COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS.

RECORDS

1959 NO. 86.

VIBRATION TEST AT THE M.M.B.W. SEWER PROJECT, BROOKLYN, VICTORIA, 1959.

BY

E.J. POLAK AND B.J. BAMBER.

RECORDS 1959 No. 86.

Vibration Test at the M.M.B.W. Sewer Project, Brooklyn, Victoria, 1959

by

E.J. Polak and B.J. Bamber.

CONTENTS

PLATES.

1. Plan of the site of the investigation.
2. Copy of recordings obtained during the investigation.

This report describes an investigation which was carried out by the Bureau of Mineral Resources, Geology and Geophysics, at the request of Yarra Constructions Pty.Ltd. of Brooklyn, Victoria, in connection with the Company's operations at the new Brooklyn Pumping Station under construction for the Melbourne and Metropolitan Board of Works. As part of the project two deep pumpwells, each 78 feet in diameter, are being sunk through basalt near existing sewerage works. The purpose of this investigation was to provide data that could be used to determine the optimum amount of explosive charge that could be used without fear of damage to other installations, particularly existing large diameter steel sewer pipes.

Measurements of ground vibrations were recorded from the blast from a currently used explosive charge which was fired in the north pumpwell on 29th May, 1959. The vibration tests were carried out by E.J. Polak and B.J. Bamber, geophysicists.

The charge which was exploded consisted of 164 lbs. of AN 60 gelignite and was divided into six sections and fired using a delay technique in the following order -

Delay number	Lbs of explosive
1	48
2	32
3	24
4	24
5	21
6	15
Total	164

The approximate delay between each section, or delay number, was 20 to 25 milliseconds.

The recording instrument was a Leet Vibrograph, which records photographically the three mutually perpendicular components of ground movement with a magnification of 50. This is achieved by optical means. The scale of the record, therefore, is such that a ground movement of 0.02 inches is represented on the record by a movement of one inch.

The vibrograph was set up on a concrete floor in the carpenter's shop at a horizontal distance of 160 feet from the blast centre. The relative positions of the blast centre and recording equipment are shown in Plate 1.

Plate 2 is a copy of the vibrograph records. From the magnitudes of the components of ground movements in three mutually perpendicular directions, it has been calculated that the peak to trough ground movement in the direction of maximum movement was 0.0023 inches.

The records also show that the ground vibrations have a pre-dominant frequency of approximately 22 cycles per second and reach a maximum at approximately 50 milliseconds after the arrival of the initial shock. A second vibration frequency of approximately 60 cycles per second and of negligible amplitude, is superimposed on the main vibration frequency.

Appendix 1 contains a series of excerpts from authoritative reports and regulations which deal with amplitudes of displacement and frequencies of vibrations from blasts, together with recommended safe amplitudes of vibrations that may be applicable to buildings.

