COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Record 1972/25

VIBRATION TESTS DURING BLASTING AT THE PROPOSED BELCONNEN 54-INCH TRUNK SEWER CONSTRUCTION SITE A.C.T. 1972

by

B.H. Dolan

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SUMMARY

Measurements of the vibration due to blasting at the site of the proposed sewer construction were taken to determine the effect on a nearby electricity pylon. The predicted level of vibration due to blasting 40 feet from the tower is unlikely to cause damage according to the United States Bureau of Mines recommendations. Short delay periods may cause larger levels of vibrations.

1. INTRODUCTION

At the request of the Commonwealth Department of Works the Bureau of Mineral Resources, Geology & Geophysics has made vibration measurements on the construction site of the Belconnen 54-inch trunk Sewer. Excavation for the proposed pipeline trench comes to within 40 feet of the nearest leg of an electricity tower. It was requested that measurements of the ground vibration due to blasting be measured at the tower and that determinations of the safe levels for blasting be made. At the time of writing, work has ceased and the Department of Works has requested that BMR make further measurements when the work continues.

2. GEOLOGY

Bedrock in the test area consists of Upper Silurian to Devonian rhyolite tuff of the Deakin Volcanics. This is hard and well consolidated. There is generally a good cover of weathered material, and few outcrops.

3. METHODS AND EQUIPMENT

The equipment consisted of a Sprengnether Engineering Seismograph Model VS-1200, S.I.E. 24-channel seismograph, four Hall-Seers HS-1 3-D geophones and four Hall-Sears HS-JLP 3-D geophones.

The Sprengnether seismograph is a calibrated instrument with a special 3-component seismometer, and it was used to measure the ground motion at the base of the tower. The 3-D geophones were spaced between the tower and the blast in order to measure the rate of attenuation of the wave motion through the ground. One 3-D geophone was fixed to a leg of the tower five feet above ground. The velocity of the ground motion due to the shock wave was measured by the seismometer and the geophones. Two of the 3-D geophones were buried with the seismometer. This served to calibrate the geophones.

According to Nicholls, Johnson, & Duvall (1971) the peak velocity of each component of ground motion can be related to distance and charge weight per delay interval by an equation of the form:

$$v = H\left(\frac{D}{W^{1/2}}\right)^B$$

Where v = velocity of ground motion (in. sec^{-1})

H = intercept at $\frac{D}{W^{1/2}}$ = 1.0

D = shot to gauge distance (ft)

W = charge weight (lb)

B = slope or decay exponent.

H and B are constants that have to be determined for each site and possibly for each shooting procedure.

The test blast consisted of three holes each filled with 9 lb of ammonium nitrate and diesoleum (ANFO) denotated by half a plug of gelignite. Delays of 50 to 60 ms were used. The geophone spacing was 25 feet and the distance from the first shot-hole to the nearest leg of the tower was 153.7 feet.

Safe vibration levels

On the basis of a statistical study by the U.S. Bureau of Mines (Nicholls et al., 1971) and the recommendations of other investigators (Edwards & Northwood, 1960; Langefors, Kihlstrom, & Westerberg, 1958) damage to structures caused by ground vibration is more closely associated with velocity of the ground motion than with either displacement or acceleration. The most widely accepted safe blasting level for buildings is 2.0 in. sec^{-1} for any one of the three components of ground motion. The average values that cause major and minor damage are shown below.

Peak Ground Motion Velocity (in sec^{-1})	Damage Level	Description
5.4	Minor	Fine plaster cracks, opening of old cracks.
7.6	Major	Fall of plaster, serious cracking.

All of the major damage recorded by the U.S. Bureau of Mines and 94 percent of the minor damage occurred at levels greater than 2.0 in. sec^{-1}.

In the Standards Association of Australia (S.A.A.) Explosives Code, section 10.7.4 deals with ground vibrations when blasting in built up areas. It is written that the maximum allowable resultant of the three components of ground vibration shall not exceed 0.75 in. sec^{-1}. It notes that the recommended limit is a compromise between safety and comfort but is heavily biased towards comfort. The recommendation gives a factor of safety of about 6 for light damage.

