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An Experimental Landslide Model for Guwahati City using Optical Sensors

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Abstract

Landslide is a major natural hazard that affects the human habitat. In this work, an experimental model is proposed that will establish the relation between slope angle, pore pressure, soil moisture and rain water. Both the seepage water as well as artificial rain water can be used for the experiment. In the introduction part, main causes of landslide are discussed. The second part defines the problem formulation. Third part of this paper list out the objectives of the experiments that are to be done. Fourth part is the various literature works that are already done in this field. The fifth part discusses the methodologies that include the basic schematic diagram for the landslide area. The expected outcome, conclusion and reference are discussed in the later parts of this paper.

Keywords: *Landslide, Pore pressure, Soil moisture, Pore pressure*

INTRODUCTION

Landslide is a very common natural hazard particularly in the hilly areas. Till now landslide has caused a loss of around 1000 million lives and also 4 billion dollar property. Asia witnesses 220 landslides in the past century. If we particularly consider Guwahati city, out of the 18 hills that are surrounding the city, 8 are declared unfit for human habitat. 3000 hectares of land out of total 7,023 hectares of the city land has been suspected to be landslide prone**.** Due to increased urbanization in the city of Guwahati, the city is experiencing a rapid growth in the development. The city has also increased its area. In 1971, the total area of the city was 43.82 sq. km, which was expanded to 216sq.km in the year 2011. The density of population in Guwahati is 579 persons per sq.km against 340 persons per sq. km in the state as per recent surveys [5]. The major hills are Nabagraha hill, Nilachal hill, Tetelia hill, Khanapara hill, Fatasil hill, Chandrapur hill, Narakasur hill and Narengi hill. Although the hills are enhancing the beauty of the city, it is also causing serious problems to the habitants residing in those hills. During the continuous rainfall in the monsoon season, there are many news of landslide in and around the city. Also, a heavy rain fall in the Meghalaya side, which is the neighboring state, landslide, may occur in the Khanapara side of the city. Some infamous landslides in and around the city and state and number of casualties are given in chronological order in Table 1.

Table1: *List of Occurrence of Landslide and Number of Casualties in Chronological Order.*

Sl no	Year	Number of Casualties
1	1948	500
2	1972	100
3	2000	8
4	2002	6
5	2003	17
6	2004	18
7	2007	11
8	2017	10

PROBLEM DEFINATION

Landslides are accepted all over the world as one of the worst natural disaster causing losses of human lives as well as infrastructure. The city of Guwahati which is surrounded by hills all around the boundaries has been worst effected by landslides triggered by different external factors like rainfall, earthquake, water level change etc. [2]. Research publications indicate that landslide risk zonation map of the city has been prepared on the basis of topographic maps, geological maps, IRS-1B, field observations etc. The early warning system consists of analyzing, evaluating and mitigating of landslide hazards which can be said to be landslide mapping, monitoring and modeling. Real time monitoring of landslide in continuous manner is one important step for early warning system. For different landslides, the causes may be different. Monitoring methods will be based on the mechanisms for landslide. Further, modeling of landslide will give the relation between triggering factors and the landslide kinetics. Hence, this work will try to relate the three i.e. mapping, monitoring and modeling in context to the city of Guwahati. The landslide monitoring system will include measurement of slope angle, rainfall and pre pressure. The change in the natural slope, rainfall quantity and pore pressure at the landslide prone zone will be found out [4, 5]. Easy data transfer, high speed of transmission, light weight, resistance to environmental impacts, electromagnetic resistance and low cost and simultaneous monitoring capability make optical sensor superior compared to other sensors in many respect. The optical fibre based inclinometer, pore pressure gauge and rain gauge will be designed and will be compared with the conventional sensors. The data acquired will be used to model landslides.

OBJECTIVE

The proposed work aims to develop an integrated sensor system for early warning system for landslide hazard. This model will be first investigated in the laboratory set up which can later be tested in the original site. In order to attain the objective we have to go through the following sub steps:

- To build a laboratory set up that can be a physical model for the landslide experiment.
- To collect information regarding rock pattern of different landslide prone zones.
- To develop optical sensors for the measurement of slope angle, rainfall, soil moisture and pore pressure.
- To compare the results obtained from the optical sensors and the conventional sensors.
- To propose an early warning system based on the relation between rainfall, slope angle and pore pressure and landslide.

