COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

RECORDS 1960 No. ~~97~~ 87

FLINDERS GUNNERY VIBRATION TESTS VICTORIA 1960.

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INTRODUCTION

At the request of the Department of Works, a series of tests was done at the West Head Gunnery Range, Flinders Naval Depot. The aim was to measure ground vibration caused by the firing of anti-aircraft guns, and assess the likelihood of its causing damage to nearby buildings.

The tests were made on 31st August 1960 by the author. The instrument used was a Sprengnether Portable Blast and Vibration Seismograph (No.1577) which gives a photographic record of the three mutually perpendicular components of the ground displacement magnified 100 times. Timing lines on the seismogram are at 20-millisecond intervals.

The ground vibration was recorded during normal gunnery practice with the gun crews firing four sets of guns of different calibre.

For the six tests the seismograph was placed as follows (see also Plate 1, Drawing No. G344-68).

Tests 1 and 2	In concrete duct opposite No. 3 gun
Test 3	On asphalt floor next to the wall
Test 4	On roof of control room
Test 5	In concrete duct opposite No. 1 gun
Test 6	In doorway of new building next to the large gun turret.

RESULTS

Table 1 shows the magnitude of the three components of ground displacement (taken as half the peak-to-trough amplitude) corresponding to the various positions of the seismograph. The resultant displacement was computed by taking the square root of the sum of the squares of the three components (all three components were scaled at approximately the same instant on the record). The frequencies listed are the predominant frequencies shown on the record at the time the displacements were measured.

The ground accelerations shown on Table 1 were calculated, on the assumption that the vibrations were roughly sinusoidal, from the equation

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

where a = maximum acceleration (in./sec^2)
f = grequency in c/s
A = ground displacement (in.)

They are given in terms of g, the acceleration due to gravity (=386 in./sec^2)

Various authorities have cited different criteria for assessing the damaging effect of ground vibrations on built-up structures. Thoenen and Windes (1942) of the U.S. Bureau of Mines concluded that the magnitude of the ground acceleration is the most useful index of damage; they proposed the following classification, applicable to ordinary buildings :

Acceleration greater than 1.0g	-	Damaging
Acceleration between 0.1g and 1.0g	-	Slightly damaging (caution zone)
Acceleration less than 0.1g	-	No damage (safe zone)

Table 2 illustrates the division into these zones, for vibrations of various frequencies and displacements.

Plate 2 (Drawing No. G344-67) shows the record obtained in Test No. 1 (which gave the highest value of acceleration). Two sets of vibrations are distinguishable; those with the large amplitudes are identified

as resulting from the large-calibre gun. The part of the record corresponding to the firing of the large-calibre gun shows a high-frequency vibration (100 c/s) superimposed on a low-frequency vibration (25 c/s). The high frequency is recognised as the body wave, and the low frequency as a surface wave. No evidence of any direct air blast is recorded, because the seismograph was screened from the blast.

CONCLUSIONS

For each of the six tests the measured accelerations fall either in the "caution" or "damage" zones as defined by Thoenen and Windes for ordinary buildings. Some of the accelerations are considerably greater than the lower limit of the "damage" zone.

REFERENCES

THOENEN, J.R. and WINDES, S.L. 1942 - Seismic effects of quarry blasting.
Bull. U.S. Bur.Min. 442.

TABLE 1

Test No.	Displacements (in.)			Resultant displacement	Approx. freq. (c/s)	Acceleration in terms of g
	Long.	Vertical	Transverse			
1	0.0015 0.0007	0.0015 0.0003	0.0006 0.0005	0.0022 0.0009	100 25	2.2 0.06
2	0.001 0.0007	0.0015 0.0003	0.0006 0.0005	0.0019 0.0009	100 25	1.9 0.06
3	0.0007 0.0005	0.0009 0.0008	0.0005 0.0004	0.00125 0.001	100 25	1.25 0.06
4	0.0005	0.0008	0.0005	0.001 1	60	0.4
5	0.0005 0.0015	0.0009 0.0013	0.0006 0.0006	0.0012 0.0023	80 15	0.8 0.23
6	0.0004	0.0008	0.0015	0.00175	100	1.75

