Analysis of data using neuro-fuzzy approach recorded by instrumentation network installed at Mansa Devi (Haridwar) landslide site

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This paper presents a case study of landslide monitoring and early warning of Mansa Devi (Haridwar), located at Haridwar by pass road. Data recorded by instrumentation network installed at Mansa Devi (Haridwar) landslide site by five sensors (Rain Guage, Inclinimeter, Tiltmeter, Crack meter, Earth pressure cell) was analyzed and a relationship between rainfall intensity-surface parameters and landslide occurrence drawn with neuro-fuzzy approach for prediction of landslide and concept of early warning system is also described. Mansa Devi site is found rain prone and developed model demonstrates a fairly accurate prediction.

Keywords: Early warning, Instrumentation network, Landslide monitoring, Neural - fuzzy technique

Introduction

Landslide monitoring is required to determine extent, magnitude and style of landslide movement, for hazard analysis and emergency risk management and/or to assist in design and implementation of site remediation and/or mitigation works. Selected landslide site is located on Haridwar by pass road and on the slope of Mansa Devi hill. This site, composed of a series of interbedded clay stones, mudstone and sandstone sequences, belongs to Middle Siwalik Formation. This discontinuity pattern that is parallel or sub parallel to surface topography with interbedding of strong and weak rock sequences is highly prone to land sliding[1]. Landslide has occurred in two phases; in first phase, vertical subsidence of rock mass was involved, while in second phase failure of mudstone sequence was involved. Inherent strength characteristics of rock mass, which are combined with increased pore water pressure due to continuous percolation of water from two drainage sources located in periphery of landslide, is main cause for initiation of landslide. Mansa Devi hill has witnessed numerous landslides of varying sizes[2]. Involvement in most of the instabilities are breaking off, toppling and or sliding of mudstone or sandstone, which form over a period of time as debris at the foot of slope. This landslide completely damaged 300 m stretch of Haridwar bypass road and put in danger railway track,

residential and commercial establishments of Haridwar Township[3].

This area is located on Haridwar bypass road that joins Haridwar township in south and village Kharkhari in north at a Longitude 78°10´4.8" and latitude 29°57'32.523 . In a geological map of Mansa Devi landslide area (Fig. 1), Mansa Devi temple is situated about 200 m away towards SSW at the top of hill. Railway track, residential and commercial establishment, is situated all along the base of hill. This area is covered under sub-tropical climate with heavy rainfall during monsoon. It is observed that 70% of rain fall is during July, August & September and light and heavy showers of longer duration also occur during December, January & February. Landslide, which occurred during 1998-2000, indicates that mass was mobilized slowly by continuous increase in pore water pressure over years, due to continuous seepage of water from channels located in immediate vicinity and overland flow from the road[3,4].

This study presents a case study of landslide monitoring and early warning of Mansa Devi (Haridwar) landslide site by analysis of data using neuro-fuzzy approach recorded by instrumentation network.

Experimental Section

Instrumentation Monitoring Network

Instrumental monitoring of landslide enables to evaluate amount of displacement in different areas and

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