LANDSLIDES; GEOTECHNICAL ASPECTS FOR EARLY WARNING SYSTEM, A REVIEW.

[1]Shakeel Ahmad Dar, [2]Dr. Amit Srivastava
[1]M.tech Geotechnical Engineering, [2]Professor Of Civil Engineering,
[1]Lovely professional university, punjab

Abstract;
Landslides are complex hazardous phenomenon occurring in nature due to interaction of nature's forces like rainfall infiltration, seismic activities etc with the soil Skelton or due to unmanaged human exploitation of soil resources for construction purposes. Landslides can cause damage to human life and infrastructure, the magnitude of damage depending upon spatial, geological and morphological aspects of vulnerable soil slopes. Mitigating the damaging effects of landslides becomes necessity and an Early Warning system based on evaluation of interaction of geotechnical parameters of soil slopes with those of rainwater infiltration at the time of trigger comes into picture. While the conventional stability analysis approaches are not convincing, for real time assessment of potential instability, concepts of unsaturated soil mechanics forms a strong basis especially for rainfall induced landslides. This paper reviews some of the fundamental geotechnical aspects for risk assessment of rainfall induced landslides.

Key words; Landslides,stability analysis, infiltration, soil suction, pore water pressure.

Introduction;

Landslides are gravitational mass movements of rock, debris or earth. Landslides occur when gravity overcomes frictional forces which is keeping layered soil masses or rocks in their place. Both lives and property are exposed to the danger of landslides especially in regions of world where local residual soils are subjected to heavy rainfall from time to time. Steep terrains of mountainous areas where climatic conditions have intense rainfall events following hot and dry periods, destabilised soil mass of slopes affect large populations in each such season of each year. Amongst the common factors are the the infiltration of rainwater and the human activities of cutting slope toes for building construction and loading of slope tops beyond their limits. Besides these deforestation over slopes, earthquake shaking, surface irrigation, soil leaching etc like factors leads to slope instability and landslide is due to slope failure. Rainfall induced land slides are common in India. Heavy rainfall besides adding extra weight to soil, percolates and mixes with it to form mud which acts as lubricant for facilitating sliding. Landslides as catastrophic events can lead to human injury, loss of life and economic devastation. Buildings and road infrastructure in hilly areas located within the boundary of landslides gets damaged. A common most method of analyses in stability of slopes includes influence of rainfall in changing the groundwater flow patterns either due to increase of pressure heads and thereby rising soil's groundwater table and reducing stability. But depending upon the infiltration characteristics of a soil, other pore water pressure profiles do exist and delimit the traditional cause of rise of water table to trigger the mechanism. This brings the scope of other possible failure mechanisms other the the traditional to be investigated. For example the rainfall infiltration may cause failure in otherwise dry slopes not due to generation of positive pore water pressure but due to loss of unsaturated shear strength due to dissipation of soil suction upon progression of wetting front(Fredlund and Rahardjo 1995; Menezes and de Campos 1991). An Extraordinary rainfall event may trigger most of the landslides, still most often majority of slopes stand and only a few of them fail by sliding. Thus it is the hydrology in and around a landslide area that is critical factor to pore pressure development in the slope soil skeleton to reduce its shear strength due to the buoyancy force generation by water within a saturated soil mass and to elimination of soil suction in an unsaturated soil slope .

Analysis of Geotechnical controlling factors, Review of Literature;

