Monitoring of Mansa Devi Landslide using GPS

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Abstract— **The aim of this study is to analyze the spatial behaviour of the landslide located in Mansa devi hill region which is situated in Haridwar. A network consisting of 5 sites has been surveyed two times from September 2008 to October 2008 using Global Positioning System (GPS). The deformation analysis has been applied to determine the landslide movement parameters of the sites using GPS measurements of the two epochs. Some stations are used to define a stable reference frame and remaining stations are the monitoring points situated in the deformation area. In this way, the determination of the movement of the control stations is done relatively to the reference ones. Mansa Devi landslide selected for its movements. This paper therefore highlights an investigation of landslide motions to discover possible precursors of mass movement and periodical changing of landslide..**

Keywords— **Mansa Devi Landslide, Landslide movement, GPS, Deformation**

I. Introduction

The assessment of landslide behavior is usually undertaken by means of monitoring scheme. Usually, the measurement of superficial displacement is the simplest way to observe the history of a landslide and to analyze the kinematics of the movement. In all cases, measurements have to be made efficiently in terms of time, manpower and budget. [1]

In the past, a variety of surveying techniques have been used to detect the superficial movements of unstable area [2]. For examples, tapes and wire devices have been used to measure changes in distance between points or crack walls [3]. Levels, theodolites, Electronic Distance Measurement (EDM), and total station measurements provide both the coordinates and changes of target, control points and landslide features [4]. In addition, aerial or terrestrial photogrammetry provides point co-ordinates, contour maps and cross-section of the landslides. Photogrammetry compilation enables a quantitative analysis of the change in slope morphology and also the determination of the movement vectors [5].

Nowadays, the Global Positioning System (GPS) has been fully operational. The GPS equipment is more reliable, cheaper, faster, and easier to use compared to conventional instruments. New hardware, field procedures and software have also been developed to assist users in data collection and processing purposes. Thus, the GPS equipment has become more progressive and used for a wide range of monitoring applications. This work also highlights the performance of GPS technology in landslide monitoring encompassing a specific large-scale area.

Measurement of landslide displacements can be undertaken by means of either static or kinematic method. The choice depends on the practical considerations: (i) the accessibility, (ii) number of points, (iii) precision and (iv) distance from point to point. Nowadays, the most productive methods i.e. modern positioning technique available for determining single points with precision of milimetres or centimeters is Rapid Static (RS) and Real Time Kinematic (RTK).

The RS method is a development of the classical static method, with improved algorithms that accelerates the ambiguity resolution procedures. For instance, measurement of one baseline with six and more satellite available is required for only a few minutes of data logging. This time increases to 15 and 20 min with five and four satellites, respectively. In this method, post-processing must be carried out. The data files from different receivers are merged in order to obtain the solution of the baselines between station points [1] .

II. Need of GPS for Deformation Monitoring

The selection of most appropriate technique or combination of techniques for any particular application will depend upon cost, the accuracy required, and the scale of survey involved. The design of monitoring scheme should satisfy not only the best geometrical strength of the network but should primarily fulfill the needs of subsequent physical interpretation of the monitoring results. Selection of monitoring technique depends heavily on the type; magnitude scheme should be based on the best possible condition of all available monitoring instrumentation.

GPS technology works extremely well in the field and is provides valuable new information on landslide deformation. The natural output from a GPS monitoring system is 3-dimensional, thereby eliminating the messy and inferential calculations associated with 2-dimensional instrumentation.

Furthermore, GPS is not plagued with the drift problems commonly associated with other geotechnical instrumentation.

III. STUDY AREA

Geodetic survey has been carried out using GPS in order to show the trends in geo-deformation of Mansa Devi hill which is spread out the area of approximately 2 km from Mansa Devi main gate to the end of Bheemgoda road. The prone area taken into consideration is regularly damaged and there is very high probability of landslide occurrence in future with possible loss of human lives and property. The area is identified as follows –

Bheemgoda road hill bypass: special consideration is taken for Shankar Ashram area which comes under this range.

Hill bypass between the Seedy Marg and Road Marg.

The various points which are taken into consideration for study are Bheemgoda Baraj, Shankar Ashram CP4, CP6 (bend road), CP1, CP3

Fig 1.Affected Area

Fig 2 Reference point-Bheemgoda Baraj

IV METHODOLOGY

A. Data collection

Two dual frequency geodetic grade GPS receivers have been used in this experiment. One of the receivers, served as a reference and other as a rover or moving.

First of all we set a base receiver at Baraj bridge (bench mark) PDOP≤ 6 .Then we set a rover receiver at Bheemgoda road Shankar Ashram with respect to base receiver, it was observation point no.CP-4 Subsequently we set three more observation station at point no. CP-3, CP-1, and CP-6, respectively w.r.t the same base station (reference point). The point no. CP-6 was at Mansa hill Bend road, whereas the other two points were located on the Mansa hill. Latitude, longitude and elevation of all the observation station point were calculated using GPS technology.

