Paper No. 32

A NOTE ON VIBRATIONAL CHARACTERISTICS OF GROUND AT CHATRA, NEPAL

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SYNOPSIS

Seismograms of Chatra Observatory, Nepal for a period of three years were scrutinised. Mostly the periods of ground vibration were found to occur in three ranges, namely : 0·27 sec. to 0·3 sec., 0·32 sec. to 0·4 sec. and 0·5 sec. to 0·7 sec. This period response lead to the conclusion that the ground at Chatra consists of several layers. The depth of bed rock was calculated utilizing the quarter wave length law of K. Tazime and was found to agree with the results of geophysical investigations in that area.

INTRODUCTION

It has been realised for long that a ground which is good or bad from the static point of view, may not be so under vibrational conditions. Obviously the investigations of vibrational characteristics of ground are important for the design of earthquake resistant structures. This can be achieved by :—

(a) Interpreting seismograms suitably along with the theoretical studies of seismic waves.

(b) Seismic prospecting.

(c) Shaking ground by vibrating machines.

(d) Statistical studies of earthquake damage.

The results given in this paper are based on the study of seismograms of Chatra Observatory, Nepal for the period May, 1959 to April, 1962. The records available for this period were from the following seismographs :

1. Milne Shaw No. 67297	To = 12.0 sec., V_s. = 250,	ε = 20:1
2. Wood Anderson No. 5	To = 1.0 sec., V_s. = 1000,	ε = 20:1
3. Benioff Short Period (Z)	To = 0.72 sec., T_g. = 0.4 sec. ε_s = 2.3:1 ε_g. = Critical.	

These seismograms were scrutinised for local shocks, microtremors and short period microseisms. The periods of P and S waves in the local shock records may be thought to be associated with the periods of ground vibration (Gutenberg 1957). In recent years microtremors have been utilized for such purposes (Kanai and Tanaka 1961). However, short period micro-

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seisms have been found most advantageous in such studies (Akamatu 1961). Though these consist of random waves generated from various sources, both natural and artificial; but their periods are found to correspond with the periods of ground vibration. The periods of all the above movements on these seismograms were determined. These can be taken as the periods of ground vibration and can throw some light on the vibrational characteristics of ground at Chatra.

LOCAL SHOCKS

Milne Shaw seismograms contained very few local shocks (Fig. 1) and for these also the period of P and S group of waves could not be measured. Because the paper speed was only 16 mm per minute and the wave periods were less than 1 second. For most of the local shocks recorded by Wood Anderson Seismograph, the period of P and S group of waves could not be picked up as the P movements were small where-as after the onset of S the records were invisible due to the rapid movement of light spot. However, ten shocks (Fig. 2) were selected for the purpose. Benioff seismograph had recorded a good number of local shocks very well (Fig. 3). Thirty suitable shocks well scattered over the period were examined and P and S wave periods were determined.

