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SEISMIC INVESTIGATIONS IN THE VICINITY OF THE RAILWAY LINE BETWEEN WODONGA AND ALBURY VICTORIA

by

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C O N T E N T S

P L A T E S

I. INTRODUCTION

The refraction seismic tests described in this report were made at the request of the Victorian Railways Department. The work was located within the railway reserve between the outskirts of Wodonga township and the River Murray, and consisted of the shooting of five refraction traverses, set out approximately parallel to the railway line and covering in detail a total length of 4,800 feet.

The aim of the seismic work was two-fold. Firstly an investigation was required of the subsurface formations in the vicinity of the bridges which carry the railway across several creeks intersecting the Murray flood plain. The subsurface information is required in connection with the design of the foundations of new bridges which will be constructed to replace the existing ones.

The second purpose of the work was to test whether the refraction seismic method would be suitable for adoption by the Railways Department engineers as a standard routine method for investigating foundation conditions. To fulfil this purpose ideally, the method would need to be applicable generally to all the foundation problems encountered by the Department and to completely eliminate the necessity for test drilling of sites.

The flood plain of the Murray, on which the seismic measurements were made, is composed of Recent alluvium, probably underlain by Tertiary river deposits and is crossed by several creeks and anabranches of the main stream. The outcrops in the vicinity of Wodonga show the bedrock to be granite and metamorphic sediments.

The field work was done between February 26th and March 12th, 1953. The field party comprised two geophysicists and three field assistants provided by the Railways Department.

II. EQUIPMENT AND OUTLINE OF OPERATIONS

The observations were made with a Heiland 12 channel truck-mounted set of seismic equipment. This equipment has been built primarily for the reflection seismic method as used in oil exploration and is therefore considerably more elaborate and heavier than required for shallow refraction work. It may be of interest to note that portable refraction equipment consisting of four or five light units and designed primarily for use in engineering investigations is now manufactured by several overseas firms.

The layout of the five traverses in relation to the railway line is shown in the accompanying plan. The usual practice was followed of recording travel times in two opposite directions, that is, with the shot point first at one end and then at the other end of each traverse. In order to obtain detailed time-distance data, the geophones were placed at 10 to 20 feet separations for the first 200 feet from the shot point and then at larger separations, not exceeding 50 feet, to the end of the traverse. Charges of gelignite up to 3 lbs. were used. With geophone distances up to 100 feet the charges were placed one foot below the surface, and for the greater distances, 4 to 5 feet below the surface.

III. RESULTS

Following the standard method of analysing refraction seismic data, the time-distance graph has been plotted for each traverse. The form of this graph, obtained by plotting the shot point to geophone distance against the travel time for the first arrival of the seismic disturbance, will show the presence of refracting horizons below the surface. If sufficient velocity contrast exists between the subsurface layers and provided that the necessary conditions is fulfilled that the velocity of a layer is higher than the one above it, the time-distance graph indicates the velocities of the different layers and enables the depths of the interfaces to be calculated.

In the present survey, a low velocity surface layer was observed on all traverses. The velocity of the layer was uniformly 1000 f.p.s. and its thickness between 10 and 15 feet. This is the weathered or aerated layer encountered almost universally in seismic work; its low velocity is attributed to inclusion of air in the pores of the surface material.

Below this, a second layer was indicated with a velocity between 5,500 of f.p.s. and 6,500 f.p.s. The change from 1,000 f.p.s. to 6,000 f.p.s. does not take place suddenly at the base of the weathered layer but is in the nature of a gradual increase over a distance of about 20 feet. This transition is probably due to a decrease with depth in the amount of air in the pores of the material together with an increase in the moisture content.

Refractions from the bedrock underlying the second layer were recorded on traverses A, B and C. Below traverse A the bedrock is approximately 140 feet below the natural ground surface. The bedrock has a general dip towards the north and at the Murray the depth, as estimated from the results on traverse E, must exceed 300 feet. A velocity of 15,000 f.p.s. recorded for the bedrock identifies it fairly definitely as either granite or metamorphic rocks.

The depth of the bedrock in the area appears to rule out the possibility of supporting any of the bridge foundations on bedrock. Attention must therefore be directed to the second seismic layer and the results were examined to find how much information they provide on the nature of this layer.

