Paper No. 133, Bulletin I. S. E. T., Vol. 10, No. 2, pp. 57–59, June 1973

SEISMIC DETERMINATION OF POISSON'S RATIO OF ROCK IN SITU

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INTRODUCTION

The practical importance of obtaining in situ values of Poisson's ratio (σ) of rock is well-known and requires no further emphasis here. But unfortunately Poisson's ratio (σ) of rock has not yet been studied sufficiently and as a matter of fact, there is no standard method as such for its direct determination in the field. With the aim of developing a routine practice for determination of in situ Poisson's ratio, the project described herein was undertaken at the Central Water and Power Research Station, Khadakwasla, Poona.

DETERMINATION OF POISSON'S RATIO

From the classical elastic theory the following simple relationship

$$\sigma = \{0\cdot 5)(V_p/V_s)^2 - 1\}/\{(V_p/V_s)^2 - 1\} \quad \ldots (1)$$

amongst compressional (V_p) and shear (V_s) wave velocities and Poisson's ratio (σ) can be deduced for a homogeneous and isotropic medium. Hence the measurements of V_p and V_s provide a direct means for determination of σ in situ. But the problem is generally complex due to the fact that separation and identification of shear wave arrivals on seismograms from the later arriving mixed signal trains of refracted and reflected body waves, Rayleigh and Love type surface waves and various converted waves, often present a formidable task, so much so that Swain (1962) commented—"It is probably safe to to say that shear waves are usually a nuisance to the exploration seismologists". However, with the use of improvised types of equipments and judicious field and interpretation techniques, it was possible to record and identify shear waves in conjunction with compressional waves with sufficient clarity during the refraction seismic work described. In fact under ideal circumstances, shear waves (SH) can be recorded even as first arrivals. Detailed discussions of the theoretical principles of shear wave as well as compressional wave generation and their registration are beyond the scope of this brief note and hence only the operational aspects of the method used and the results obtained are presented herein. However, interested readers in the subject may find useful materials in the works of Jolly (1956), Swain (1962), Meidav (1967), Cherry and Waters (1968) and others.

The field operations were confined mostly on rock exposures scattered over an area of about 0.5 sq. km. around the campus of the Central Water and Power Research Station establishment at Khadakwasla, Poona. This area forms a part of the Decan trap of Lower Eocene-Upper Cretaceous age. The trap rocks exposed over the area had undergone varying degrees of weathering and exhibit moderate jointing and fissuring at places.

A multichannel seismic refraction unit was employed for registration of seismic signals. A 10 kg. hammer served as the source of seismic energy and was operated

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horizontally against a vertical face carved out on the rock surface. The hammer was stuck in transverse orientation with respect to the profile bearing so as to generate more of horizontally polarised shear (SH) energy. Horizontal geophone was placed in transverse direction with respect to the profile alignment to facilitate maximum reception of the SH wave energy. The first arriving P-wave energy was recorded by a vertical geophone placed adjacent to the horizontal geophone. This set of two geophones, one horizontal and another vertical, was then moved outward for the seismic source in measured steps till a profile was completed.

Even after taking advantages of all the special techniques for generation and reception of shear waves (SH type), as indicated above, at times it may so happen that, what is thought to be shear wave arrival on seismograms may not actually be so due to some peculiar field conditions (Meidav, 1967). Hence a number of auxiliary criteria (Jolly, 1956) were used for positive identification of shear waves which included (i) source polarizability, (ii) comparison of time-distance curves of various phases recorded on seismograms and the velocities computed therefrom and (iii) dispersion characteristics of surface waves.