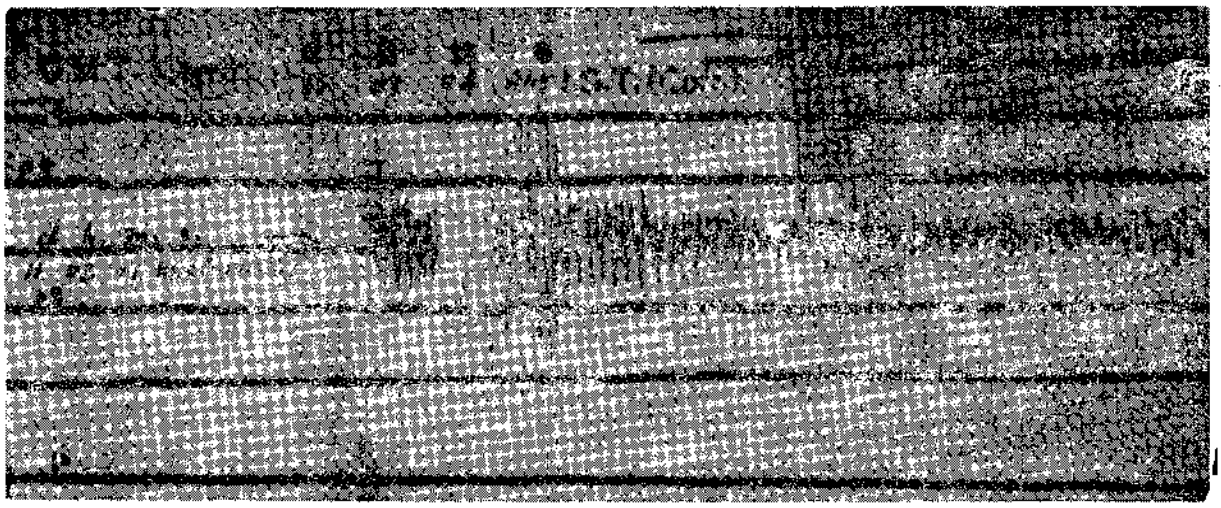

Fig. 1, Section of Chatra Milne Shaw Seismogram, 11-12 Jan. 1962

SHORT PERIOD MICROSEISMS AND MICROTREMORS

Benioff seismograph had very prominently recorded short period microseisms. Occasionally microtremors were also found to be well recorded. A scrutiny of these seismograms revealed that the microseismic activity had a marked daily variation during the period September–October to April–May (Fig. 4) whereas during the period April–May to September–October the daily variation of the same was very small and gradual (Fig. 5). The seismograms for the above two periods were very distinctly different in appearance. From year to year it

