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TITLE: GEOPHYSICAL INVESTIGATION OF THE
HELENA RIVER BRIDGE-SITE, KALA -
MUNDA - MUNDARING ROAD.

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HELENA RIVER BRIDGE - SITE,
KALAMUNDA - MUNDARING ROAD.

by

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INTRODUCTION

A geophysical survey was carried out by the Geological Survey Branch of the Mines Department in December 1962, at the proposed site of a bridge over the Helena River, just below Mundaring Weir. The Main Roads Department of W.A. (M.R.D.), requested aid in determining the depth to granite bedrock below alluvium after auger drilling failed to give conclusive information. Knowledge of the thickness of overburden above solid granite is necessary for contract specifications and foundation design.

Drilling has indicated that the site section consists of some 20 feet of alluvium, sands and clayey sands, overlying granite. Deep weathering of the granite appears to be absent; decomposed granite is in places about six feet thick. A sharp velocity contrast between the alluvium and granite was anticipated, and the seismic method was selected as the most suitable to obtain the required information.

GEOPHYSICAL METHODS

A "Dynametric" Seismic Timer equipment, consisting of an electronic timer, geophone and sledgehammer fitted with an impact switch was used for the work. The seismic refraction techniques are fully described in the standard texts such as Jakosky (1950) and Nettleton (1940). In brief, a seismic shock is initiated by a sledgehammer blow which also starts the electronic timer. The shock wave travels through the ground along paths determined by strata thicknesses and velocities to the geophone which generates a voltage pulse to stop the timer. Different times are registered at each variation of the geophone to impact point distance. The geophone /impact point distance is usually varied along a straight line in a systematic manner and the observed times so obtained are plotted against the appropriate distance. The resultant

travel time curve can be used to determine the strata velocities and depths to the velocity interfaces in multi-layer problems.

Two traverses, Line 1 and Line 2, oriented as shown on Plate 1 were investigated. The geophone was alternately placed at each end of each traverse and impacts made at 5 and 10 foot intervals along the traverses. By obtaining reversed travel time curves it was hoped that the depth to granite in the central section of the site could be determined by the reciprocal method of interpretation. Additionally, where possible, the depth to bedrock at each geophone station was calculated by the critical distance and time intercept methods.

LIMITATIONS OF THE SEISMIC REFRACTION METHOD

It is desirable to draw attention to some of the more important limitations of the method as they apply to the Dynametric Seismic Timer instrument operating under the local conditions. These limitations have a considerable influence on the interpretation and accuracy of the results and are due mainly to the instrument, which normally is intended for use in a simpler environment.

Perhaps the most serious disadvantage is the variation in recorded travel times from one particular station. It is not uncommon to register five different times in, say, ten hammer blows, and have these differences range over 10 milliseconds or more. The discrepancies are usually more pronounced when distances between the geophone and impact stations exceed 80 feet. They are due in part to variations caused by different amplifier gain settings and can be minimised by using a constant gain for all observations on a particular traverse or survey. Compaction of unconsolidated soils with successive hammer blows also results in appreciable time variations; the time selected is usually the most repetitive reading in the group but is not always correct. It is

sometimes possible to eliminate incorrect times by comparing results obtained from measurements in the reverse direction.

The seismic timer can only register one arrival time and this may, according to the energy level of the wave front, be that of the first or subsequent events. Here again it is frequently difficult to discriminate between first and later arrivals, and if a second arrival time is registered the important first arrival time must be interpolated. In problems involving reasonably uniform layering and small topographic and refractor relief, time errors can be detected by unusual departures from the general travel time curve.

At the Helena River site the ground level varies abruptly and the bedrock topography is by no means regular. The times for each station have been selected after a very careful study and, with due consideration of the limitations discussed above, are the ones most likely to be correct.

INTERPRETATION AND DISCUSSION OF RESULTS

The results of the seismic survey are shown in section on Plate 1 as the granite profiles along Lines 1 and 2. The dispositions of the seismic lines in relation to the M.R.D. centre line are also given.

The interpretation is based on the assumption that only two velocity layers occur and that there is no increase in the velocity of the uppermost layer with depth, although such increases are common.

The velocity of the upper layer in all instances fell within the limits 1130 to 1140 feet per second and this velocity is consistent with that typically associated with unconsolidated sands and near surface material. Measurements over an outcrop of granite gave a velocity of 10,000 ft/sec. It is usual for solid granite to have velocities in excess of 13,000 ft/sec. and the somewhat lower velocity encountered here is attributed to jointing. This measured velocity agrees substantially with

those obtained from the travel time curves although velocities of about 16,000 ft/sec. would fit the erratic distribution of times in the curves equally well. The use of this higher velocity would not significantly alter the depth estimations for a two layer solution.

The profiles given were calculated from the vertical travel times (corrected for elevation and reduced to the datum R.L. 45 feet) and a velocity of 1,130 ft/sec. The vertical segment times were obtained from the overlap section 2160 to 2230 of the reciprocal measurements, wave paths in this section having travelled through the bedrock refractor.

