Effect of Natural Hazards on Types of Landslide

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ABSTRACT
To improve human settlement, the behavior of geo-hazard requires to be investigated. The geological, geotechnical and geomorphological of site, plays important role in occurrence of landslide. The rainfall, earthquake, erosion, tectonic features, major uplift, hurricanes, construction activities, sand/silt boiling air, volcanic gases, impulsive waves, and snowmelt are among the important factor in trigger of landslide. Authors made an attempt to review landslide phenomenon with consideration some important factors in trigger types of landslide.

Keywords: Geo-hazard, Landslide, trigger of landslide, types of landslide.

INTRODUCTION
The recent improvement investigation finding has been made near clear understanding in landslide, although much progress in reconnaissance is required be realize research priorities and summarizing requirement knowledge. The earthquake, triggered landsliding in saturated soil is a challenge of research in earthquake geotechnical engineering. The multidisciplinary from engineering geology, geomorphology, geotechnical engineering, seismology, hydrogeology and geophysics are required for solving and predicting geo-hazard mitigation and disaster management. To improve human settlement, the geo-hazard mitigation has to be investigated in detail.

It has been shown that the significant impact of landslide on landscape, regional and urban planning (Varnes, 1984; Anbalagan et al., 2008; Korup et al., 2010). The landslide is accelerated during rainy season in mountainous area due to heavy rainfall and severe rain storms subsequently caused destruction of infrastructure, environmental degradation and loosing life (Aleotti and Chowdhury, 1999; NCDR, 2004; Chen, 2009; Bui et al., 2011a; Song et al., 2012). For example Morakot of Taiwan faces big amount of rainfall over 3400 mm estimated annually. And sometimes extreme amount of rainfall not only caused severe flooding in coastal areas, and also triggered landslides (Lin et al., 2011), the dam site is generally located in valley and it is associated with potential landslide (Schuster, 2006), due to over surcharge during heavy rain. Earthquake can induce landslide and in the Peruvian earthquake of 31 May 1970 around half the 54,000 victims were due to a landslide (Kuroiwa et al., 1973; Keefer, 2002; Yin et al., 2009; Chigira et al., 2010; Dai et al., 2011;), the Terremoto delle Calabrie” earthquake in southern Italy is induced landslide (Sarconi, 1784). The erosion and tectonic features are triggering landslide (Bozzano et al., 2008). The tectonic features are prone to the landslides particularly in metamorphic rocks crop out, due to the extent of fracture and reduction of shear strength of the rocks (Conforti et al., 2014). The major uplift change site geomorphology and relocate clay sediment to the surface and due to
changing subsoil shear strength and drainage capability the landslide is expecting (Leroueil, 1997; Ma et al., 1999). The hurricanes is triggering landslide in submarine and imposed high risk to offshore structures (Mulder and Alexander, 2001). The 1999 Chi-Chi, Taiwan earthquake (Mw=7.6) caused in triggering around 26,000 landslides, over 2400 deaths and many casualties (Wang et al., 2002). The Cameroon is facing landslides periodically, and resulted in the loss of lives, flooding, failure of the transportation network, degradation of agricultural land, and collapse to infrastructure (Che et al., 2012). And many other part of world like are faced landslide frequently (North and Byrne, 1965; Guzzetti et al., 1999; Pradhan, 2010a; Preuth et al., 2010; Lin et al., 2010; Burns et al., 2011). It has been reported that China, Japan and Nepal have average over 150 deaths annually from direct and indirect landslide hazards. And landslides in Canada, the United States, Japan and India bring huge economic costs annually (Sidle and Ochiai, 2006). Due to landslide occurrence in many part of the world for that especial attention given to issue by Holmes and the World Bank, while there is an under estimation of landslide impact to the fact, subsequently United States Geological Survey indicated that the landslides destructive effect may exceed all other losses by natural hazard” (USGS, 2003). An attempt on landslide phenomenon with consideration priorities in next generation of research.

