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# Landslide Monitoring and Early Warning – Special Reference to NE Region of India

**ABSTRACT : Landslide hazard is a major natural disaster in India. Out of the total landslide occurrences in the country, nearly 20% are found in NE region of India. Conventional method of monitoring landslide is not reliable. A real time monitoring of landslide has been under research stage. Some important technologies under studies are wireless monitoring, GPS system, optical fiber sensing etc. The wireless monitoring of landslide has been undertaken by NEIST, Jorhat. The place selected for this purpose is at Karsingsa in Arunachal Pradesh. It is located in a particular section of NH-52(A) and is identified as potentially dangerous landslide hazard area in the National highway. Geophysical study of the region reveals that, mass sliding due to heavy rainfall during rainy season (June-July) is the main cause of landslide. Basically, grained silty-clayey-sand layer of colluvium nature contributes to the landslide hazard. This process due to flow of land masses may be termed as static liquefaction. To get a proper monitoring method an attempt has been made in that area by using wireless network of sensors. The hardware embedded software for these sensors are used and altogether five different sensors are placed in a network. This system of sensors is then wirelessly connected using RFID technology to a server for monitoring and collection of data for prediction of landslide.**

**Key words:** *Landslide monitoring, geophysical parameters, wireless sensor, GPS, optical fiber sensor*

One of the major natural disasters faced by the world in general and India in particular is landslide hazard. This is occurring every year in different states of the country. India, due to its varied climatic condition and physiographic structure experiences landslide. Approximately 15 % of the land area of the country is vulnerable to landslide hazard. Loose sediment, rocks, heavy rainfall and earthquake are the major contributors to landslide. The Building Material and Technology Promotion Council (BMTPC) and Ministry of Urban Development and Poverty Alleviation, Centre for Disaster Mitigation and Management (CDMM), Anna University have prepared an Atlas for Landslide hazard zone of India, wherein major parts of the Landslide area falls in NE Region of India.

The unique geo-environmental setting of the region via-vis heavy rainfall, weak geological formation, active seismicity, accelerated rate of soil erosion, vegetation etc. are some important factors responsible for landslide. Some other factors like deforestation, unscientific drainage system, land use pattern and agriculture are also triggering the Landslide hazard. The economic development is interrupted by landslide disaster and thereby contributes to poverty and slow human development. Thus, Landslide primarily affects directly the populace of the region and derails development process. To tackle this problem, many measures have been developed and used. Several analysis for the cause of landslide also have been undertaken at different parts of the landslide prone areas. These include studies of properties of the soil, rock and related geophysical observation.

However, the main tasks before researchers are the monitoring of landslide occurrence and remedial measures. Several methods of landslide monitoring have been proposed at various levels. These can be taken as conventional ones and new ideas of technology. In the conventional system, the equipments used are extensometer, tilt meter, load cell, rain gauge etc. based on geophysical parameters. New methods are underway to get easy monitoring system by development of high sensitive sensor based equipments. However, the main criteria for new technique is to get sensors based methods which are simpler, available at comparatively lower prices and easy operational technique.

Landslide mitigation strategies comprises a range of activities including hazard mapping and assessment, real time monitoring and warning system for active landslide, protective engineering measures, development of public awareness. The development of landslide monitoring system and pre-disaster alarm are the most important subjects in saving human life and properties.

***Monitoring of Landslide and Early Warning – a Research Prospective*:** The monitoring of landslide and development of an alarm system is a challenging job. Since the nature of landslide and geophysical parameters are different in different areas, a common system of early detection is difficult. However, several methods of landslide monitoring have been proposed by different workers in the field. The traditional method of using conventional sensors has been used to monitor landslide in most of the cases. Although these are more or less helpful in monitoring landslide, the uses of these are limited to manual operation and have many drawbacks. New methods are underway and research works are going on at different parts of the

world to find a reliable, easy, economic and suitable method.

Recently, more importance has been given on the monitoring of landslide and early warning based on real time technology application. Various proposals made on the subject are in experimental stage. These techniques are mainly, (i) wireless monitoring system, (ii) use of optical fiber based sensors, (iii) GPS aided automatic monitoring, (iv) other small area observation.

In the wireless system, real time monitoring by wireless communication in a network of sensors are made in the place of landslide prone area. Several sensors for detection of various geophysical parameters are installed at the place in multiplexing mode[1]. The system of network includes zigbee, crossbow, imote etc. These sensors are software embedded hardware for RFID communication. These sensor data are monitored by the server placed nearby. These data are analyzed and critical stage of landslide has been recorded. Based on the data obtained a software has been developed for early warning. These systems are in works at different parts of the world including India.

In the optical fiber method, the sensors are coupled with optical fiber technology for data acquisition. The conventional sensors have been incorporated with optical fiber for better reliability and accuracy in obtaining data and for onward transmission to the nearest station. This technology has been applied in different countries like Japan, Indonesia, China etc. In India also, Central Scientific Instruments Organization (CSIO) has designed and developed data acquisition system for landslide monitoring using virtual instrumentation[2]. North-East Institute of Science and Technology, Jorhat, has also proposed to study landslide with optical fiber arm based sensor in which fiber arms will be designed for effective monitoring of the geophysical changes occurred. The basic principle for optical fiber sensors is the sensing of deformation occurred in the fiber arm. The fiber sensor placed underground is deformed by the movement of landmass and thereby exhibit light loss in the transmission. This perturbation of fiber axis results in redistribution of guided power between modes of the fiber and that results in the effect of coupling network. In the highly sensitive mode, a minute microbend of fiber arm can be effectively monitored by using continuous ray of light source in the fiber.

