DISCUSSION ON TILT DATA FOR TWO INDIAN SITES

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SUMMARY

The importance of measurement of small scale displacements associated with earth deformations has been pointed out and has lead to the **initiation** of these investigations in India. The infrastructure for the measurements of earth's tilt and strain in different geological settings in India has been briefly described. Tilt data from two different locations namely Pophali, Maharashtra and Barapani, Meghalaya for over 25 and 19 months respectively have been analysed and discussed.

INTRODUCTION

The measurements of ground deformations accompanying the slowly accumulating elastic strain provide useful basis for attempting earthquake prediction. A large number of tilt and strain precursor data for earthquakes with magnitudes 3.0 to 7.9 and precursor time as low as 0.0008 days have been reported (Rikitake, 76). A magnitude 5.2 Hollister earthquake on November 28, 1974 and the accompanying tilt changes at a distance of 11.2 km from the epicentre recorded about 36 days in advance is an excellent example of the potential of monitoring tilt (Mortensen & Johnston, 74) for prediction research. Similarly several local earthquakes along the San Andreas fault with magnitudes $\geqslant 2.5$ typically generate offsets in tilt and show impulsive tilt behaviour at the time of earthquake (McHugh & Johnston, 78) in records at 20 to 50 km.

The development of simple but sensitive instruments and recording of anomalous tilt and strain changes has been taken up in India. Four special vaults have been constructed at Kalawar (Dehradun), Harabagh (Sundernagar), Pophali (Ratnagiri) and Barapani (Shillong). These are being instrumented with water Tube Tiltmenters and Silca Tube Strainmeters. Accummulation of useful tilt data has already started from some of these sites. The data from Kalawar (Sinvhal, et.al., 73) was already discussed and utilised for taking important decisions on the linning of a water pressure tunnel for Yamuna Hydroelectric Project. The priliminary data from Pophali vault was discussed earlier (Agrawal, 71). The paper is a report on the tilt data so far obtained from Pophali and Barapani.

VAULTS AT POPHALI AND BARAPANI

An existing adit in massive basalts (Deccan Traps), with a T-shape plan (280m x 80m) with its approach from the long arm, near Pophali Power House, ment for inspection of penstocks, has been utilised for the purpose. The vault has an excellent annual temperature stability (within 1.0°c). The measurements of tilts and strains have been primarily initiated here to study their possible Correlation with recent seismic activity around the Koyna region. A Portable Water Tube Tiltmeter has been employed(Agrawal,71)

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for measurements on bases 30m apart in the two orthogonal limbs near their junction. A 10 meter long Silca Tube Strainmenter has been installed (Kumar, et.al./74) in the long arm adjecent to the tilt bases. The tilt measurements taken at an interval of about 2 months have become available systematically from February 1973. Since November 1976 measurements could be taken weekly since modified tiltmenters (Agrawal & Mam, 78) were installed on both the pairs of bases to sit permanently. The strainmeter data was obtained for a very limited period due to instrumentation problems and has therefore not been discussed in the paper.

A vault in homogeneous phyllites (Shillong plateau) at a carefully selected location with L - shaped plan (35m x 35m) has been constructed for the purpose near the Umiam Dam project in Meghalaya. The vault has a special significance because of its being at a considerable distance from the coastline and in the solid earth tide records, the noise due to sea loading effect is expected to be very small. Two Water Tube Tiltmeters have been installed on two pair of bases 30m apart in the two limbs near their junction. A 10m long Silca Tube strainmenter has also been recently installed and limited data (not included here) collected. The annual temperature changes has been less than 1.0°c. The systematic tilt data for daily morning and evening observations here have become available since June 1976 and have been given here.

DATA ANALYSIS AND ITS DISCUSSION

The repeat measurements have been utilised to calculate the relative heights of the bases on respective dates. Taking into account the distance between the bases the vertical strain (tilt) has been obtained corresponding to changes in the relative height and plotted againsts time and is shown in "Fig.1 (a) and (b)" for Pophali and Barapani respectively. There have been some interruptions in the observations for various reasons associated with malfuntioning of the instrument on dates as marked in the Fig. However, the strain at the begining and end of each interruption has been arbitrarily presented as no absolute control was available to inter relate the measurements.

The monthly frequency of earthquakes of magnitude ≥ 3 has also been shown for the Pophali region. The long limb of the vault at Pophali had a gradually increasing over-burden towards the junction of the limbs. The base closer to the junction was initially higher and subsequent measurements have shown a increase in their relative height. Perhaps, we could assume the base near the junction to have a greater fixity and in that case the data generally reflects a slow sliding of the hill slope. The information on the monthly frequency of earthquakes $\geq$ 3M also show some associated changes in strain. It is but natural to expect that the rate of slide of a hill slope may be effected instantaneously by such earthquakes. However, continuous measurements alone can permit firm conclusions.

