LANDSLIDE-ISSUES AND ITS PREVENTIVE MEASURES

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ABSTRACT

Landslides are natural hazards that are frequently responsible for considerable losses and are subsequently considered among the most serious geologic hazards, which play havoc in many parts of the world and have high socioeconomic significance. This paper consists of description of basic landslide processes, causes, related issues, corrective measures, and various investigation methods. Furthermore, detailed investigations have been discussed prior to studying various deformation models for landslide. Various models, viz., dynamic, static, kinematic, congruence and identity models have been proposed to solve various landslide problems

Keywords: *Static, Kinematic, Dynamic, Congruence*

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INTRODUCTION

Landslide is a major geological hazard, which poses serious threat to human population and various other infrastructures like highways, rail routes and civil structure like dams, building and other structures. Expansion of urban and recreational developments on hill areas results in ever increasing number of residential and commercial properties that are often threatened by landslides (Aleotti and Choudhury 1999). Landslides also occur very often during other major natural disasters such as earthquakes, floods and volcanic eruption. Since the land routes are often disturbed by landslides, they cause major hurdles in mobilizing relief and reconstruction efforts. Mitigation of disaster caused by landslides is possible through detailed knowledge of the properties and characteristics of the terrain and geology of that area (Saha 2004).

It is of primary importance to understand the conditions under which mass movement is caused and the factors that triggers the movement. In general, the factors identified as causes of landslide (Anbalagan et al 2007) are categorized into two major categories as follows—

1) **Natural factors:** These are further subdivided into

(a) *Inherent factors*: These factors represent the inherent characteristics of hill slope and they can be studied and evaluated on slope itself. These factors include geology, slope gradients, local relief, hydro-geological conditions, land-use and land-cover.

(b) *External factors*: These are outside factors, which can be studied on a hill slope. They usually affect a large area and hence called regional factors. These factors include rainfall, earthquake, etc.

Anthropogenic factors: These factors are the ones that are caused due to human ctivities such as deforestation, improper land-use, construction activities, etc

LANDSLIDE ISSUES

Natural calamities including earthquakes, landslides, avalanches, floods, cyclones, droughts and volcanic eruptions have been affecting mankind since beginning of civilization. These are believed to account for up to 4% of total annual deaths. Distribution of casualties due to natural disasters is, however, not evenly distributed around the globe. The impact of these disasters is more severe in developing countries which have higher population densities. Globally, landslides alone, a prominent natural disaster, are estimated to cause approximately 1000 deaths annually apart from damaging property worth millions of US dollars (GSI 2007).

CORRECTIVE MEASURES

Corrective measures should be taken in order to avoid disaster and hazard caused by landslide. Various corrective measures of landslide hazards (GSI 2007) are as follows

1) *Profile Modification* – suitable modification of soil and rock profile for reducing the risk of slump and /or slide. Decreases the shear stress.
2) *Drainage* – Draining through runoff of accumulated water to avoid saturation of water.
3) *Stabilization of Landslides by Vegetation* – It substantially increases the cohesiveness of subsurface material, prevents surface erosion and shallow mass failures.
4) *Restraining structures* - To arrest the movement of rocks and soil in the affected area. Increases the shear strength.
5) *Permeable walls* - To arrest the movement of rocks and soil together with dewatering of the affected area.
6) *Piles* – Stabilizes the mobile part of the affected mass.
7) *Ground Anchors* – This gives support to the mobile mass and arrests its further movement.
8) *Miscellaneous Methods*
   (a) Electro-osmosis – for drainage of low permeable soils
   (b) Grouting
   (c) Hardening of soil by thermic treatment
   (d) Breaking of slip surface by blasting

LANDSLIDE INVESTIGATIONS

Investigations related to landslides (Anbalagan et al 2007) are carried out primarily based on three different approaches— analytical methods, observational methods and empirical methods. Depending on the importance of investigation, detailed used of analysis, scale, nature of output data required as well as budget, any relevant method may be chosen.

Analytical method: Analytical methods are used to carry out detailed study of unstable slopes on scales of 1:1,000 to 1:2,000. This approach is also called micro-zonation approach. Analytical methods essentially require data on the properties of rock/soils, particularly shear strength properties. Such properties are estimated in, both, field and laboratory. In addition, these properties can be investigated by back analysis, where a known slope is analyzedby assigning a suitable value of factor of safety with various combinations of strength parameters. After obtaining strength parameters, the equations of stability are set up considering the resisting and mobilizing forces to work out factor of safety.

Observational method: It is based on monitoring of the slopes through instruments or repeat ground observations. Instrument like extensometers, inclinometers as well as piezometers are installed in affected slopes. In general these studies are costly and time consuming

Empirical method: It involves identification of causative factors of landslides and their influence in inducing instabilities. The qualitative natures of field condition are quantified based on relative rating scheme.

In this approach large areas can be covered in relatively short duration and therefore they are comparatively economical Important and well known techniques like landslide hazard zonation, rock mass rating, slope mass rating and q system fall under this category.