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

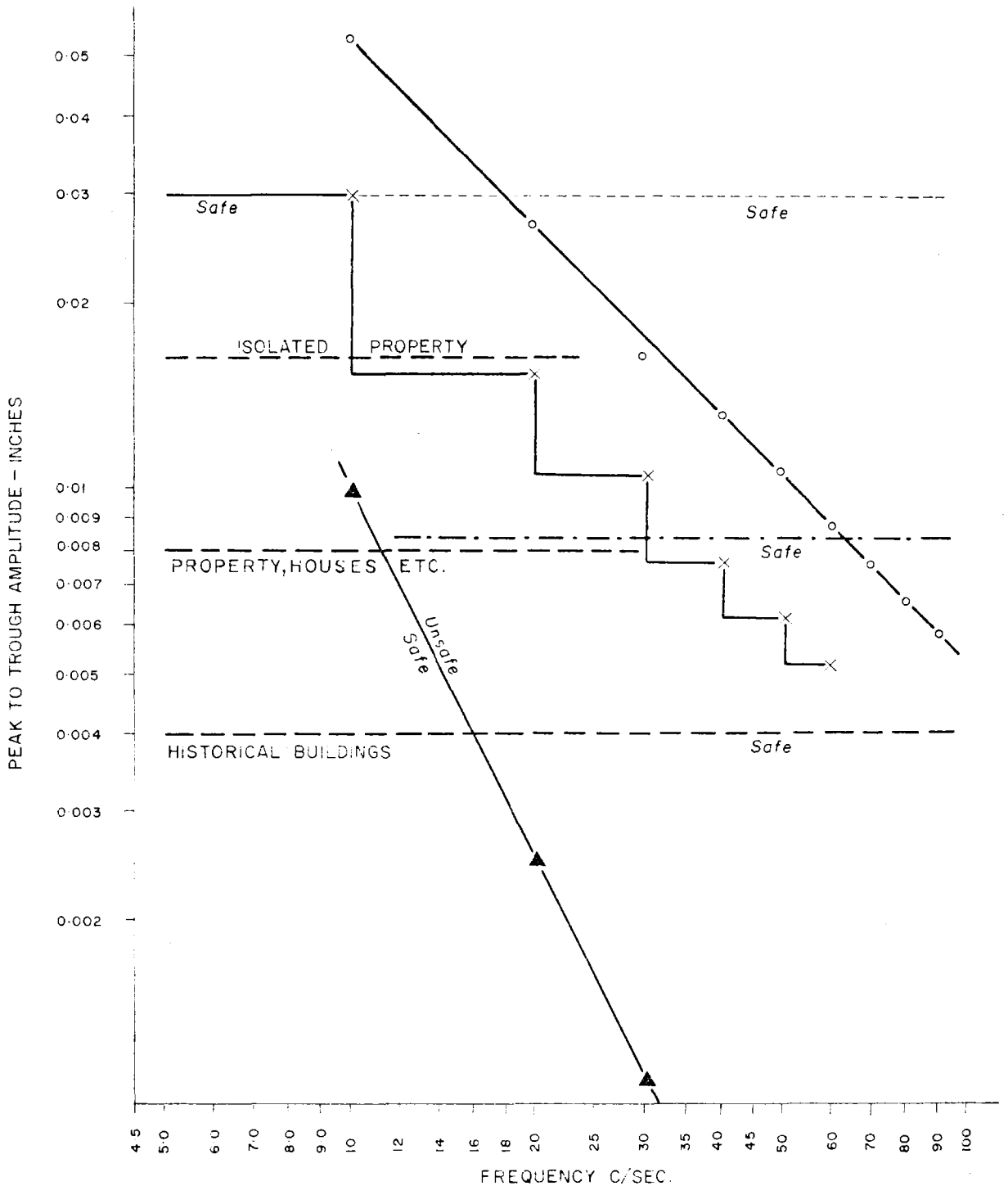
2 — State of Pennsylvania as specified by regulation for any structure