The depths to granite revealed by drilling, particularly those in drill holes Nos. 6, 7, 1 and 2, correlate well with the seismic results. In drill holes No. 4 and No. 5 where granite was encountered at 4 and 6 feet respectively, true bedrock appears to be about 12 feet below the surface. The drill hole granite may well be a floater. The degree of jointing in the granite cannot be deduced because of the uncertainty of the true velocity of the bedrock refractor.

This interpretation is the simplest possible but in view of the local conditions and somewhat uncertain seismic results, some discussion of an alternative solution is necessary.

The travel time curves contain no sure evidence of a layer with a velocity intermediate between those of the alluvium and granite, although in the local circumstances such a layer could be present. On the assumption that the rock material below the water table (arbitrarily taken as R.L. 49 feet) is saturated, then a layer with a velocity of 2,000 - 4,500 ft/sec. should be apparent in the curves. This saturated layer, if present, should have a thickness in excess of 10 feet and radically increase the estimated depths to granite. The decomposed granite with a probable seismic velocity of the order of 8,000 ft/sec. would only effect the vertical travel times by less than one millisecond and may

be neglected.

In an attempt to justify the inclusion of an intermediate velocity layer in the interpretation a hypothetical case was considered. Travel time corrections for the material of 1,130 ft/sec. above R.L. 49 feet were made, and a velocity of 3,000 ft/sec. used to calculate the depths to granite below datum. These depths exceeded those of the granite in drill holes Nos. 6, 7 and 3 more than 15 feet in every instance and it was concluded that the original interpretation shown on Plate 1 is the most reasonable.

It is considered that the results given are probably accurate to within plus or minus ten percent with due allowance for errors incurred in the selection of travel times due to personal judgement.

SITE APPRAISAL AND BRIDGE FOUNDATIONS

With from 20 to 30 feet of unconsolidated sands of alluvial origin lying above massive granite, it would appear that the driving of pre-cast piles would provide the best method of foundation for the proposed bridge. It would appear certain that, lying on top of the granite bedrock, there would be found cobbles and boulders, especially in the middle of the site. These may cause some small local variations in the pile lengths at any particular pier.

At this part of its course it is obvious that the Helena River is considerably under grade, and the present channel is located on alluvium and slope talus, about 20 ft. above the former channel which was eroded in solid rock. This means that decomposed rock material (usually granitic) will only be encountered higher on the rock slopes (which correspond roughly with the present slope surface) under the cover of unconsolidated materials. Therefore, piles driven near the centre of the bridge will show an abrupt increase in penetration resistance and there will be little 'seating' material. Under either end of the structure, however, there