### Table 1: The some important landslides from 1949 till 2009

<table>
<thead>
<tr>
<th>Landslide Place</th>
<th>Date</th>
<th>Economical effect</th>
<th>Trigger</th>
<th>Type of slide</th>
<th>Area of 0.05 km² was overwhelmed by debris and 20 kishlaks buried</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khat in Tajikistan</td>
<td>July 1949</td>
<td>Approximately 7200 people killed</td>
<td>Liquefaction due to earthquake</td>
<td>Rockslide and loess flowsides</td>
<td>(Evans et al., 2009)</td>
<td></td>
</tr>
<tr>
<td>Vajont in Northern Italy</td>
<td>9 October 1963</td>
<td>about 2000 casualties and valley completely destroyed</td>
<td>Unknown</td>
<td>Sliding</td>
<td>(Bosu and Petti, 2011; Datei, 2003)</td>
<td></td>
</tr>
<tr>
<td>Calabria region in southern Italy</td>
<td>6 February 1783</td>
<td>1500 casualties</td>
<td>Main seismic shock</td>
<td>Rockslide and rockfall</td>
<td>(Gerardi et al., 2008; Bozzano et al., 2011)</td>
<td></td>
</tr>
<tr>
<td>Tal valley of Garhwal Himalaya in India</td>
<td>Late January 1990</td>
<td>-</td>
<td>Uplift</td>
<td>Rotation and slump movement</td>
<td>(Bartaryya and Sah, 1995)</td>
<td></td>
</tr>
<tr>
<td>Eastern Belgium</td>
<td>Late 1990s</td>
<td>Infrastructure damaged</td>
<td>Industrial sewage and rainfall</td>
<td>A rotational slide with a circular shear plane</td>
<td>Continued landslide</td>
<td></td>
</tr>
<tr>
<td>Limpio, Mount Cameroon, West Africa</td>
<td>27 June 2001</td>
<td>Destroyed 120 houses and 2800 people homeless</td>
<td>Minor earth tremor on volcanic cones</td>
<td>Planar sliding or mud flows</td>
<td>(Ayounghe et al., 2004)</td>
<td></td>
</tr>
<tr>
<td>Moravian of Czech Republic</td>
<td>27 March to 4 April 2006</td>
<td>-</td>
<td>Rainfall and thawing</td>
<td>-</td>
<td>(Bill and Müller, 2008)</td>
<td></td>
</tr>
<tr>
<td>Sichuan of China</td>
<td>7 July 2001</td>
<td>Around 200 people homeless</td>
<td>rainfall of 521.6 mm</td>
<td>Debris flow</td>
<td>(Zhang et al., 2011)</td>
<td></td>
</tr>
<tr>
<td>Kashiwazaki of Japan</td>
<td>16 July 2007</td>
<td>Destruction of road and railway sections</td>
<td>Mw 6.6 Earthquake</td>
<td>-</td>
<td>(Collins et al., 2012; Kuyey et al., 2009)</td>
<td></td>
</tr>
<tr>
<td>Wenchuan in Beichuan, China</td>
<td>12 May 2008</td>
<td>More than 20,000 fatalities</td>
<td>Mw 8.0 Earthquake, rainfall, uplift and erosion</td>
<td>Rockslide, rockfalls, debris flows and debris slides</td>
<td>(Tang et al., 2011; Yim et al., 2009; Gouram et al., 2011; Ouinet, 2010)</td>
<td></td>
</tr>
<tr>
<td>Southern Taiwan</td>
<td>7 August 2009</td>
<td>More than 400 people killed, dammed the river and buried village</td>
<td>rainfall of 1676.5 mm</td>
<td>Rockslide and rockfall</td>
<td>(Hsiieh et al., 2012; Tsou et al., 2011)</td>
<td></td>
</tr>
<tr>
<td>Sicily of Italy</td>
<td>1 October 2009</td>
<td>37 fatalities, 31 people death and 6 missed</td>
<td>Rainfall</td>
<td>Shallow soil slide and debris flow</td>
<td>(Mondini et al., 2011)</td>
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THE SOIL MINERALOGY ASSOCIATION TO LANDSLIDE

The extensive sediment from erosion process has been accumulated in vessel and it is decreased drainage capability and accelerated heavy erosion on slope side beneath vessel due to heavy rainfall water over flow when the vessel drainage not work under appropriate condition, in this case the rainfall and over flow from drainage system are important factors in erosion quantity. The shear crack appeared on vessel body due to reducing subsoil shear strength and subsoil differential settlement, subsequently resulted in failure of drainage facility (figure 1). The soil shear strength is imposed by drainage capacity and vessel self-weight. The area of vegetation-less more vulnerable on erosion and make more suitable slope for sliding and flowing debris. In figure 1 part 5 and 6 show the heavy erosion resulted in changing site geomorphology. The appropriate vegetation cultivation helps in enhancing slope safety factor as well as stabilization site geomorphology. It may be recommended that the naturally slope stabilization from suitable vegetation cultivate is more permanent and help in improving environment. Water tends to seep fast in loose layers. In clay layer the amount of water flow velocity is depend on bonding between silica and alumina sheets of clay mineral. In montmorillonite bond between silica and alumina are very weak and water easily enter between layers and caused swelling and impermeability of layer. The illite and kaolinite have stronger bonding between silica and alumina sheets, it is caused less swelling and impermeability. The bond between silica and alumina are controlled time for increasing degree of saturation if the bond between silica and alumina strong the increasing degree of saturation are need more time compare to weak bonding. The soil mineralogy is important factor in erosion caused landslide. The landslide accelerates during heavy rainfall, with in site subjects to erosion with respect mineralogy types. According to (Cevik and Topal, 2003; Dai et al., 2001; Saha et al., 2002; Yalcin, 2008) the slope instability effect by drainage systems, as river erosion undercuts the foot of the slopes together with saturation of their lower part. In landslide mitigation requires to investigation soil texture, mineralogy and morphology.