Global Positioning System (GPS) is a major tool for automated continuous monitoring of landslide and avalanches. This system is being increasingly used for detection of displacement of land masses even for the order of millimeter. This is done with the help of more than one GPS satellite data with their relative displacement. In GPS based monitoring systems, the accuracy, availability, reliability and integrity of the positioning solutions heavily depend on the number and geometrical distribution of satellite being tracked. The importance of GPS system is that it can be used in all the weathers and inter-station visibility is not required. Moreover, the station relative positioning can be achieved upto millimeter accuracy[3]. The technique has been used by countries like China, Japan, Turkey etc. with good results.

Other small scale landslide monitoring includes, (i) remote sensing, (ii) photo-programmetric technique, (iii) ground based geodetic technique, (iv) total station etc.

**Landslide occurring in NE Region of India and works undertaken:** The states of NE Region have been experiencing landslide every year. Out of the total landslide occurring in the country, 20% have been situated in NE region of India. The states of NE Region which are mostly affected by landslide are Arunachal Pradesh, Tripura, Mizoram, Manipur and Meghalaya. In Assam, few places are said to be landslide prone area. A few major landslides occurred in the past few years in NE Region of India can be mentioned as:

- *Assam in 1991* - Nearly 300 people died with damage to road and buildings
- *Mizoram in 1993* - 4 persons were buried
- *Arunachal Pradesh in 1993* - 25 people buried and road damaged
  *in 2008* - 14 people died and more than 15 people injured
- *Nagaland in 1993* - Nearly 40 people died with loss of property
- *Mizoram in 1995* - 25 people died with damage to road

Research and development work on landslide hazard mitigation is a stringent need of the time particularly for the NE region of India pertaining to Himalayan and non-Himalyan hillocks, where inhabitation of middle and poor class people is increasingly growing up because of the attraction towards the modern urbanization. Several measures have been taken earlier by the Govt. of Arunachal Pradesh, to prevent the landslide occurrences by erecting Crated Masonry along the highway and river bank, but were not as successful as projected. However, the monitoring of landslide and early warning is the main issue towards landslide hazard management.

NEIST has taken the initiative to take up the subject on Landslide hazard in NE region for the last few years. To study this hazard and probable causes, the laboratory had taken up a project on this subject in 2001. The project was funded by DST, Govt. of India. For this purpose the group had selected a place in Arunachal

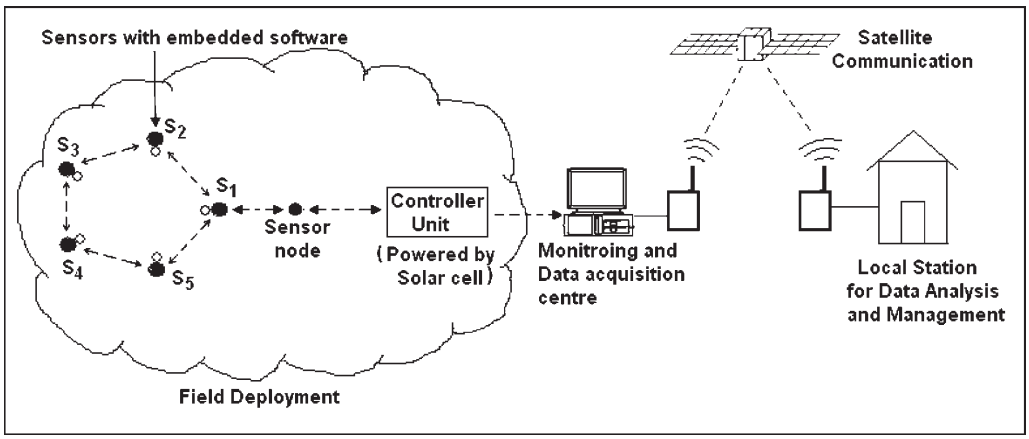


**Fig. 2.** Wireless monitoring network system at Karsingsa


**Fig. 1.** Karsingsa (where project is going on)

Pradesh on the way to Itanagar. This place, called Karsingsa, is 15km away from Itanagar and is known to be a major Landslide prone area of NE region of India. The place Karsingsa is a hilly terrain and is an integral part of the lower Himalayas. It is located in a particular section of NH – 52A and is identified as a potentially dangerous landslide hazard area. An investigation of the project revealed that, mass sliding due to heavy rainfall during rainy season is the main cause of Landslide. The grained silty-clay-sand layer of colluvium nature contributes to the Landslide hazard[4]. To get a proper real time monitoring of landslide and early warning, NEIST has taken up the next project on the subject at Karsingsa considering the importance of Landslide hazard and management (Fig. 1). This is a system of wireless network in the area with five different types of sensors fitted with specific hardware embedded software. This is a collaborative work with two other CSIR Laboratories. The aim of the project is to monitor the landside occurrences and to develop a software, based on the data generated by the sensors for early warning. The works are in progress. The network system for the plan for wireless monitoring is shown in Fig. 2. The CSIR-NEIST has also proposed to take up a project on landslide early warning and management based on optical fiber arm based sensor in the next few years. ❐

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