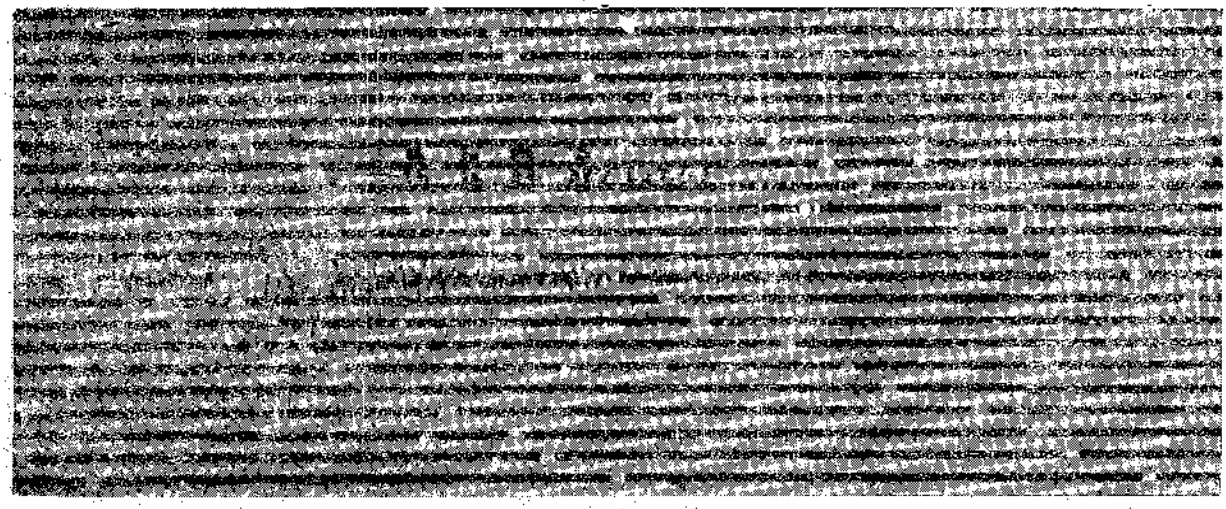

Fig. 2. Section of Chtra W. Anderson Seismogram, 16-17 Dec. 1961

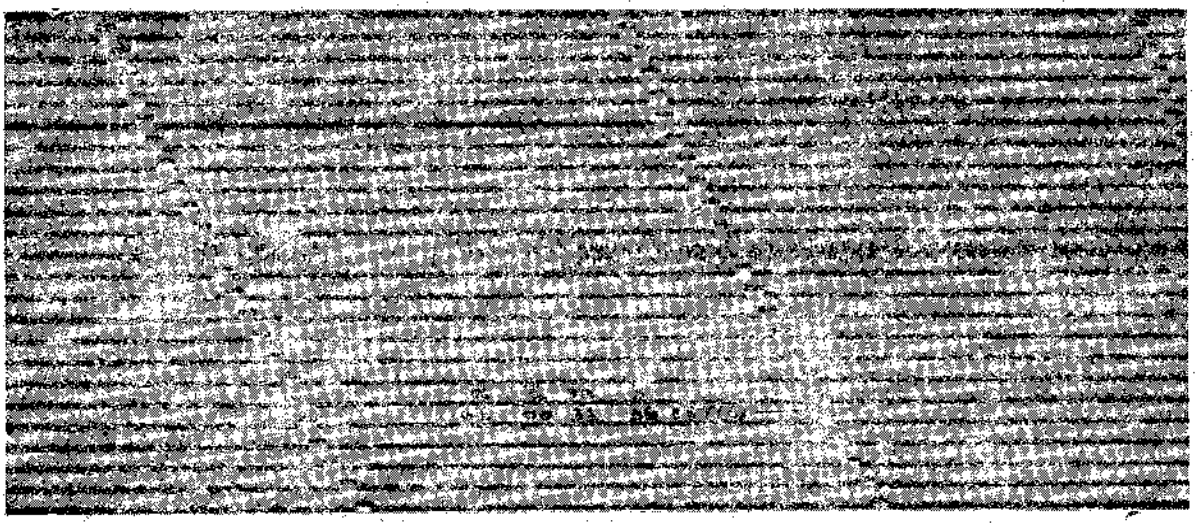

Fig 3. Section of Chatra Vertical, Short Period Benioff Record 05–06 May 1961

was found that the change from one kind of appearance of the record to the other was abrupt and not gradual. One typical day for each of the above periods has been taken and the maximum amplitude of the dominant period microseisms averaged over two minutes around every hour have been plotted so as to represent the daily variation in microseismic activity. Graph corresponding to first period (Fig. 6a) shows that nights were quiet whereas the days were disturbed, only one exception found to this was where the microseismic activity was more even during late evening hours. Corresponding synoptic conditions were examined. The microseisms present were of short period. But during the other period (Fig. 6b) this feature could not be clearly seen due to regular presence of long period microseisms. The nature of daily variations as represented by these two graphs could be very clearly seen on the daily charts