Significant challenges regarding pore water behavior in accelerating positive pore water pressure and creating liquefied zone and layer which can be applied suitable mitigation technique are include:

- High cost of lithology and subsoil mineralogy investigation.
- Incomplete coverage of area is vulnerable against liquefaction.
- Imperfect geological, geotechnical and geomorphological data leading to errors in selecting suitable mitigation technique.
LIQUEFACTION, LANDSLIDE AND PORE WATER PRESSURE IN SOIL

Some of factors increase the pore water pressure is ground shaking, soil moisture condition, soil morphology, soil mineralogy, flow speed, and hydraulic conductivity.

The material mechanical property is changed from unsaturated state to saturated state and induced internal stress while the friction angle is varied according to water content and the cohesive force reduces substantially and resulted in plastic deformation and it changes from static frictional strength to lower dynamic strength. The landslide is situated in the rainsstorm center. Most of the precipitation occurs during increasing underground level (Qi, 2006). Excess pore water pressure in subsoil occurs due to rainfall, earthquakes, coastal erosion, and construction activities (Bull et al., 1994). The pore water pressure has been analyzed for slope stability of the landslide dam (Chen, 2011). The sand/silt boiling accelerates excess pore water pressure and liquefying subsoil and expect sliding slope in subsoil. And in rock slope the saturation don’t have important role (Evans et al., 2009). Under dynamic condition with seepage, the water is isotropic medium with elastic and incompressible behavior, in such condition the excess pore water pressure is in relation to the plastic material inertial displacement, deformation and confined loads. And the numerical model does not simulate excess seismic pore water pressure. While the frequency has important role in controlling excess pore water pressure (Martino and Mugnozza, 2006).

The high groundwater level in subsoil make environment suitable for high pore-water pressure and liquefying subsoil, it results shear strength reach to less than shear stress. The degree of saturation in soil is responsible for many landslides, but still several landslides can be seen when the soil is under dry condition. According to the Legros (2002) air, water, vapor, and volcanic gases can cased fluidize landslide.
The large rockslides can be started by pore-water pressure. And submarine landslides and rockslides may generate impulsive waves (Ataie-Ashtiani and Najafi-Jilani, 2008; Schulz et al., 2012), such wave accelerate excess pore water pressure in the subsoil and resulted in slide instability and reducing factor of safety. Galve et al., (2009) identified some large slides are triggered due to water level variations in reservoirs, and it is depend on distance of reservoirs, which is very important in hazard risk assessment. Ayalew et al., (2005) are realized that landslides occur when additional moisture is induced during rainfall and snowmelt. Borgatti and Soldati (2010) climate change increased landslide. It can be understand that the gravitational force, and shear resistance of soil is changed. Lo et al., (2011) have been indicated that the due to increasing degree of saturation in soil and under liquefaction condition the effective stress and the shear resistance almost drops to zero, although low friction along the sliding surface is the reduction of effective friction coefficient because of pore-fluid pressure. Malet et al., (2005) has been declared slope failure process from starting landslide up to end sufficiently high pore-pressure to reduce the effective stresses is required.

The water stored in sensitive layers influences on slope stability (Preuth et al., 2010), It is due to the pore-water pressure data is important factor in landslide (Ohlemacher, 2007), and it has to more investigate. The pore water pressure can change shear strength and shear stress, duing rainfall (Crozier, 2010). The ephemeral stream in hill in rainy season is a factor for water level (Che et al., 2011). The rainfall plays an important factor in reduce the soil suction and increase the positive pore-water pressures (Corominas and Moya, 2008), the history of rainfall can help in predicting pore water pressure in subsoil for mitigate seasonal landslide disaster. This point has to consider in urban design, site planning and infrastructure planning improving factor of safety. Schulz et al., (2012) has been find that rockslides not occurred from gravitational loading and rising pore-water pressures. The rockslide formed from rising pore-water pressures caused by seismic force.

LANDSLIDE ZONATION AND MAPPING

Data-mining is introduced by Shannon (1948). Landslides occur under water, in lakes, seas, and the oceans (Mosher et al., 2010). To investigate on landslide mechanisms monitoring required high accuracy in order to better mitigate natural all hazards including liquefaction. The liquefaction may be generated in form of static or dynamic which is depending on nature of pore water pressure. However the precise research works consumes time and requires especial attention in all stages for avoiding produce poor information. The liquefaction is triggering landslide.