From the results of other seismic surveys carried out by the Bureau and by reference to tables of seismic velocities published in geophysical literature, it is known that the velocity range of 5,500 to 6,500 f.p.s. is typical of unconsolidated sediments such as clays, silts, sand and gravels. From the local geology such materials would be expected to constitute the river deposits filling the Murray valley. These river deposits are probably in part Tertiary. In the transition zone between 10-15 feet and 30-40 feet, in which the velocity increases from 1,000 f.p.s. to 6,000 f.p.s., there may be an increase of compaction with depth but any such increasing compaction is probably not important to the foundation problem as the maximum velocity reached at the base of the zone is still only typical of the unconsolidated sediments mentioned above.

The time-distance graphs show no increases in velocity which could possibly be regarded as due to refractions from higher velocity beds within the river deposits. In the absence of any control information, it is not known whether the section of sediments is geologically uniform or whether beds of different types of sediments are present. The latter condition is more likely. However, it has been found in seismic surveys over Tertiary sediments in other areas such as Oaklands, N.S.W., and Cobram, Victoria, that the method is not capable of differentiating between the clay, sand and gravel beds. The reasons for this are probably that the beds are too thin and there is not sufficient velocity contract between them. Hence in the Wodonga survey it is considered very likely that there are beds of gravel, which probably give better support for bridge piles than clays and silts, but which have not been detected by the seismic observations.

The information given by the seismic work with regard to the sediments between the surface and the bedrock consists then of the thickness of the weathered or aerated layer, the general unconsolidated nature of the sediments and their total thickness. In so far as the seismic tests have not detected a hard rock at a convenient depth for the support of bridge foundations, the results must be regarded as inconclusive.

IV. SUMMARY AND CONCLUSIONS

The refraction seismic tests carried out alongside the railway line between Wodonga and Albury show that the thickness of river deposits overlying the granite bedrock increases from 140 feet at the southern end of the area investigated to over 300 feet at the River Murray. The seismic velocities observed indicate that the river deposits consist of predominantly unconsolidated sediments. No evidence was obtained of any beds of harder rock suitable for bridge foundations at a suitable depth.

In considering the possible general use of the seismic method in foundation problems encountered by the Railway Engineers, it is clear that the method is limited in its ability to give detailed information on the different beds that probably occur in a thick section of river deposits. It seems likely that most bridge construction will be required on sedimentary formations of this type and although some useful information could be expected from seismic work, drilling tests would also be required.

The seismic velocity in any material is an indication of its rigidity but there is considerable doubt as to what extent the velocity in low velocity materials such as sands, clays, and gravels (i.e. in range 4,000 to 7,000 f.p.s.) can be used as an indication of such properties as the bearing capacity or resistance to plastic flow under the action of stresses of long duration. If any such relation exists it would have to be established empirically for each particular locality.

In areas where a hard bedrock occurs close enough to the surface to be useful for the support of foundations, the seismic method is particularly useful for tracing the contours of the bedrock surface beneath the overburden. Typical of such a problem would be granite or other igneous rock (velocity range 14,000 to 18,000 f.p.s.) or shale (10,000 to 13,000 f.p.s.) beneath an overburden of say alluvium or weathered rock with velocity up to 6,000 or 7,000 f.p.s. It is on sections of this kind that the refraction method is being mainly used in investigations related to hydro-electric developments in Australia and has been used extensively overseas for many years. In particular, the method has proved useful for the reconnaissance of unknown areas to decide on the most favourable sites for engineering projects.

A certain amount of test drilling is normally required to provide a control on the seismic interpretation. The amount of drilling required is dependent on the local geological conditions, being greater when the overburden is non-uniform or the bedrock surface very irregular. In some areas where the subsurface formations are uniform and are differentiated by large velocity differences, the seismic method could conceivably give sufficiently reliable and accurate depth determinations to make drilling tests completely unnecessary.

From the foregoing discussions, it will be seen that the refraction seismic method will not be applicable to all the foundation investigations required for the design of railway bridges and similar structures; in some places, such as on the Murray flood plain it will give some useful information but not the complete data sought by the engineers; in others, where a hard foundation rock occurs at shallow depths, it may give all the data required. Clearly, each site would have to be considered on its own merits and with reference to the local geology before deciding whether or not seismic investigations were warranted.

N. G. Chamberlain.
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Melbourne.
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REFRACTION SEISMIC SURVEY

CARRIED OUT FOR VICTORIAN RAILWAYS

BETWEEN **WODONGA & ALBURY**, VICTORIA

GEOPHYSICIST