COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORDS 1960 No. 130

NORTH BALWYN VIBRATION TESTS, VICTORIA 1960

by

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ABSTRACT

Vibrations of the ground resulting from explosives fired in the course of trench excavations were recorded in the North Balwyn area for Prentice Bros. and Minson Pty. Ltd.

The measured vibrations are compared with those regarded as safe by various authorities.

1. INTRODUCTION

In response to an application by Prentice Bros. and Minson Pty. Ltd., who are digging a sewer trench at North Balwyn, the Bureau of Mineral Resources conducted vibration tests near the trench. The tests were intended to measure the amplitude and frequency of ground vibrations caused by the explosives used in excavating the trench.

The vibrations were recorded with a Sprengnether Portable Blast and Vibration Seismograph. This instrument records on a photographic strip the vibrations in three mutually perpendicular directions. The records show the ground displacement magnified 100 times, with timing lines at intervals of 0.02 seconds.

The recordings were made by the author on 25th August 1960.

2. RESULTS

Records were taken with the seismograph at two different positions, which are shown on Fig. 1. Fig. 2 shows details of the shot patterns from which vibrations were recorded.

Table 1 shows the magnitude of the three components of ground displacement (taken as half the peak-to-trough amplitude) corresponding to each of the positions of the seismograph. The resultant amplitude is computed by taking the square root of the sum of the squares of the three components.

The shot pattern from which the Position 1 records were made consisted of eight holes each loaded with 8 oz of AN60 gelignite. The pattern from which the Position 2 records were made consisted of five holes each loaded with 8 oz of AN60 gelignite. In both cases millisecond delay series detonators were used.

The largest amplitude component recorded was 0.00045 in. which occurred on the longitudinal component of the record taken in Position 1. The recorded frequencies ranged from 50 to 80 c/s, the most commonly occurring frequency being about 65 c/s (See Table 1).

The ground accelerations shown in Table 1 were calculated from the formula

$$a = 4\pi^2 f^2 A/g$$

where a = acceleration of the ground in terms of gravity

f = frequency in cycles per second

A = amplitude in inches

g = acceleration due to gravity (=386 in./sec^2)

The largest resultant amplitude and the largest ground acceleration were recorded at Position 1. The displacement here was 0.0007 in. and the frequency was about 67 c/s.

Extracts from different authorities recommending safe amplitudes of vibration and other criteria, are shown in Appendix 1. Appendix 2 is a graph of amplitude against frequency showing safe vibration limits according to different authorities. The first five of these references would describe a resultant amplitude of 0.0007 in. at 67 c/s as a safe vibration. Reference 6, however, shows that the U.S. Bureau of Mines would regard such a vibration as unsafe for buildings.

3. CONCLUSIONS

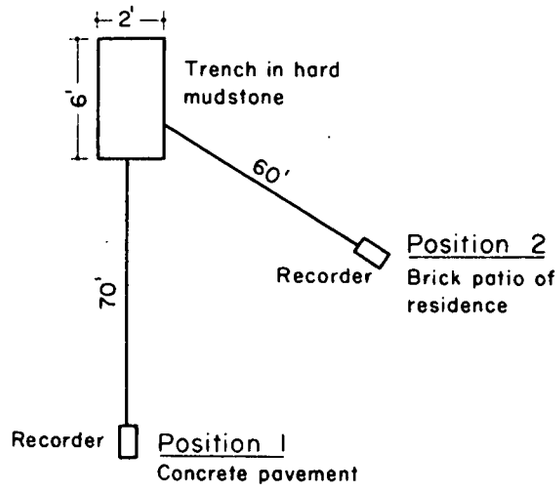
The ground vibrations at a distance of 70 feet from the explosion would be regarded as safe by several quoted authorities, but would be unsafe according to the standards adopted by the U.S. Bureau of Mines.

5. TABLE 1

Position No.	Distance of Recorder from Trench	Components of Vibration									Resultant Amplitude (inches)	Resultant Acceleration
		Longitudinal			Vertical			Transverse				
		Amplitude (inches)	Frequency (c/s)	Acceleration	Amplitude (inches)	Frequency (c/s)	Acceleration	Amplitude (inches)	Frequency (c/s)	Acceleration		
1	70 feet	.00045	67	0.21*g*	.0004	67	0.18*g*	.00035	50	0.09*g*	0.0007	0.29*g*
2	60 feet	.00025	62	0.10*g*	.0004	62	0.16*g*	.00025	50 80	0.06*g* 0.16*g*	0.0005	0.20*g* 0.24*g*