Unlike Pophali where a unidirectional trend of tilts had been recorded, at Barapani a change with approximately annual priodicity has been recorded. Superimposed on the annual trend are short period fluctuations which could not be attributed to the personal errors of measurements since the changes in the morning and evening measurements show a general correspondence. Perhaps the important contributing factor for the annual change could be the water level in the Umiam Reservoir and the possibility of its association

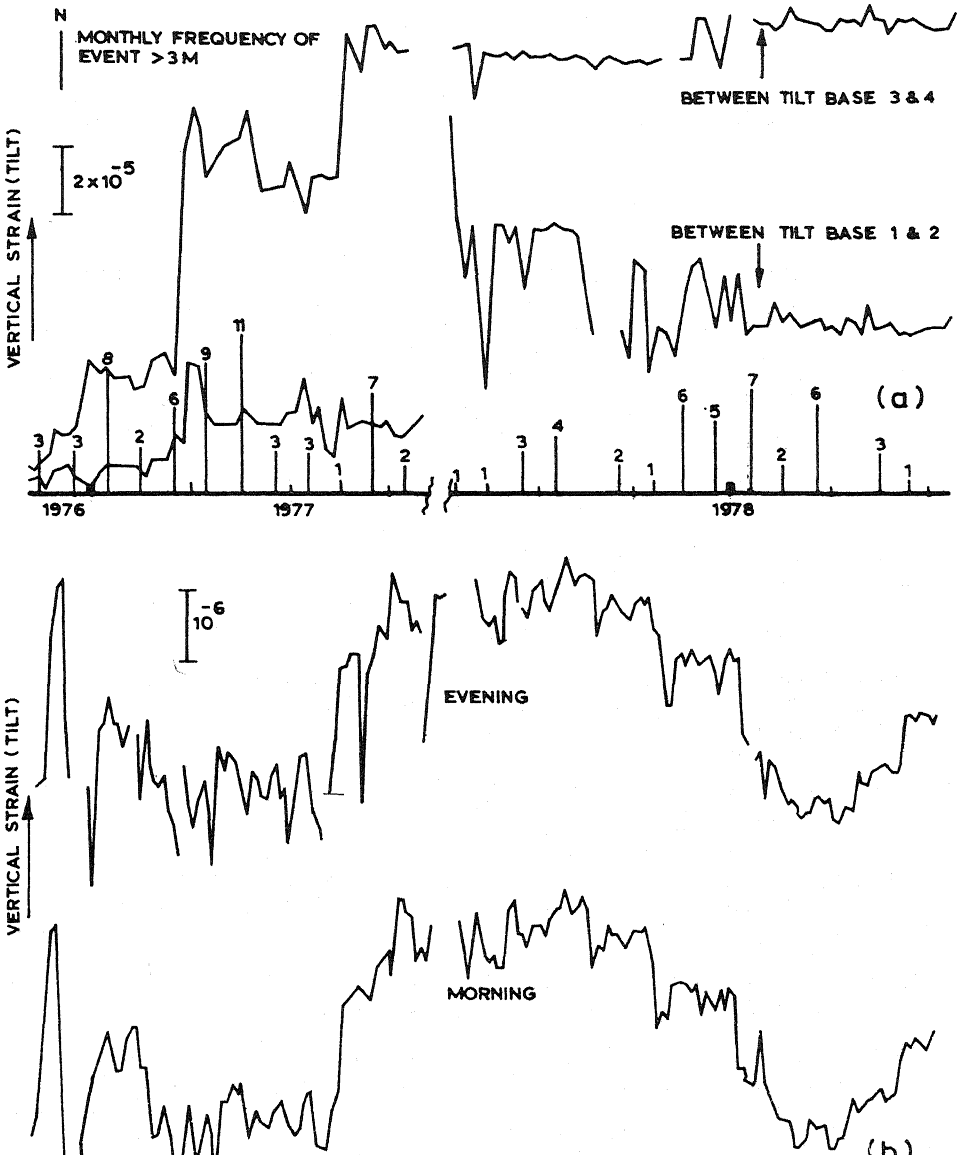

Fig.1_Vertical strain as calculated from weekly and daily measurements on pillars 30m apart in the vaults at (a) Pophali and (b) Barapani respectively

with Chandler wobble could also be verified by harmonic analysis. The short period changes may be related to microseismic activity and the ground excitation due to severe winds. Sampling of microseismic activity for a short time for verifying this may prove useful. The daily measurements at Barapani could be considered close to continuous measurements and provide a greater confidence in the data compared to weekly observations from Pophali.

CONCLUSION

The data from Pophali generally reflect the gravity sliding (unidirectional) of the hill slope. However, the instataneous sliding associated with individual earthquake may also be contributing to the total recorded signal. The data from Barapani has an approximate annual periodicity for the main signal which is supperimposed with shorter period signal perhaps related to local microseismic activity or the reservoir water level or both. The daily measurement provide a better confidence in results compared to the weekly observations.

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