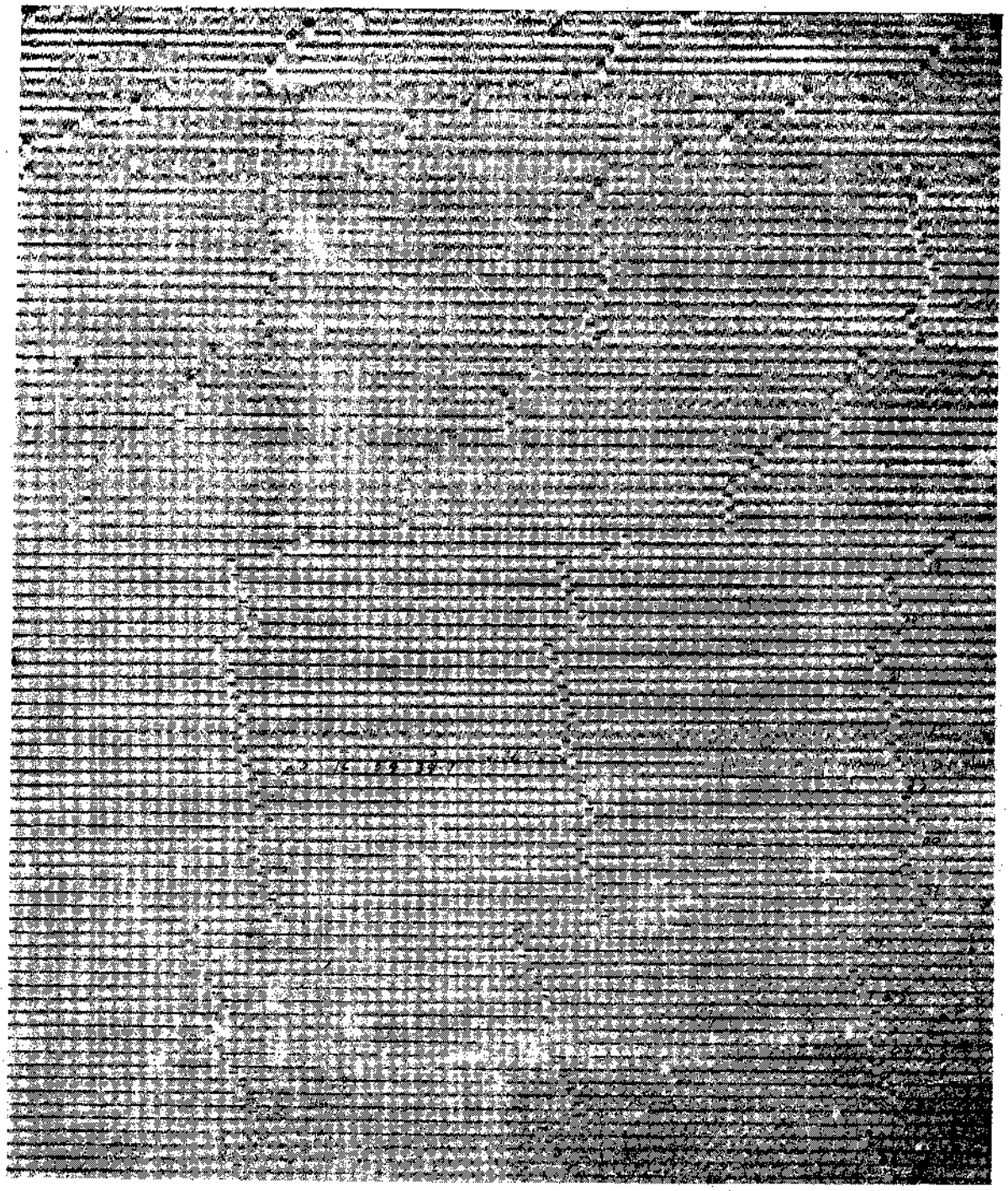

Fig. 4. Section Chatra Vertical, Short Period Benioff Record, 23–24 Nov. 1960

at a glance. Dominant wave periods prevailing in these microseisms of different kind and also microtremors were measured.