3 — As recommended by Teichman

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

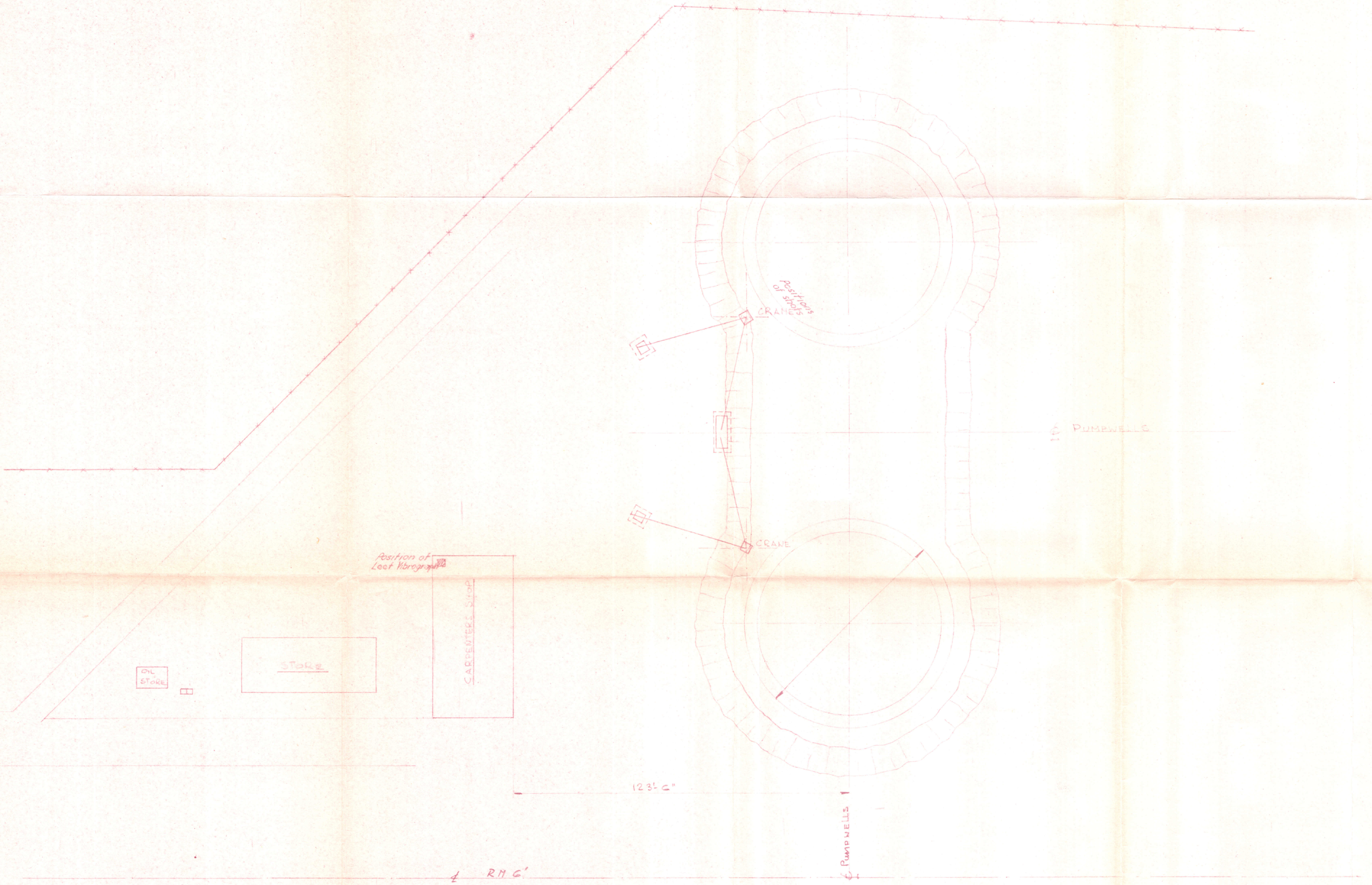
5 — As recommended by Morris

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



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

PLATE 1



YARRA CONSTRUCTION P/L

BROOKLYN SEWER PROJECT
BROOKLYN PUMP STATION
VIBROGRAPH TESTS

SCALE 1:20		
APPROVED	DATE 28.5.59	B V 810

To accompany Records 1959, No 86

PLATE 2

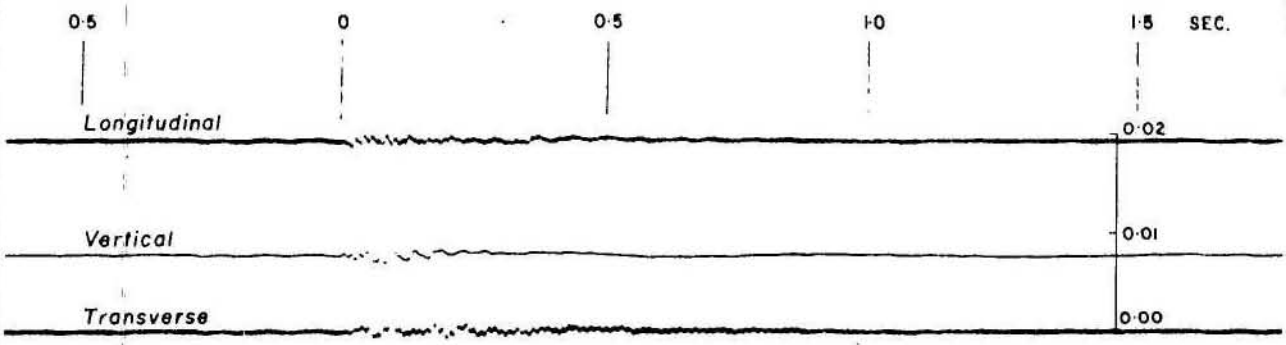
Date : 29/5/1959

Instrument : Leet 3 - Vibrograph

Observers : E.J. Polak & B.Bamber

Blast : 164 lbs. of Explosives in 5 Delays, 20 to 25 milliseconds interval

Distance shot - instrument : 170 feet



Ground Displacement:

Longitudinal	:	0.001 inches
Vertical	:	0.0017 "
Transverse	:	0.0012 "
Resultant Displacement	:	0.00232 "
Frequency	:	22 c/sec with superimposed 60 c/sec

M.M.B.W. Sewer Project
Brooklyn, Victoria

VIBRATION TEST