LITERATURE REVIEW

Some major contributory work relating to this field is listed below in chronological manner:

In 2000, a paper was published in Elsevier named “A critical review of landslide monitoring experiences” that aims to understand the mechanism of disruptive processes, define adequate prevention measures for the mitigation of their effects and reduce the loss of human lives and assets. For this purpose, automatic recording systems connected to different sensors have been installed. During this research activity, several problems arose, and several solutions were found out. In this paper, some of the main problems concerning the installation and management of monitoring equipment used for the study of three landslides were discussed. [17]

In 2002, another paper was published in the IEEE symposium named “Landslide early warning monitoring system”. They have set up a monitoring system called "Early warning monitoring system" based on "National Instrument" Lab View software and an A/D (analogue/digital) converter with internal processor, which collects data from a laser diastimeter, seismic detectors (geophones), pressure transducer to measure groundwater level variations and a rain gauge. The alerts are automatically activated when the other instruments placed on the landslide body confirm an out-of-range signal generated by a single instrument [1].

Finally in 2011, a paper namely “Monitoring and warning of landslides and debris flow using an optical fiber sensor technology” was published by Springer that first uses optical fiber for landslide monitoring by using Fiber Bragg Grating. This paper presents two new optical fiber sensor systems: one is the Fiber Bragg Grating (FBG)-based in-place inclinometer for monitoring landslides and the other is the FBG-based column-net system for monitoring debris flows. It also presents the calibration results of FBG-based in-place inclinometers in laboratory. It is found that the calibration results are in good agreement with theoretical results. Both the FBG-based in-place inclinometers and the FBG-based column-net system have been installed at a site in Weijiagou valley, Beichuan County, Sichuan Province of China. Some preliminary results have been obtained and reported in the paper. The advantages of the FBG monitoring systems and their potential applications are also presented [18].

In 2014, a paper named “Susceptibility mapping and estimation of rainfall threshold using space based input for assessment of landslide hazard in Guwahati City” was published which is one of the best paper if anybody wants to know about the type and zonation of landslide in and around Guwahati city [3]. This study elucidates the potential of space-based inputs in addressing the problem of landslide in absence of field-based observing networks. First, Landslide susceptibility map in 1: 10,000 scales was derived by integrating geospatial datasets interpreted from high resolution satellite data. Secondly, the rainfall threshold for dynamic triggering of landslide was estimated using rainfall estimates from Tropical Rainfall Measuring Mission Multi-satellite Precipitation Analysis. The 3B41RT data for 1 hourly rainfall estimates were used to make Intensity-Duration plot. Critical rainfall was estimated for every incidence by analyzing cumulative rainfall leading to a landslide for total of 19 incidences and an empirical rainfall intensity-duration threshold for triggering shallow debris slides was developed (Intensity = 5.9 Duration-0.479).

However, till now no experiment was performed for the landslide investigation by taking into account the inter relationship between rain fall, soil moisture, pore pressure and their cumulative effect on the landslide basically for the city of Guwahati. For different hill sides those are prone to landslide the soils are of different types. The experiment focuses in the early warning method of the landslide for various soil types and with varied slope angle.