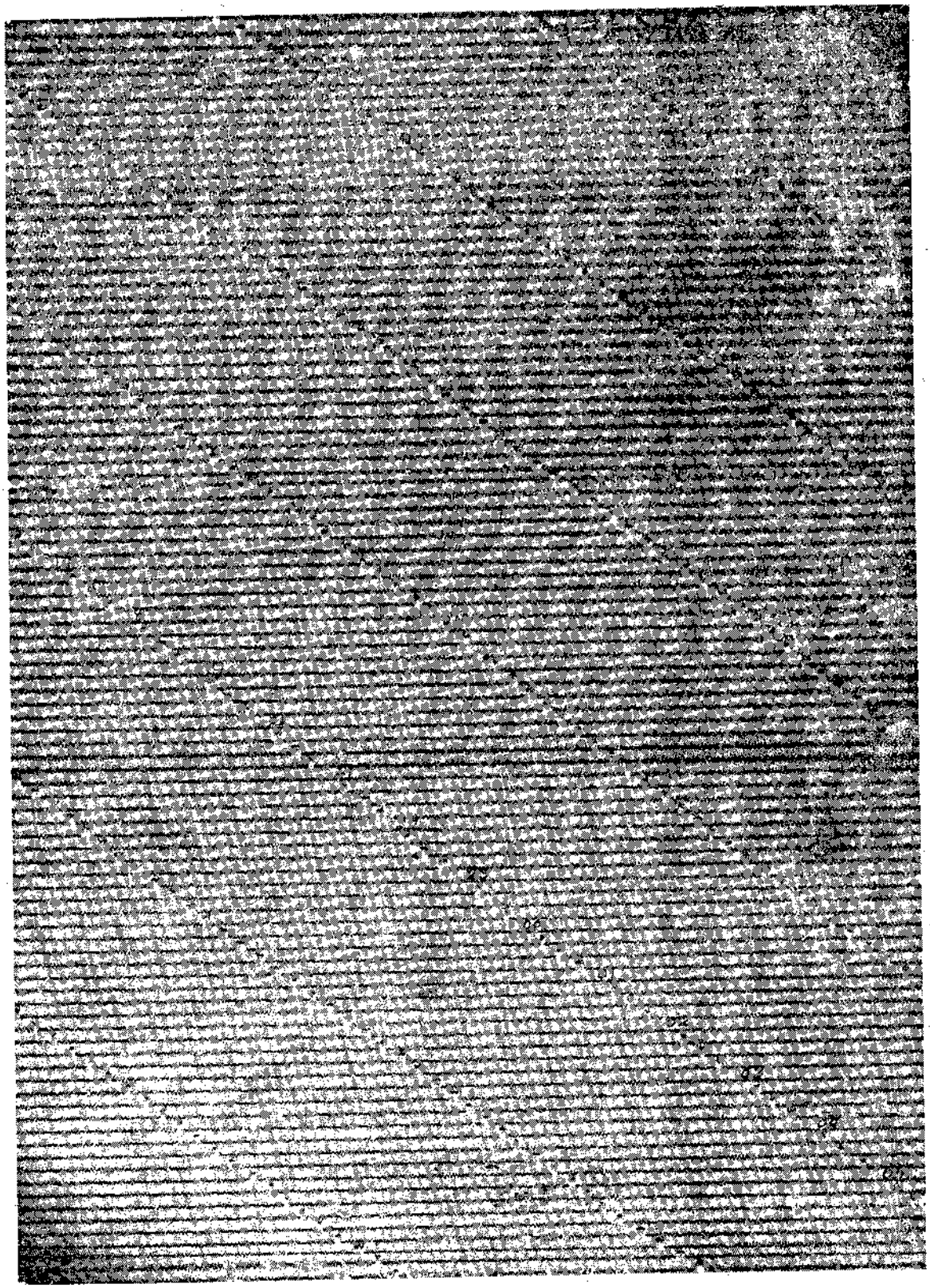

Fig. 5. Section of Chatra Vertical, Short Period Benioff Record, 30–31 July 1960

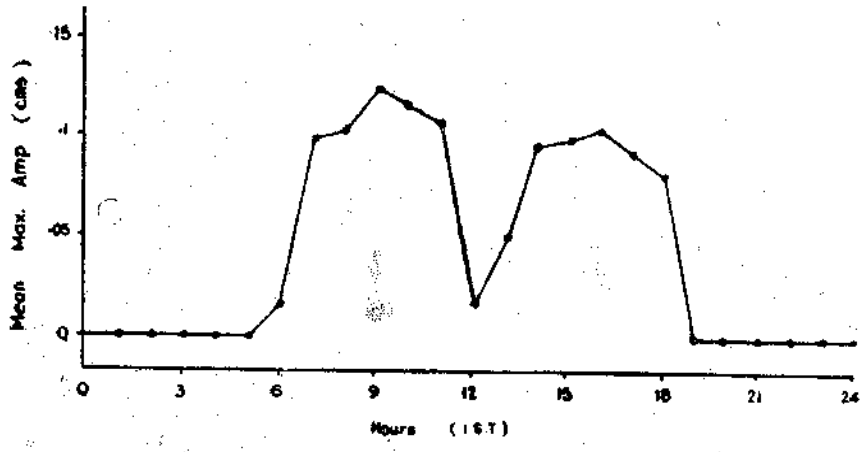

FIG - 6 (a) DATE 3rd OF DEC 1960

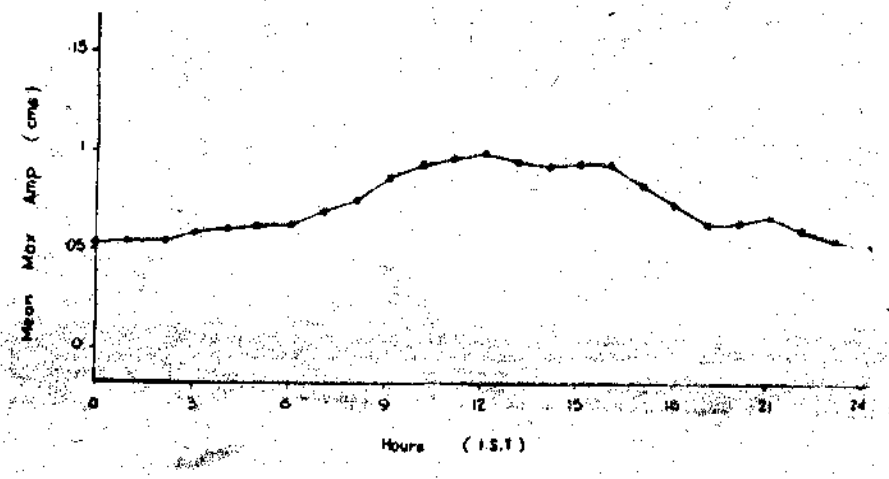

FIG - 6 (b) DATE 10th OF AUG. 1961

FINDINGS AND DISCUSSIONS

The wave periods of P and S movements of local shocks were found to lie between 0.5 to 0.7sec in general. The dominant periods of microseisms and microtremors appeard to be occurring in the ranges: 0.27 sec. to 0.30 sec., 0.32 sec. to 0.40 sec. and 0.50 sec. to 0.70 sec. The shorter periods mostly corresponded to the microsesims of day time. The appearance of these microseisms during the working hours of day time suggests that these might have been due to artificial disturbance of workings in the Kosi Project causing a thin surficial layer to vibrate. The sudden decrease in microseismic activity during mid-day may correspond to lunch break in the work. The occurrence of microseisms with greater periods during April-May to September - October might be associated with the increased flow of water in the Kosi river or some other natural cause like weather. Because. it has already been realized that the microseisms due to

natural causes are of longer period than can be induced by artificial causes. Though the short period microseismic activity also appears to exist but it has been almost not seen due to the dominence of long period microseisms. The increased microseismic activity in late evening hours on a particular day during September – October to April – May, unlike the general trend might have been due to the thunderstorm activity over that region on that day as found by the examination of synoptic conditions.

Ordinarily, there are two kinds of spectral response of ground possible—one having a predominant period peak and the other having an irregular shape with number of flattened maxima. Theoretical study of Kanai (1957) indicates : in case of the predominant vibration appearing at the free surface, the surface amplitude seems to be concerned with the rigidity ratio of two layers; and values of rigidity themselves of the two layers have no connection with the predominant period amplitude. Also that as the number of layers increases the number of requisite conditions of the predominant vibration increases. In other words, the case of the predominant vibration of ground becomes