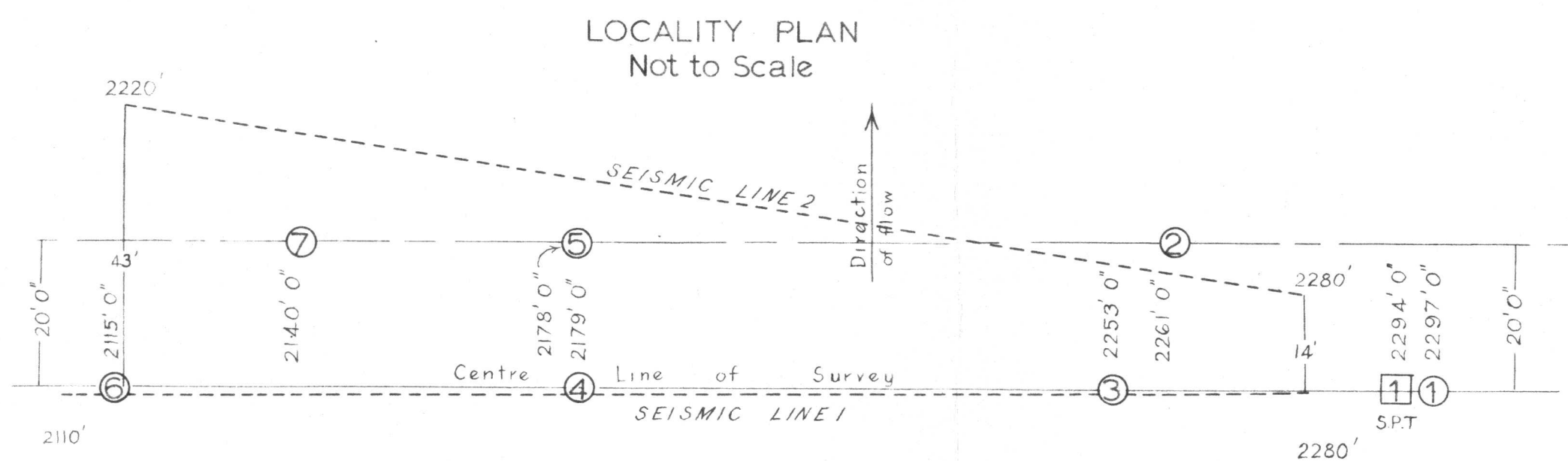
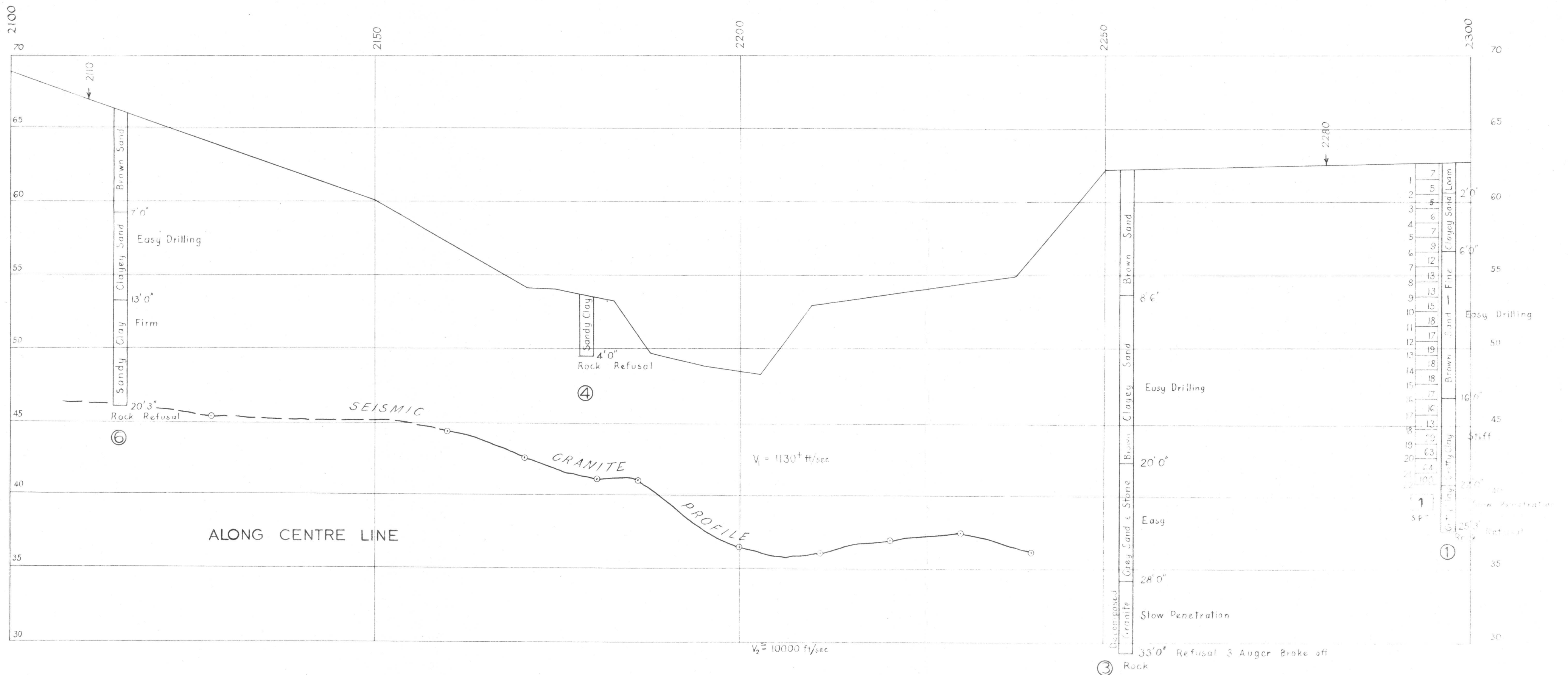
will be 5 - 10 ft. of decomposed granite above the solid, and this will provide gradually increasing resistance to driving and an adequate seat.

The seismic survey indicates that the 'rock', encountered in boreholes 4 and 5 between 4 and 6 feet below the surface, is a floater, albeit of great extent. There is no reason to suppose that other large sized boulders would not be encountered, although no indications were recorded on the seismic lines. It would be prudent to drill on the finally selected pier positions in order to obviate the danger of the piles encountering boulders at shallow depths.

In locating the piers, it would be as well to straddle the 'floater' equally in both directions if possible; however, even if this is not feasible, then, as indicated above, exact site drilling should be initiated.

REFERENCES

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LEGEND

Bore No2 shown thus

Penetration test "

Geophone Station "

Calculated Depths

②

①

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○

G.S.W.A.

SEISMIC SURVEY — HELENA RIVER BRIDGESITE

KALAMUNDA-MUNDARING RD. No.56^C

SHIRE OF MUNDARING & KALAMUNDA

Scale — Horizontal 1 Inch = 10 feet

Vertical 1 Inch = 5 feet