Based on resolution requirement several techniques of remote sensing have been introduced to create digital terrain models (DTMs) for investigation on landslides (Metternicht et al., 2005). The application of key technique in landslide prediction is interesting issue in international scientific committee (Zhu et al., 2004; Wang and Niu, 2010). In landslide prediction using mapping technique the several independent factors related to the landslides have been investigated such as slope geometry, land use, soil using, landslide hazard assessment map, rock and soil strength, slope geometry, permeability, precipitation, presence of the old landslides, proximity to the streams and flood-prone areas, land use patterns, excavation of lower slopes and/or increasing the load on upper slopes, alteration of surface and subsurface drainage, engineering rock group, reservoir water fluctuation, geological structure, stratum, lithology, terrain, geomorphology, vegetation coverage, rainfall, human activities, elevation, topographic-wetness index, stream-power index, beding attitude, seismicity, stream evolution, groundwater conditions, climate, vegetation cover, relief amplitude, distance to roads, distance to rivers, distance to faults, drainage density, Paleotopography in Quaternary sedimentary environments, material, effective thickness, forest and soil texture (Guzzetti et al., 2000; Dai and Lee, 2002; Gokceoglu et al., 2005;
Jamaludin et al., 2006; Pan et al., 2008; Yeon et al., 2010; Chauhan et al., 2010; Wang and Niu, 2010; Bui et al., 2011a; Bièvre et al., 2011; Xu et al., 2012; Cheng et al., 2012; Bui et al., 2012; Piacentini et al., 2012) still several factors have been left for precise understanding fundamental of landslide prediction.

MITIGATION TECHNIQUE FOR LANDSLIDE AND ROCKSLIDE

The numerical simulation of landslide is investigated (Tinti et al., 2006). The landslide has been modeled based on measuring acceleration (Watts, 1998), the produced date is applicable for reconstruct velocity (Watts et al., 2000). The landslides characteristics such as frequency, magnitude and consequences are important for hazard risk assessment (Stefanini, 2004; Gorsevski et al., 2006). The modeling natural hazards result in acceptable mitigation (Abadie et al., 2010).

To propose mitigation technique for slope failure, there are several factor caused landslide and rockslide.

Figure 3: Rockslide on Road into Beichuan, China. Photo was taken around October 21, 2008 (Photo by Dave Wald, U.S. Geological Survey).
Several recommendations are indicated here incorporate to discussions have been presented for identifying research priorities for mitigate landslide hazard. It will coverage appropriate next research generation.

Analysis of void ratio in triggering landslide in unsaturated soil and comparison its effect with linear and nonlinear pore water pressures in saturated soil.

The pore water pressure in linear shape produced from seismic force, it is able to generate stress more than strength of slope material. The static or linear pore water pressure collapse whole or partially slope. The climate change is an important issue in producing static pore water pressure and required to be more investigate. Among the factors produced landslide the soil degree of saturation, flow speed, permeability coefficient, internal stress in soil mass, friction angle of soil mass, soil cohesive, soil natural displacement, soil natural deformation and soil suction are will be change due to climate change and require to be investigate perfectly in detail.

Identify liquefiable layer and zone, and liquefaction magnitude movement for realize landslide zone and slope stability assessment.

As mentioned many factors have been investigated to predict landslide, the liquefaction zonation, wave propagation in subsoil zonation due to soil and rock mineralogy and morphology and tsunami have to be investigates in order to find acceptable mitigation method. Understand slope potential failure in respect to allowable settlement and deformation to comparative mitigation techniques. The numerical simulation, experimental and physical landslides are required to be compared for near accurate failure mechanism interpretation.
CONCLUSION AND SUMMARY

- The several factors cause landslide including rainfall, earthquake, erosion ..... have discussed.
- Quantitative erosion due to rainfall and rainstorm have to be assess in performed at the landslide potentially affected areas, based on the observation of past landslide events as well as soil engineering properties.
- None appropriate drainage infrastructures accelerate erosion and it is resulted in collapsing drainage infrastructure as well as occurrence of landslide under heavy rainfall.
- The mineralogy investigation is shown that there is close relationship between soil mineralogy with amount of erosion, workability of drainage facility and landslide possibility.

REFERENCES


27. Crozier, M.J., Deciphering the effect of climate change on landslide activity: A


43. Kayen, R., Brandenberg, S.J., Collins, B.D., Dickenson, S., Ashford, S.,


Internet Sources

http://landslides.usgs.gov/learning/photos/international/landslides_from_the_sichuan_wenchuan_earthquake_china_may_2008/img_0843.jpg
http://landslides.usgs.gov/learning/photos/international/landslides_from_the_sichuan_wenchuan_earthquake_china_may_2008/wenchuanday2_164.jpg

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