4. RESULTS

The peak velocity of ground motion recorded from the test blast at the base of the tower was 0.15 in. sec^{-1} (peak displacement for f = 100 Hz is 0.00002 in).

The peak velocity of ground motions recorded by each geophone is plotted against the shot-to-geophone distance for the first shot (Plate 2, fig. 1) on a log-log scale. This is the distance in a straight line to the shot, not a distance measured along the ground.

The average ground motion velocity is related to the distance and charge size by the equation.

$$v = 4.6 \left(\frac{D}{W^{1/2}}\right)^{-1.5} \text{ in. sec}^{-1}$$

The constants H and B were determined from the measurements of ground motion velocity. Plotted in Plate 2, fig. 2. D is measured in feet and W in pounds of explosive (ammonium nitrate and diesoleum (ANFO)).

The linear regression line (the dark line) through the data points passes through 1.0 in. sec^{-1} at 40 feet. The error involved, principally in measuring the trace deflection and because of the variations in reponse between geophones, means that the peak velocity of ground motion at 40 feet could reach 1.8 in. sec^{-1}.

It was observed also that a high reading of peak velocity of ground motion (4 in. sec^{-1} at 25 feet) was obtained from the third shot of the 3-shot sequence. Interpolated to 40 feet this represents a reading of 2 in. sec^{-1}. It is considered that this may be due to addition of vibrations from the preceding shots, a phenomenon that has been observed in previous investigations elsewhere (Davis, 1970).

5. CONCLUSIONS AND RECOMMENDATIONS

Using the present blasting procedure the ground vibration at 40 feet from the shot will be unlikely to cause damage to a structure according U.S. Bureau of Mines recommendation, but short delay periods between shots may cause an additive effect that may be damaging. Therefore it is recommended that the delay period be increased to twice the present delay and that further measurements of the ground vibration be made.