rarer. The spectral response of amplitude of the surface layer is very irregular and maximum value of peak is not so large as in the case of single layer since the elastic wave reflections at the various boundaries interfere with one another. Interpretation of Chatra seismograms with this background of knowledge would indicate that the ground at Chatra seems to consist of a series of layers. The middle range of periods seems to be associated with the vibration of the total thickness of weathered layer. The shorter periods may correspond to the vibration of a thin layer of the overburden. According to Tazime (1959), $T = \frac{4H}{V_p}$ where T is the corresponding period, H is the thickness of the overburden and V_p is the longitudinal velocity in weathered layer. Taking mean (more common) T as 0.35 sec. for the middle range and the longitudinal velocity as 1270 ft./sec (Banerjee), the thickness of overburden comes out to be $H = \frac{V_p T}{4} = \frac{1270 \times 0.35}{4}$ ft. = 110 ft. approx., which is in fair agreement with the findings of Banerjee by geophysical investigations near Chatra.

CONCLUSIONS

1. The vibrational response of ground at Chatra as studied with the help of local shocks, microtremors and short period microseisms points out that it consists of several layers.

2. The predominent period of ground vibration was absent. The more common ground vibration periods ranges from 0.27 to 0.30 sec., 0.32 sec. to 0.40 sec. and 0.50 sec. to 0.70 sec.

3. The thickness of the overburden as calculated from the middle range of ground period is 110 ft. approximately and is in fair agreement with that determined by geophysical

investigations at Chatra. Hence it may be concluded that period 0.32 sec. to 0.40 sec. corresponds to the vibration of overburden.

ACKNOWLEDGEMENT

I wish to express my thanks to Dr. Jaikrishna, Director, School of Research and Training in Earthquake Engineering, University of Roorkee, as he had suggested the problem and gave encouragements during the preparation of this paper. I am also thankful to Dr. V.K. Gaur, Reader, Department of Geology and Geophysics, University of Roorkee, for his going through the manuscript.

Thanks are also due to Shri B.P. Saha, Meteorologist Incharge, Central Seismological Observatory, Shillong who extended all the facilities for the scrutiny of seismograms at Shillong.

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