METHODOLOGY

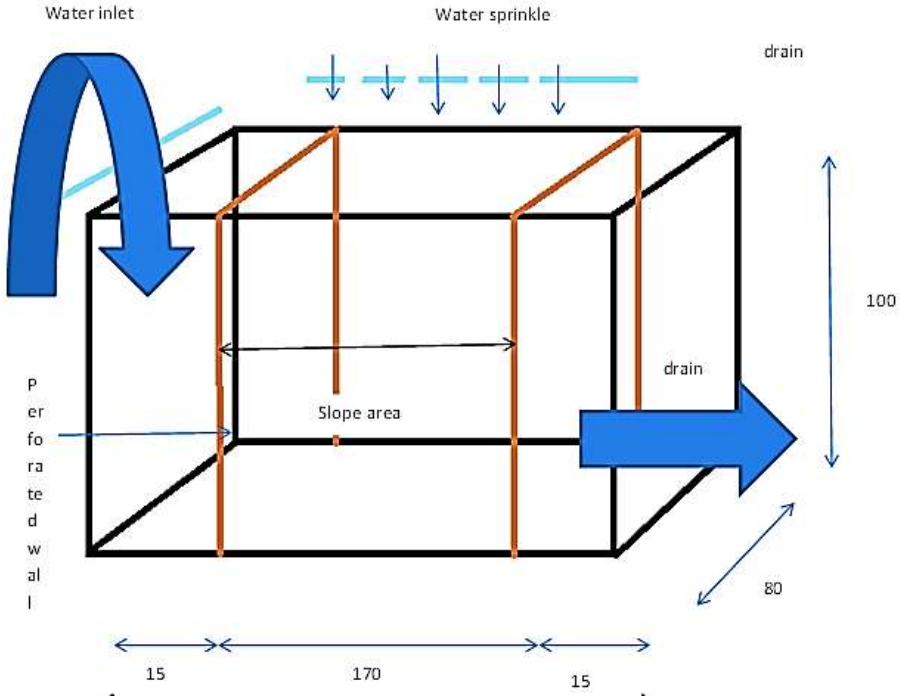

Figure 1: *Experimental set up (all dimensions are in cm).*

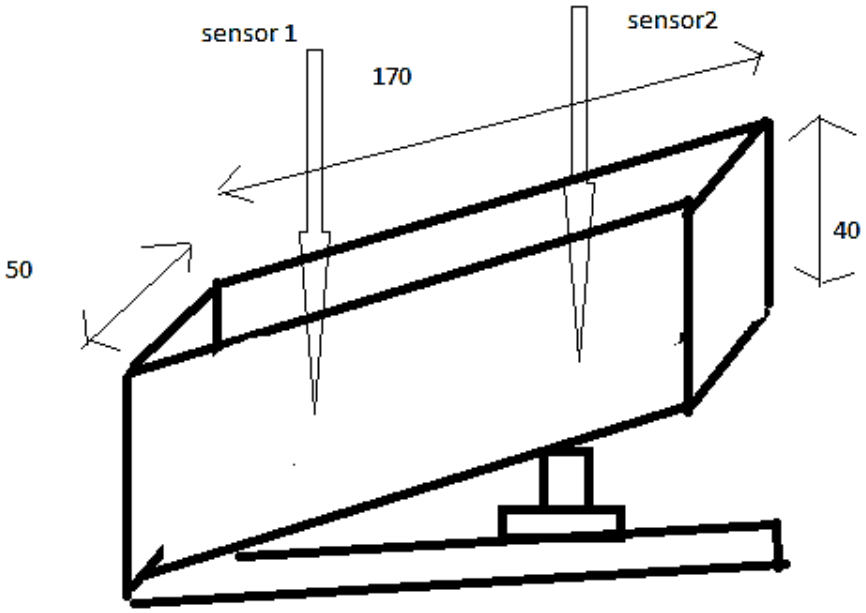

Figure 2: *Slope Area (all dimensions are in cm).*

Experimental Setup*:* The laboratory set up for landslide model is to be prepared. Soils from various hills are to be collected. Soil test is to be done for soil moisture, grain size etc. Conventional sensors such as accelerometer, soil moisture sensor and pore pressure sensors will be used. Accelerometer is used to detect the vibration in the three dimensions. Soil moisture can be also measured by comparing the weight of dry soil and wet soil. Optical sensors will be developed for

the measurement of slope angle, rainfall, and soil moisture and pore pressure. The experimental set up for the landslide box and the slope area are shown in the Figure 1 and 2 respectively. Water sprinkle system will be present for artificial rain as the landslides in and around the Guwahati city are rainfall induced types. The ground water system is obtained through some inlet water valves. The excess ground water will come out through the outlet chamber as shown in Figure 1 [6-9].

Optical Sensor Based Inclinometer: An optical inclinometer is based on interferometry sensor that operates by measuring environmentally induced change in the delay in the fiber as a change in optical phase [10, 11]. Inclinometer with different lengths can also be fabricated depending on the purpose. Tapering can also be done for measuring angle [12].

Optical Sensor Based Pressure Sensor: For a pressure sensor, the measured is used to induce modulation of light reflected from a reflecting surface. Here, a Y-coupler fiber optic probe can be used that consists of two multimode fibers cemented or fused along some portion of the length. These sensors are based on the concept that if the cemented end of the Y-power divider is made to face a light reflecting diaphragm and light is injected through the source, and then the intensity of back reflected light that will reach the detector will depend on the distance of the reflecting target from the fiber probe [14, 15].

Optical Fiber Sensor Based Liquid Level Detector: An optical fiber sensor based liquid level detector can be used to measure the amount of rain fall in a particular area as shown in the figure below. This sensor involves optimally connecting two independent fibers to the base of a 90^{o}glass micro prism [16]. The ray paths are such that when the prism is surrounded by air, the detector will pick up relatively large signal due to total internal reflection at the sides of the prism.

EXPECTED OUTCOME

This research will lead to a novel optical sensor based monitoring system for monitoring of landslide and modeling for early warning system. This will be a cost effective substitute for already existing expensive geotechnical instruments and economically used in multiple location for effective monitoring of landslide.

FUTURE SCOPE

This research can be further extended with the help of zigbee or GPS system to provide warning system for the habitants of the landslide prone area.

CONCLUSION

Landslide is a natural hazard that has caused loss of thousands of life in the past. An early warning system in landslide prone areas will be very useful in saving human lives and preventing loss of property. All the threshold values that are obtained from optical sensor based inclinometers, piezometers and rain fall level detectors will be collected and processed by using any neural network framework to give some prior warning in landslide prone areas.

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