DETAILED INVESTIGATIONS

Micro-level studies of slopes considering various relevant factors responsible for instability of slopes give a more accurate result with respect to real landslides. These have to be carried out in a systematic way in order to account for all parameters responsible for instability. The steps for proper detailed investigations are as follows—

(a) Preparation of geological maps and sections.

(b) Identification of mode of failure.

(c) Estimation of shear strength parameters of slope forming materials.

(d)Calculation of factor of safety.

DEFORMATION MODELS

The use of deformation models (Gunzburger et al 2006) has now become a common place in order to understand landslides. Many different types of models are indeed available. Among them, however, it has to be understood which ones are truly helpful for comprehending major movements? What inputs are needed? What are they actually contributing to the understanding of movements? What are the benefits from the output?

This literature summarizes some of the knowledge existing about the models, as well as current thinking on modeling techniques. Deformation analysis is the determination of geometrical changes of an object to be monitored. Geometrical changes are movement and distortion of the object. The prognosis of an event which may occur in future requires the laws of object behavior to be known. These laws relate, on the one hand, to the influencing factors or load which may cause the deformation, and on the other hand, to the geometrical and physical structure of the object (Welsch 2002)

CLASSIFCATION OF DEFORMATION MODELS

The deformation models can be classified with respect to variables as follows—

Deformation model	**Congruence model**	**Kinematic model**	**Static model**	**Dynamic model**
Time	No modeling	Movement is a function of time	No modeling	Movement is a function of time
Acting forces	No modeling	No modeling	Displacement is a function of loads	Movement is a function of loads
State of the object	Sufficiently in equilibrium	Permanently in motion	Sufficiently in equilibrium under loads	Permanently in motion

Table 1: Classification of Deformation Models (Heunecke and Pelzer 1998)

Hierarchy of deformation models on basis of specific description of the actual problem is shown below.

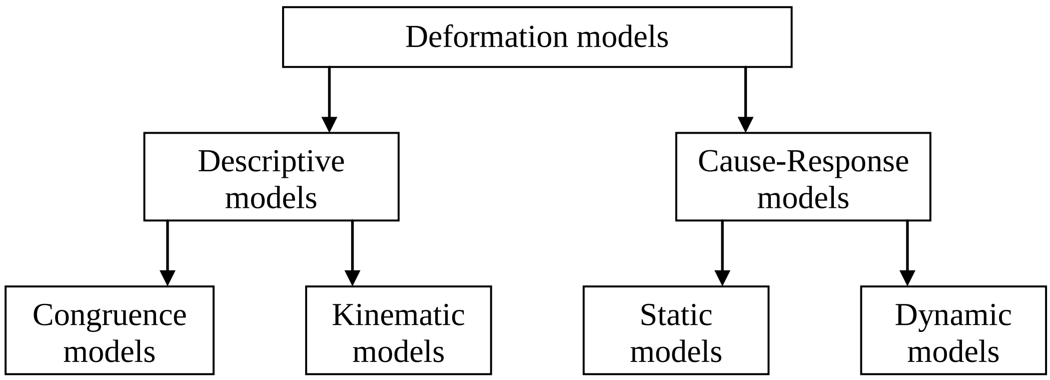

Fig. 1: Hierarchy of Models in Geodetic Deformation Analysis

DYNAMIC MODELS

These models describe behaviour of an object with respect to time and forces. A dynamic model integrates the capabilities of all other models (Welsch 2002). It is most general and comprehensive model from which, by simplifications, static, kinematic and congruence models are derived

STATIC MODELS

A static model describes the functional relationship between loads as a causative forces and geometrical reactions of an object without regarding time aspects (Welsch 2002). The object has to be sufficiently in the state of equilibrium during and between the observation epochs. The behaviour between the epochs remains unknown and is not of interest in a static model.

KINEMATIC MODELS

It deals with description of point movement by time functions without regarding the potential relationship to causative forces (Welsch 2002). Polynomial approaches, specially velocities and accelerations, and harmonic functions, are commonly applied

CONGRUENCE (OR IDENTITY) MODEL

It relates purely geometrical comparison between two states of an object as represented in space domain by a number of characteristic points without explicitly regarding time and loads (Welsch 2002).

CONCLUSIONS

Landslides represent a major type of natural hazard that extracts a steady, painful toll from inhabitants of mountains, hilly regions, escarpment and river valleys around the world. The impact of landslides is sudden and erratic in time and reliable warnings are difficult to implement.

Detailed investigations are mainly helpful in assessing the status of stability of a particular slope. The output of analysis helps us to evolve and implement suitable control measures before hand for protecting the slopes.

Advanced models have, in recent years, received a much wider acceptance both in research and in routine engineering practice. It is essential that the rapid development in sophisticated rock slope analysis codes be balanced by increase in the quantity and quality of engineering geological field data collected.

Rules must be established for using sophisticated models and judging their reliability. Different types of models should be compared against each other. Above all, we must exercise healthy skepticism regarding the results of any models, no matter how complex and impressive

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