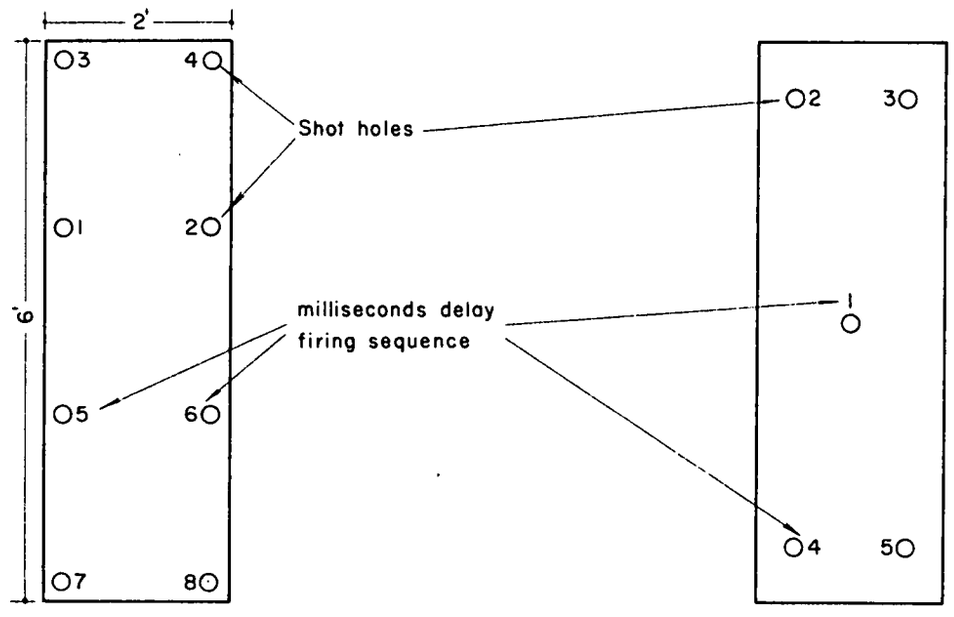
POSITION OF RECORDER

FIG. 1



DETAILS OF SHOT PATTERNS

FIG. 2



8ozs of AN 60 gelignite per hole

Shot Pattern No 1

8 ozs of AN 60 gelignite per hole

Shot Pattern No 2

BALWYN

APPENDIX I.

The following are references to and extracts from regulations and authoritative publications in the United States and Great Britain covering or recommending safe amplitudes of vibrations that may be applicable to buildings:

(Note: **f** = frequency in cycles per seoond.
A = peak to trough amplitude, inches).

Reference 1.

State of New Jersey, U.S.A. Extract from rules and regulations governing Quarry Blasting and Related Operations. March 26, 1954.

"6.1. Allowable Limits. Allowable Limits of ground motion and sound pressure contained in this section shall be considered neither to produce structural damage in any structure that has been reasonably well constructed according to accepted engineering practice nor to constitute a nuisance to persons."

"6.3. Frequency - amplitude relations. When ground frequency and displacement characteristics in relation to known quantities of detonated explosives in primary blasts have been determined by approved means of instrumentation to the satisfaction of the Commissioner, the allowable limits of the maximum amplitude of ground vibrations related to frequencies of vibration shall be as indicated in the following table:

Frequency of ground motion in cycles per second.	Maximum amplitude of ground movement, in inches.
up to 10	not more than 0.0305
20	0.0153
30	0.0102
40	0.0076
50	0.0061
60	0.0051"

Reference 2.

Rules Concerning Blasting in Strip Mine Operations in the Anthracite Region, Pennsylvania, Act No. 472, June 27, 1947.

"Section 20.

..in no case shall the ground displacement be in excess of 0.03 inches at any dwelling house, public building, school, church, commercial or institutional building."

Reference 3.

Teichman, G.A. and Westwater, R.

Blasting and Associated Vibration.

Engineering, April 12, 1955, pp. 460/465.

> "Because of the variation in the types of structure it has been recommended that they should be broadly classified into four groups:
>
> (a) structures of great value and frailty. This will include certain ancient monuments, such as churches and certain badly designed properties.
>
> (b) Property, houses etc. closely congested.
>
> (c) Isolated property.
>
> (d) Civil engineering structures.
>
> Taking suitable safety factors and after the site has been investigated by a vibrograph caution limits are applied. These limits usually are 0.004, 0.008, 0.016, 0.030 inches, respectively."

Reference 4.

Crandell, working on behalf of a United States Insurance Co., suggests fA as a suitable relationship and quotes -

"fA = 0.745 as the damaging level

fA $\leq$ 0.527 as safe level. "

Reference 5.

C. Morris - Vibrations due to blasting and their effect on building structures.

The Engineer, Nov. 3, 1950. pp. 394/395, 414/418.

> "the limiting amplitude of 8.2×10^{-3} (0.0082) inches gives a conservative estimate of the limiting amplitude for conventional structures. The state of repair of the building does not seriously affect this estimate, as an old building technically less strong than a new one will have benefitted by a process of "bedding in" due to long-continued small movement."

Reference 6.

Thoenen, F.R. and S.L. Windes, 1942. Seismic Effects of Quarry Blasting.

