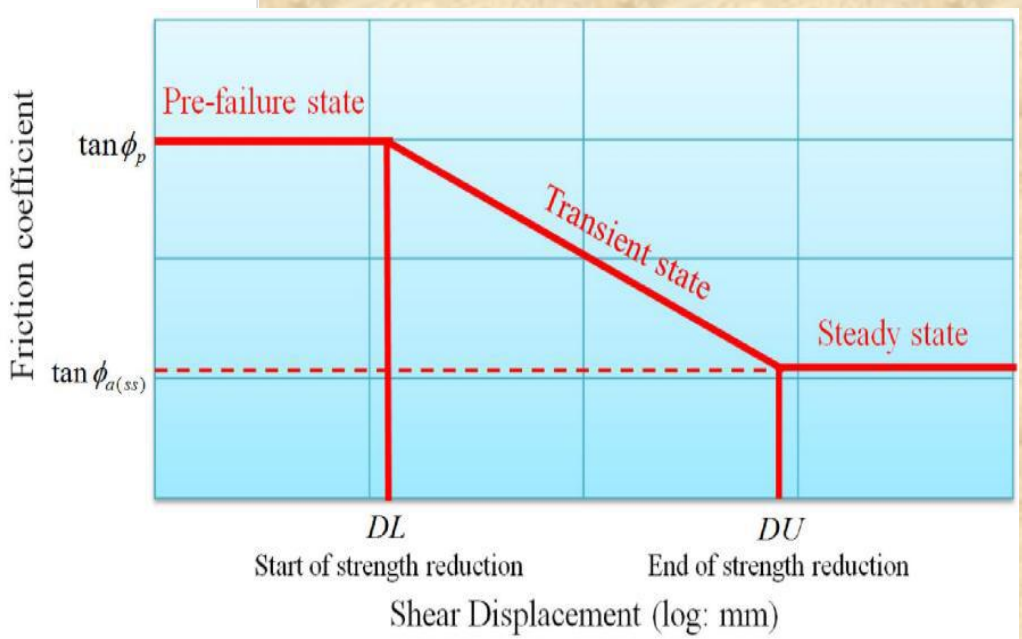

Pore water pressure ratio due to rainfall triggered landslides (Ru)
Ru = 0.31
40⁰
Shear Stress (kPa)
Normal Stress (kPa)


Shear Stress (kPa)
Normal Stress (kPa)
ϕp=43.6⁰
ϕm=42.6⁰


Total normal stress
Shear displacement
Shear resistance
Pore water pressure
Stresses and pressure (kPa)
Shear displacement (mm)
Time (sec)