After that we came to the observation station point no. (CP-4) ,Bheemgoda road shankar ashram and set it as base(reference point) station named as bheem.b.m Then w.r.t the new reference point, observation station were established at point no. (CP-6, CP-3 and CP-1)

Then we came to observation point no CP-1 and set it as base station and w.r.t it observation station was established at point no CP-6 and CP-3 were established

At last we came to observation point no CP-6 and set it as base station and wrt it observation station was established at point no CP-3

In this way, the entire landslide affected prone area was covered. First of all, every time the data was collected, proper centering and leveling was done. Then receiver and antenna, controller placed and activated then the logging rate was set as 5 sec in both the receiver and the elevation mask was set at 15º and slant height of the instrument were entered and the static data was calculated. It was taken care that PDOP mask should be lesser than 6 and no. of satellites observed should be greater than or equal to 4.

B. Data processing

The data collected were post processed in TGO software in base line processing mode using broadcast ephemeris. In this carrier phase raw data from both L1 and L2 frequencies along with both codes have been used. Ambiguities were resolved at each epoch by applying stringent constraints on the approximate coordinate of the unknown point. The output of post processing is the temporal variation of the position of the rover station w.r.t. reference station and these are in Cartesian WGS84. The same have been converted to a local coordinate system with reference axes along the north east and vertical direction.

V RESULT

The data collected from the GPS instrument at the two epochs are summarized and compared in tabular form as shown below. The baseline length are also compared. Finally, the network adjustment is done using TGO software. The area calculated by the TGO software of survey which is held on the date of 25/09/08 and 14/10/08 of the observation point no.(CP-4, CP-6, CP-1 and CP-3) are 76572.736 sq m. and 76934.322 sq m respectively

TABLE I

DIFFERENCE IN TWO EPOCS

SNO	LATITUDE 14.10.08	LATITUDE 25.09.08	DIFFERENCE
1 baraj b.m	29°57'31.23612" N	29°57'31.29162" N	-0°0'0.05550”
2 cp-4R	29°57'50.50224" N	29°57'50.49423" N	0°0'0.00801”
3 cp-6R	29°58'10.77712" N	29°58'10.77732" N	-0°0'0.00020”
4 cp-1R	29°58'04.94098" N	29°58'04.98611" N	-0°0'0.04513”
5 cp-3R	29°57'57.94660" N	29°57'57.97925" N	-0°0'0.03265”
6 cp-4 .b.m	29°57'50.54184" N	29°57'50.56273" N	-0°0'0.02089”
7 cp-6R	29°58'10.82430" N	29°58'10.78107" N	0°0'0.04323”
8 cp-1R	29°58'05.05223" N	29°58'04.98678" N	0°0'0.06545”
9 cp-3R	29°57'58.02008" N	29°57'57.98769" N	0°0'0.03239”
10 cp-1 b.m	29°58'04.98118" N	29°58'05.00770" N	-0°0'0.02652”
11 cp-6R	29°58'10.78108" N	29°58'10.84735" N	-0°0'0.06627”
12 cp-3R	29°57'57.98570" N	29°57'58.02231" N	-0°0'0.03661”
SNO	LONGITUDE 14.10.	LONGITUDE 25.09	DIFFERENCE
1 barajb. m	78°10'42.28219" E	78°10'42.25392" E	0°0'0.02827”
2 cp-4R	78°10'20.73735" E	78°10'20.71504" E	0°0'0.02231”
3 cp-6R	78°10'06.39953" E	78°10'06.29855" E	0°0'0.10098”
4 cp-1R	78°10'03.46849" E	78°10'03.43319" E	0°0'0.03530”
5 cp-3R	78°10'08.94485" E	78°10'08.89592" E	0°0'0.04893”
6 cp-4 b.m	78°10'20.73436" E	78°10'20.76982" E	-0°0'0.03546”
7 cp-6R	78°10'06.34402" E	78°10'06.35980" E	-0°0'0.01578”
8 cp-1R	78°10'03.37571" E	78°10'03.42493" E	-0°0'0.04922”
9 cp-3R	78°10'08.94342" E	78°10'08.92332" E	0°0'0.02010”
10 cp-1b.m	78°10'03.38144" E	78°10'03.44477" E	-0°0'0.06333”
11 cp-6R	78°10'06.35798" E	78°10'06.37407" E	-0°0'0.01609”
12 cp-3R	78°10'08.89805" E	78°10'08.91082" E	-0°0'0.01277”

Table II
BASELINE PROCESSING REPORT 25-09-08 and 14-10-08

From	To	Baseline Length	Baseline Length
cp-1/b.m	cp-6	208.763m	209.252
cp-1/b.m	cp-3	260.376m	261.13
baraj b.m	cp-4	828.242m	828.56
Cp-4 b.m	cp-3	406.409m	406.63
Cp-4 b.m	cp-1	653.449m	654.2
Cp-4 b.m	cp-6	735.579m	735.87
baraj b.m	cp-3	1220.296m	1218.71
baraj b.m	cp-1	1476.884m	1475.91
baraj b.m	cp-6	1551.942m	1551.675

VI CONCLUSION AND RECOMMENDATION

A Conclusion: this project work employs the appropriate GPS technique, i.e., fast static for monitoring the landslide behavior at a site near Mansa Devi hill. On the basis of above surveying experiment, we find that the observation made were fairly consistent, expect for that at some point where disturbance to the control point position occurred due to irrelevent human intervention and which irreconcilible errors.

The results (excluding the erroneous observations) indicated that the site is experiancing a landslide that is quite measurable within the period of 20 days.

B Future Recommendation

New advancement in software and algorithms must be integrated with GPS to provide better analysis of landslide deformation monitoring. The present study required that development of new algorithms to enhance monitoring results should be encouraged

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