United States Bureau of Mines Bull. 442.

"f^2 A $\geq$ 10 Damage

f^2 A $\leq$ 1 Safe "

"Vibrations of very low amplitude and short duration were neglected, even though the accelerations may have been high, because these conditions were noticeable in the records of many tests that did not cause damage."

LEGEND

1 — State of New Jersey as specified by regulation

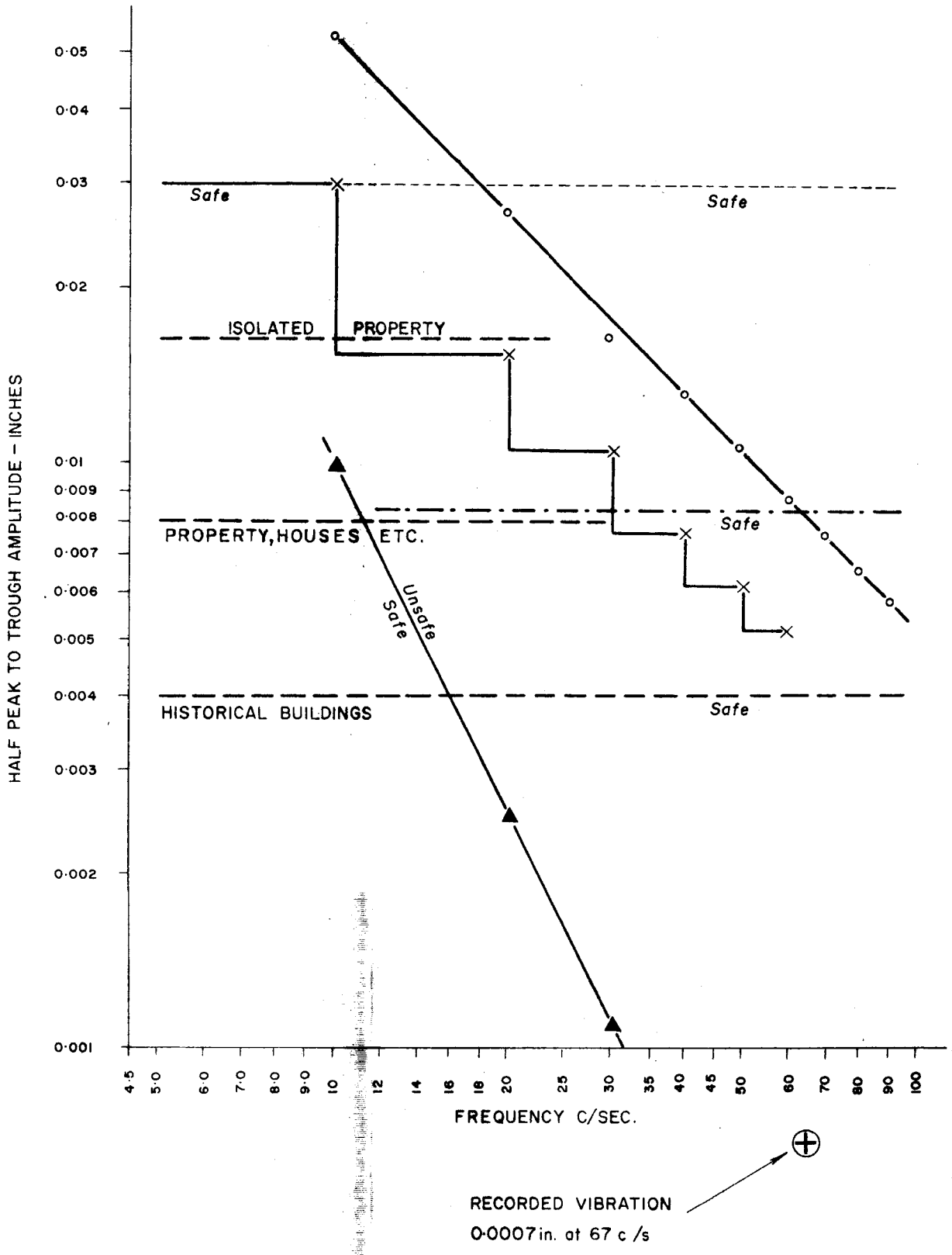
2 — State of Pennsylvania as specified by regulation for any structure

3 — As recommended by Teichman

4 — As recommended by Crandell to a United States Insurance Co.

5 — As recommended by Morris

6 — As recommended by U.S. Bureau of Mines



MAXIMUM SAFE HALF PEAK TO TROUGH AMPLITUDE OF VIBRATION PLOTTED AGAINST FREQUENCY AS SPECIFIED AND RECOMMENDED BY VARIOUS U.S. GOVERMENT AUTHORITIES AND BY INDIVIDUALS

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G 344-8-1

To Accompany Records 1960, No 130