Landslide is the detectable sliding down of soil mass (debris and earth) or rocks under the influence of gravity. The cause is usually the reduction of shear strength in saturated soils due to infiltrated water's buoyancy effect or the dissipation of suction in unsaturated soils. For such soil masses, the shear strength will be decided by the degree of suction i.e. negative pore water pressure in their pore water pressure profile. Such a change occurs over a long time making slope prone to failure and a trigger acts as a last push to throw the slope to become unstable. The conventional trigger of positive pore water pressure generation by rainfalls of severe intensity in saturated slopes is well explained (Jaakkola 1999 and Fennin 1990; Sitar and Johnson 1990). Thus any change in the driving force can cause landslides and when it is the pre-wetting of soil system , then this cause has hydrological nature or for rainfall induced landslide trigger is hydrometeorological in origin(Roberto Greco and Thom A. Bogaard, 2016). In the slope of soil mass, the evolution of the pore water pressure profile will decide the origin and progression of seepage forces also. This pattern of pore pressure developing in the soil will occur as a transient process with wetting front moving ahead in soil pores (Dobroslav, brian D. Collins 2004). For a thorough investigation of failure depth, both the shear strength and soil's hydraulic characteristics are contributing and not a single one is deciding factor. Besides rainfall event's duration and intensity, the matric suction and its impacts on degree of saturation and permeability variation are other critical factors for assessment of state of instability (Chiranjib et al. 2015). A relationship between parameters of a rainfall and soil properties with the cause of failure upon rainfall infiltration shows that in case of fine-grained soils it is loss of suction due to low infiltration rate that causes loss of shear strength and hence trigger of slide. However it is the high infiltration rate in coarsegrained soils that cause the seepage forces to develop due to positive pressure heads in their slopes.

More likely shallower slope failures are results of positive pore pressure development(d Campos et al.1990) and that deeper failures due to loss of suction(Rahardjo et al. 1996). For a calamity like landslide the measurement of probability of a given magnitude of failure is an assessment of its hazard. Any such technique is dependent upon acquiring detailed geotechnical information of the in situ conditions. Anyway the examination results relies significantly upon the information parameters and in this way broad field examinations, laboratory soil testing, and precipitation information should be gathered. A geotechnical analysis on this data can be used to establish a relationship between analysing agent and initiating agent with that of triggering threshold for a predictive formulation of landslide event. Thus in a broad framework of Landslide risk assessment and management, the parameters to be evaluated will be probability of a particular magnitude landslide, spread behaviour of landslide, risk associated, exposure and vulnerability of people and their assets to landslides(Dai F.C. et al. 2001) and management will include decision making in estimation of the level of risk, devising mitigation measures to reduce the impact, if the level of risk is unacceptable(Ho et al., 2000).

The success of landslide risk assessment and management will depend upon thoroughness and quality of historical landslide data and related social and physical data.A landslide early warning system(EWS) aims at minimising loss of life and property and avoiding costly projects of ground stabilization as an alternative. Such a tool forms an important component in the management of landslides. This EWS based on corelative geographical and geotechnical aspects comes into need for an advance/early recognition of land slide indicators, so that vulnerable inhabitants can be rescued from potential landslide hazards in their areas. Such a framework is conceivable through comprehension of soil actual properties in real time or near real time with changes in destabilizing factors like precipitation occurrence. For an illustration, from the analysis of available literature regarding landslides occurrence, it is observed that these catastrophic events start to occur or are triggered only once a maximum or minimum level of some quantity like moisture content in the case of rainfall induced landslides called ‘threshold value or critical value’ occurs. The reliable estimate of such triggering factor can be incorporated into landslide early warning system, the success of the EWS will depend upon the correct correlation and quantification of this triggering threshold value to a reliable one. For reliable results from rainfall- landslide relation, the data should extend over large time span of history both for landslides and rainstorms. The analytical results being greatly influenced by period of historic data, landslide-rainfall relation should be upgraded every time new data becomes availed(Dai

and Lee 2001). Since a region’s specific geology, soil or rock characteristics and soil hydrology with decide the volume and intensity of storm required, these EWS can be used in collaboration of regional hazard maps to effectively estimate the timing of landslide initiation and delineation of vulnerable areas (F.C.Dai et al 2002).