Test results

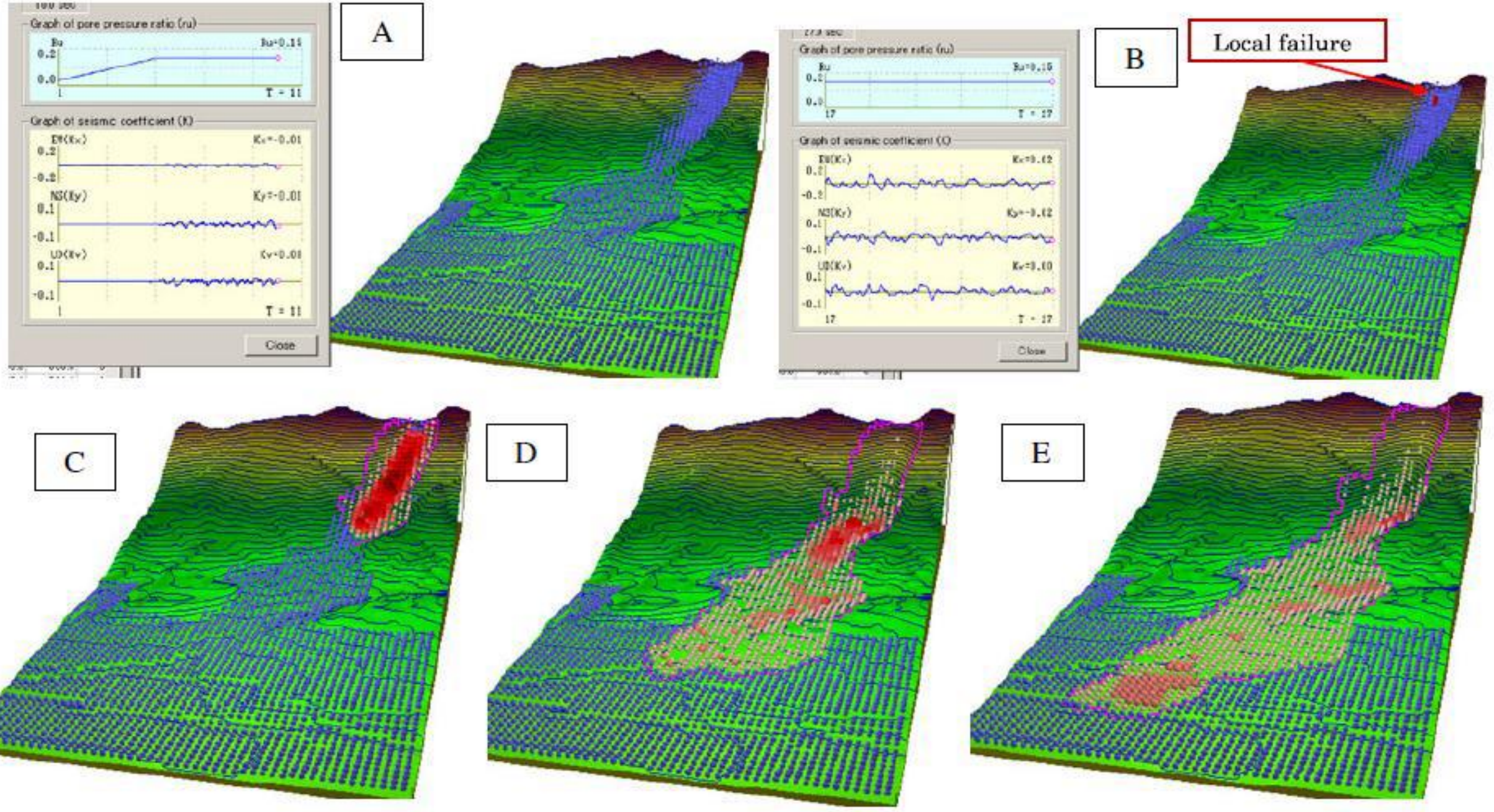




Excess pore water pressure generated under shear displacement which initiated the landslide failure; DL = 3-5mm.