6. REFERENCES

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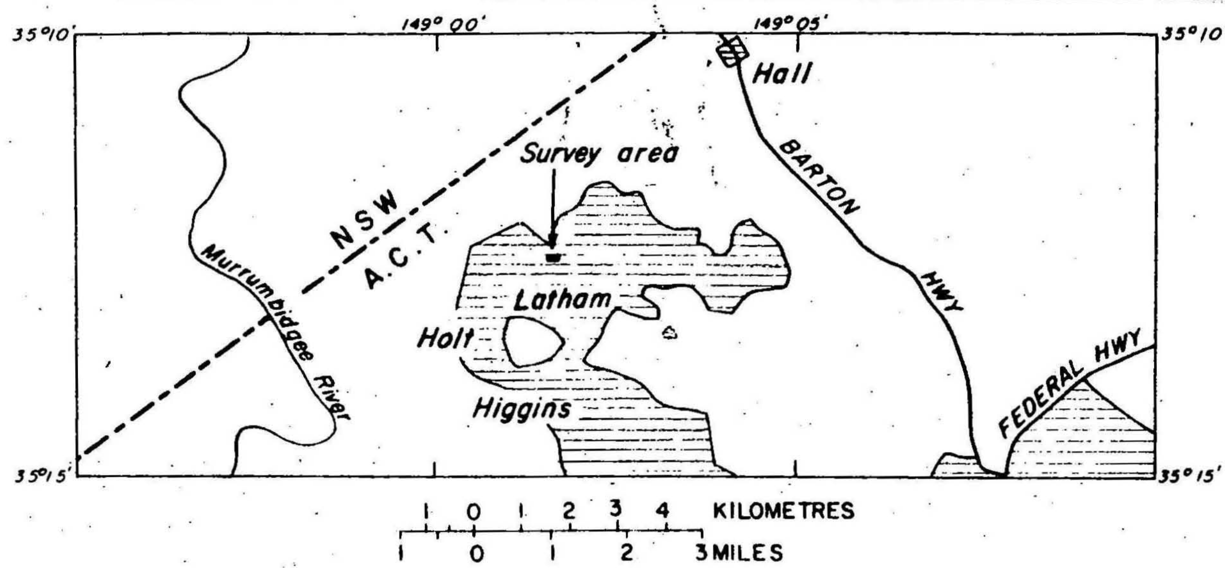
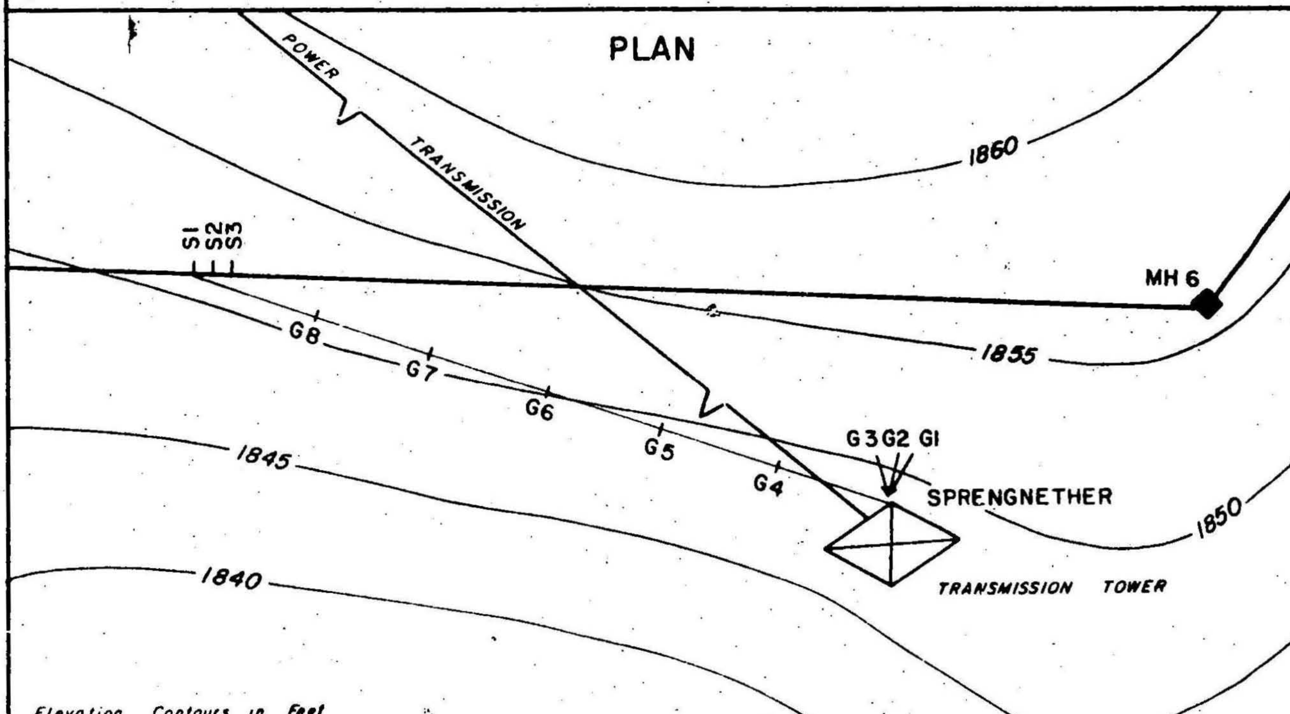
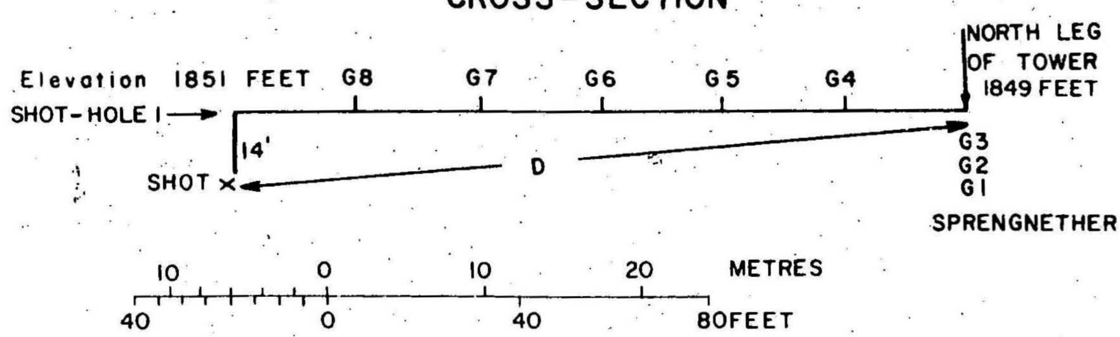