Conclusions;

1. Landslide occurance is a complex phenomenon, controlled by more than one factors encompassing fields of geology, hydromechanics and geotechnical engineering. The triggering factors vary from place to place and time to time. There is not a single triggering factor that could control the occurance of landslides.
2. An early warning system involves integration of geological science, geography, hydrology and soil mechanics.
3. So far the detection of landslides is concerned, most of them are based on the detection of movement of 'wetting fronts' after rainfalls of triggering pottential. And early warning systems are based on the detection of this moisture before it crosses critical depth.
4. From geotechnical point of view, one of the most critical factors to control the landslide occurance is 'variation of suction pressure' or one could say the understanding of unsaturated soil mechanics laws plays a role. Application of laws of unsaturated soil mechanics is critical to undetrstanding the failure mechanism of slopes of unsaturated soils, making estimate of quantitative relationship between destabilization of such soils with invading infilteration. Thus for evaluation of stability of steep natural slopes in dry seasons and a realistic result of factor of safety, consideration of suction is critical.

References

1.Rahardjo, H., Ong, T.H., Rezaur, R.B.,Leong, E.C.(2007), Factors controlling Instability of Homogenous Soil slopes under rainfall, Journalof Geotehnical and Geoenvironmental Engineering,133(12), 1532-1543.

2.Chiranjib Prasad Sarma, Arindam Dey & A. Murali Krishna, Landslide Early Warning Based on Geotechnical Slope Stability Model For The Guwahati Region, 50th Indian Geotechnical Conference 17th–19th December 2015, Pune, Maharashtra, India .

3.F.C.Dai, C.F.Lee, Y.Y. Ngai, Landslide risk assessment and management: an overview, Engineering Geology 64 (2002) 65–87.

4. Ajin M Murali, Geethumol S T, Gino Baby, Shaharban.Pari, Anniamma Chacko, A Case Study On Landslide: A Geotechnical Investigation, International Research Journal of Engineering and Technology (IRJET) ,2016.

5.Benni Thiebes, Rainer Bell , Thomas Glade , Stefan Jäger , Julia Mayer Malcolm Anderson ,Liz Holcombe, Integration of a limit-equilibrium model into a landslide early warning system, Landslides (2014) 11:859–875.

6.Fawu Wanga, Kyoji Sassa, Landslide simulation by a geotechnical model combined with a model for apparent friction change, Physics and Chemistry of the Earth 35 (2010) 149–161.

7. Thom A. Bogaard and Roberto Greco, Landslide hydrology: from hydrology to pore pressure, WIREs Water 2016, 3:439–459.

8. Bordoni, M., Meisina, C., Valentino, R., Lu, N., Bittelli, M., Chersich, S., Hydrological factors affecting rainfall-induced shallow landslides: from the

field monitoring to a simplified slope stability analysis, Engineering Geology (2015).

9. Brian D. Collins and Dobroslav Znidarcic, Stability Analyses of Rainfall Induced Landslides, 10.1061/(ASCE)1090-0241(2004)130:4(362).

10. Giovanni Crosta, Regionalization of rainfall thresholds: an aid to landslide hazard evaluation, Environmental Geology 35 (2–3) August 1998.

11. Fang Wei, T. Esaki, Rapid assessment of regional superficial landslide under heavy rainfall, J. Cent. South Univ. (2012) 19: 2663−2673.

12. Gulzar Hussain1, Yudhbir Singh, G. M. Bhat, Swati Sharma, Rameshwar Sangra and Arjun Singh, Geotechnical Characterisation and Finite Element Analysis of Two Landslides along the National Highway 1-A (Ladakh Region, Jammu and Kashmir), JOUR.GEOL.SOC.INDIA, VOL.94, JULY2019.

13. An-Bin Huanga, Jui-TingLeea,n, Yen-TeHoa, Yun-FangChiub, Shyr-YuanCheng, Stability monitoring of rainfall-induced deep landslides through pore pressure profile measurements, Soils and Foundations 52 (2012) 737–747.

14. Hans-Balder Havenith, Alexander Strom, Fernando Caceres, Eric Pirard, Analysis of landslide susceptibility in the Suusamyr region, Tien Shan: statistical and geotechnical approach, Landslides 3 . 2006.