Shear strength reduction in progress of shear displacement

Integrated computer simulation model (LS-Rapid)-an example study



Countermeasures in Practice

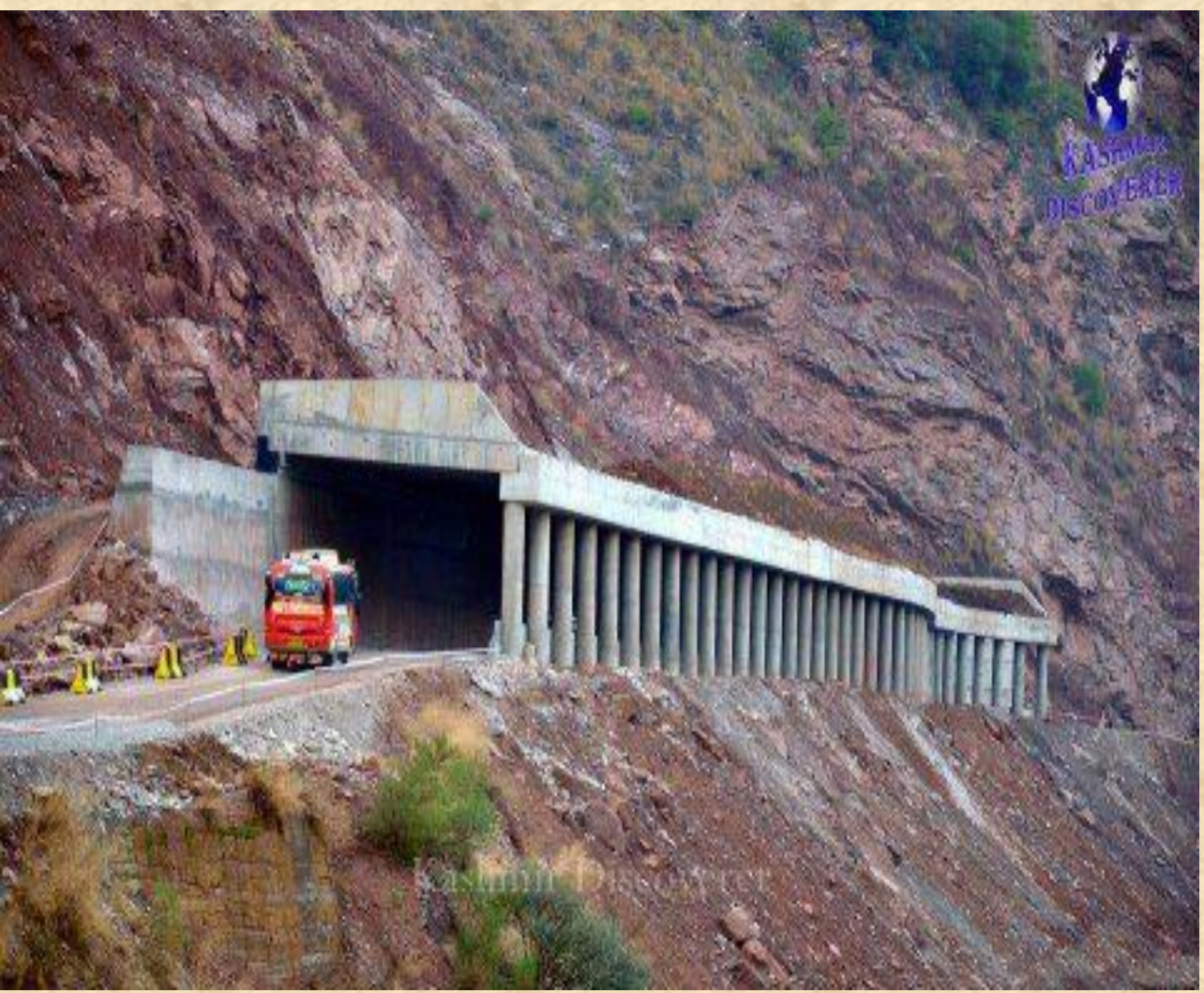
RCC Retaining Walls along Muzaffarabad-Islamabad Highway

Plantation Projects in Muzaffarabad

Gabion Retaining Walls near Murree

Stone Masonry Retaining Walls

Countermeasures in Practice



Land sliding Protection Tunnel in Muzaffarabad (Year 2012)

Conclusions/ongoing research

- The Panjgran landslide was first activated in 1988 and 1992 floods and was reactivated during the 2005 Kashmir earthquake in northern Pakistan causing many causalities and blocked the Neelum valley road for 60 days. The factors controlling the landside activity includes steep slope, presence of clayey material, construction of the Neelum road and river under cutting.
- The pore pressure control test for simulating the source area of the landslide suggested that a pore pressure ratio of 0.31 could have caused the landslide without an earthquake.
- Excess pore water pressure generated under shear displacement which initiated the landslide failure; DL = 3-5mm.
- Sliding surface liquefaction behavior observed during tests.
- This study can not only help in reducing the casualties but also in saving millions of dollars of nation by detailed analysis of the active landslide in landslide prone areas including geological, geotechnical, hydrological, and topographical data essential for the assessment of landslides. This research can provide a strong and practical base for the evaluation of risk and vulnerability assessment of the active landslides and slope failures in study area, and for the secured and cost-effective buildings and sustainable infrastructure in landslide prone areas.
- Seismic loading test results and simulation on LS-Rapid software are under process and their data will be published later.
- By this Project, the author will find an opportunity for long term international collaboration between Disaster Prevention Research Institute, Kyoto University and University of Engineering and Technology, Lahore Pakistan which will be beneficial for both countries.


Thank you for your Kind Attention