LOCALITY MAP

PLAN



CROSS-SECTION



BELCONNEN 54-INCH TRUNK SEWER CONSTRUCTION
LOCATION - PLAN AND CROSS SECTION

I 55/85-131A

To accompany Record No. 1972/25

PLOT OF PEAK GROUND MOTION VERSUS DISTANCE FROM THE No. 1 SHOT OF THE TEST BLAST

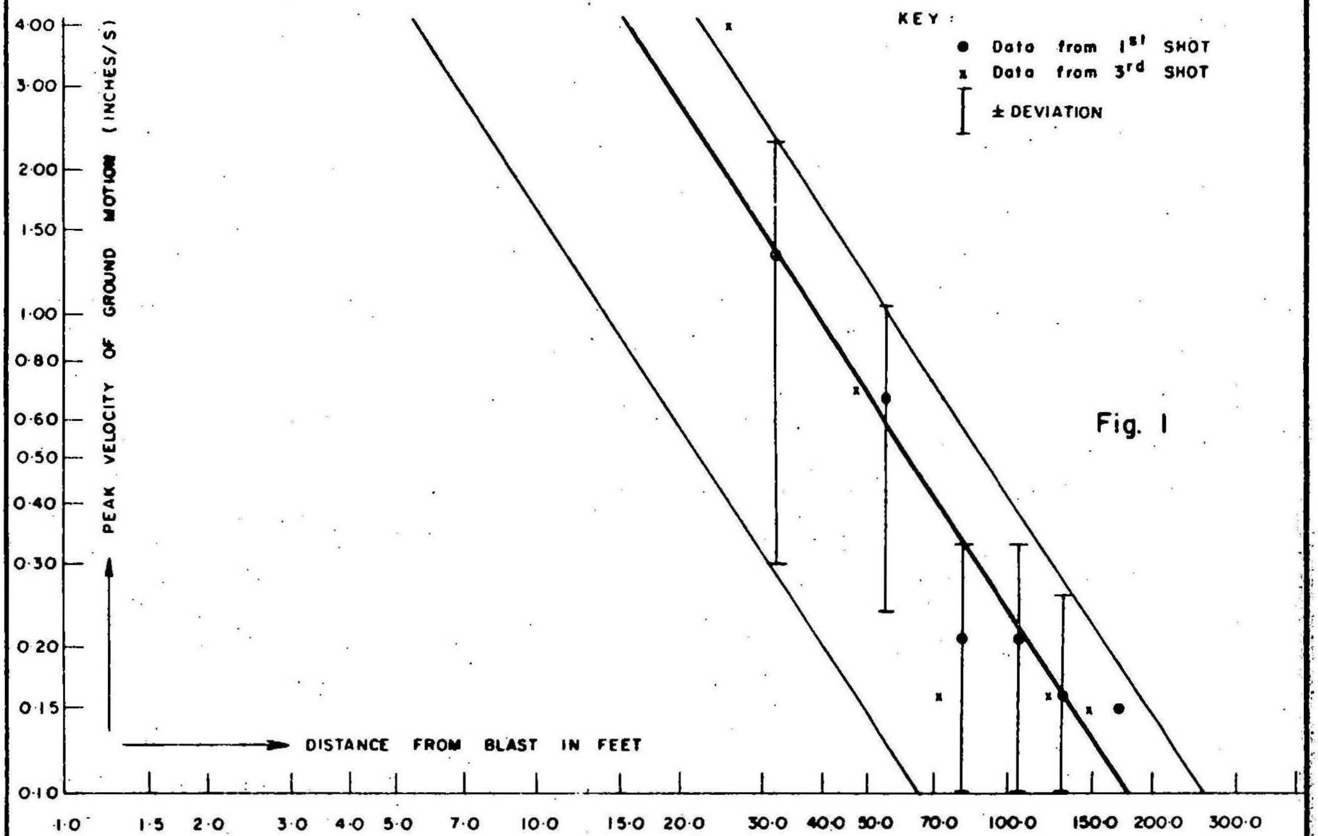


Fig. 1

PLOT OF PEAK GROUND MOTION VELOCITY VERSUS SCALED DISTANCE $(D/W^{\frac{1}{2}})$

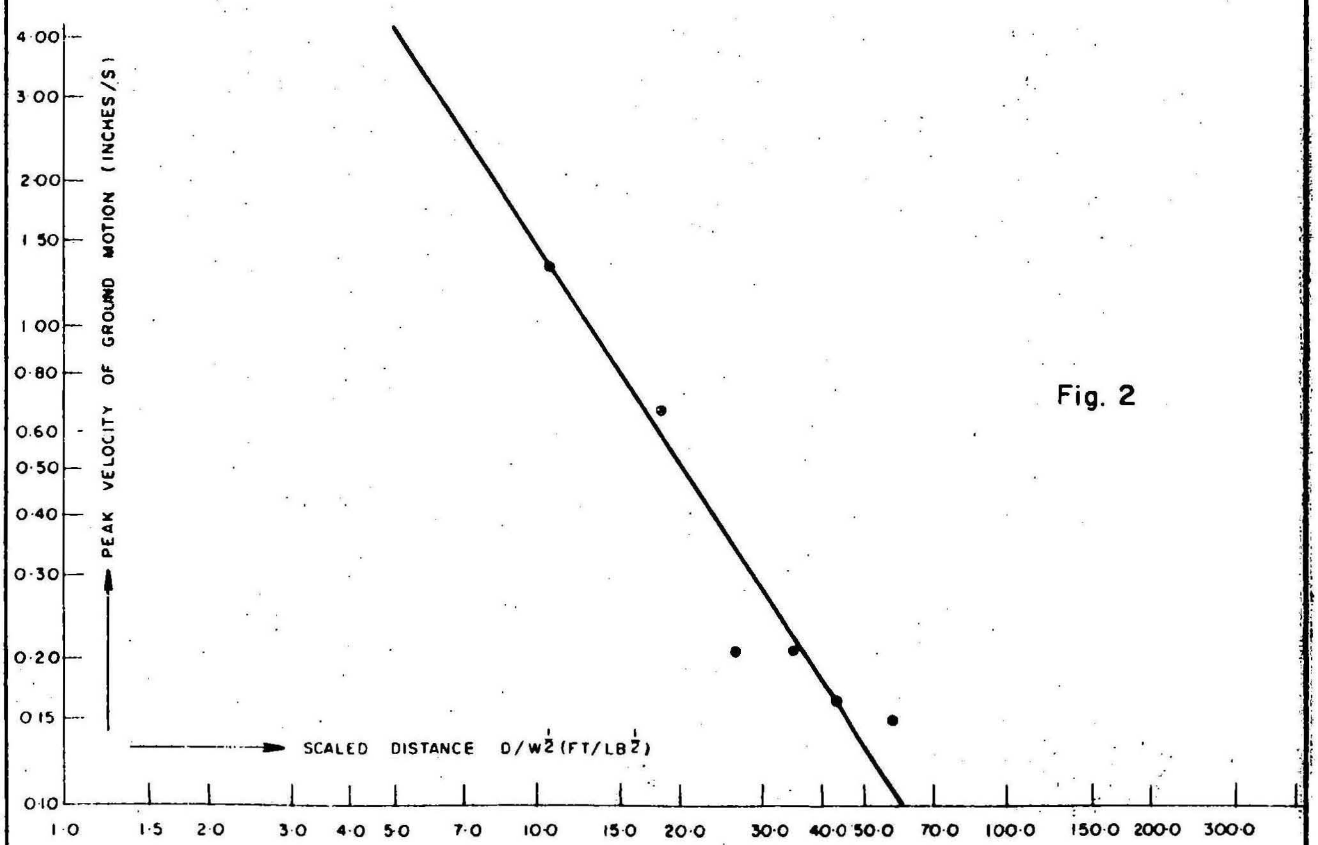


Fig. 2

To accompany Record No. 1972/25

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