A typical seismogram obtained during the experiment is reproduced in Fig. 1. The record was taken by placing a set of two geophones (one horizontal—'H' and one vertical—'V') at 50 m from the transverse impact-source. The trace marked 'O' shows the instant of hammer impact whereas in the trace 'H' the SH-wave arrival almost free of P-wave energy is clearly seen as first arrival. The onset of earlier arriving P-wave is registered on the 'V' trace. Such seismograms aided the determination of the P and SH wave velocities for various profiles taken. Using these velocity data Poisson's ratio was calculated from equation-1. The variation of Poisson's ratio over the test area is presented in Fig. 2 in the form of a histogram and may be attributed to the existing physical state of the different exposures of the rock. It can be seen from the histogram that whereas for sound basalt the values of σ fall in the range of 0.20 to 0.28, jointed and weathered basalts exhibit variation in their σ values from 0.32 to 0.44.

CONCLUSIONS

(1) P-wave recording in seismic refraction survey may, perhaps, be considered as a "fool proof" technique by now. Hence the success and accuracy of the present method of Poisson's ratio determination depend mainly on the correct recording and identificaton of the SH wave. Under favourable field conditions it is possible to record P and SH waves simultaneously and fairly accurately provided, suitable seismic source and detectors are employed in proper orientations.

(2) The physical state of in situ rock masses is well reflected in the values of Poisson's ratio determined by the seismic technique described here, and hence the present simple and direct method of finding the in situ Poisson's ratio appears to have great potentiality.

(3) In the technique described, only horizontally polarised shear wave (SH) was considered, but perhaps, inclusion of the vertically polarized shear wave (SV) in this method will help in further refinement of the in situ Poisson's ratio values. Further, measurement of velocities of vertically travelling stress waves in boreholes, it is expected, will lead to determination of more representative values of in situ Poisson's ratio of rock, so far its engineering applications are concerned.

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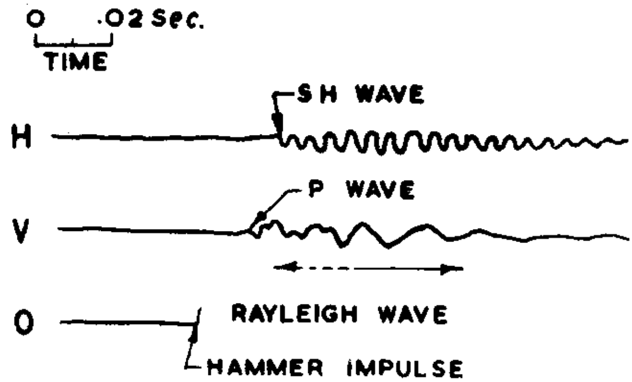

Fig. 1. A Typical seismogram recorded at 50m from the source

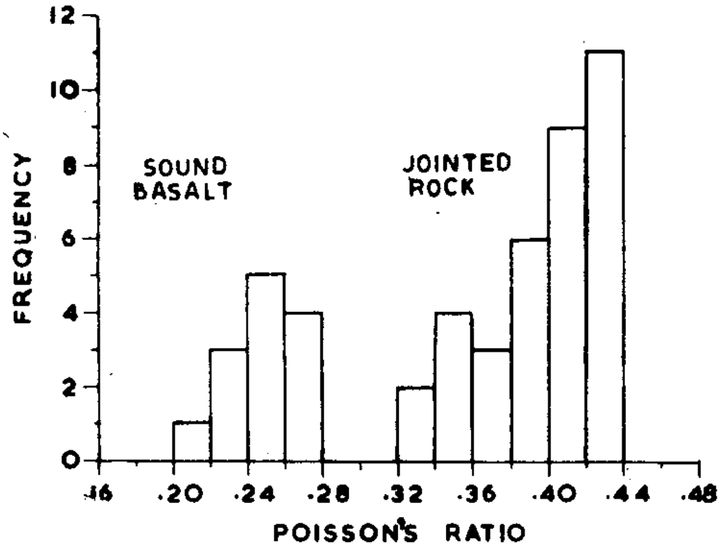

Fig. 2. Histogram of poisson's ratio obtained over the test area

APPENDIX—NOTATIONS

σ=Poisson's ratio
P=Elastic Compressional wave
S=Elastic Shear Wave
SH=Horizontally polarised shear wave
SV=Vertically polarised shear wave
V_p=Compressional wave velocity
V_s=Shear wave velocity.