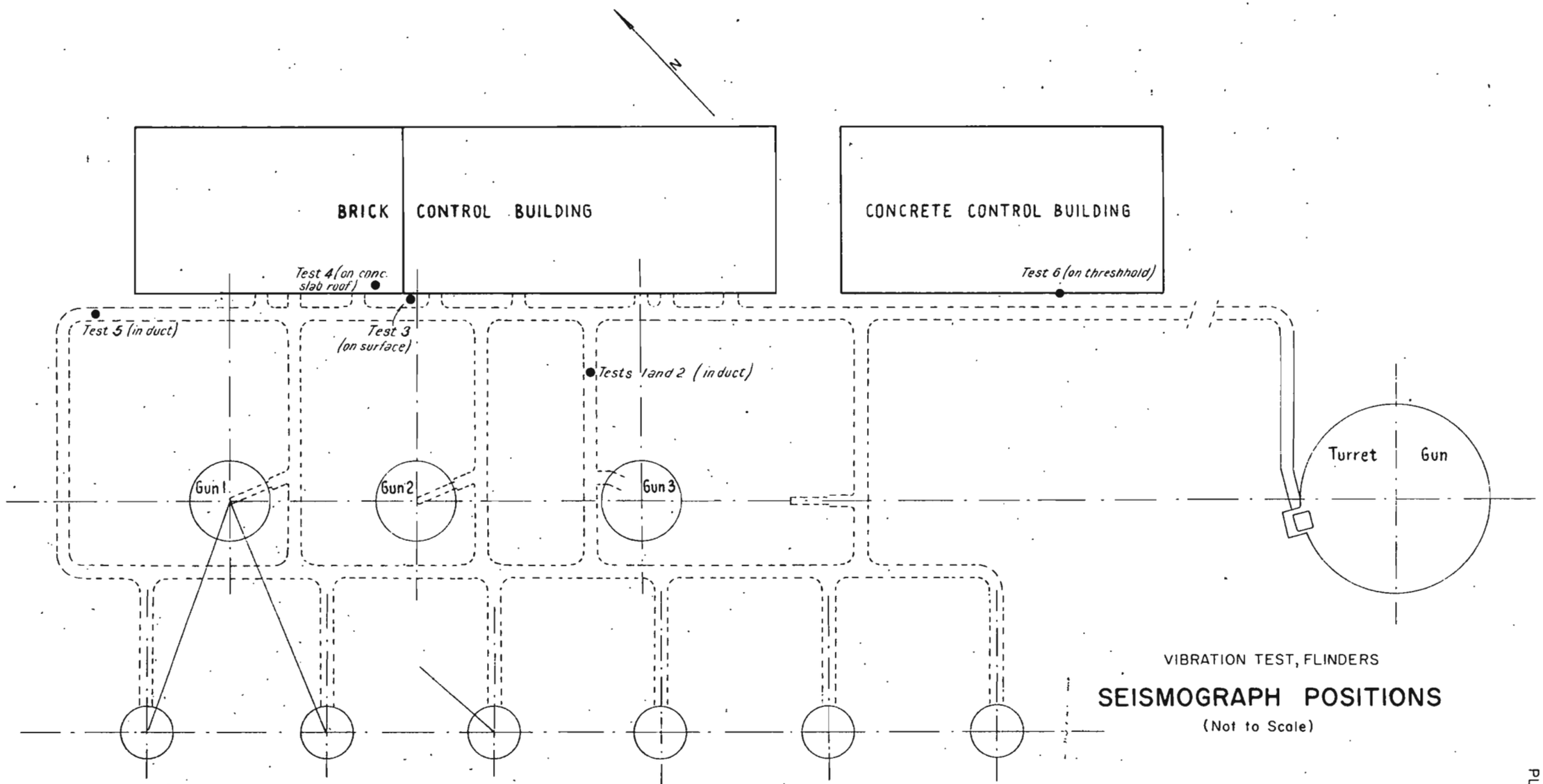
Note: In Test 4 only one shot was recorded before the recording paper ran out.

DISPLACEMENT (INS.)	FREQUENCY C.P.S. 2	4	6	8	10	15	20	40	60	80	100
0·24	0·10	0·38	0·86	1·50	2·40	5·40					
·22	0·09	·35	·79	1·40	2·20	5·00	8·80				
·20	·08	·32	·72	1·30	2·00	4·50	8·00				
·18	·072	·29	·65	1·20	1·80	4·10	7·20				
·16	·064	·26	·58	1·00	1·60	3·60	6·40				
·14	·056	·22	·50	0·90	1·40	3·20	5·60				
·12	·048	·19	·43	·77	1·20	2·70	4·80				
·10	·040	·16	·36	·64	1·00	2·20	4·00				
·08	·032	·13	·29	·51	0·80	1·80	3·20				
·06	·024	·10	·22	·38	·60	1·30	2·40				
·04	·016	0·06	·14	·26	·40	0·90	1·60	6·40			
·02	·008	·03	0·07	·13	·20	·40	0·80	3·20	7·20		
·01	·004	·016	·036	0·064	·10	·20	·40	1·60	3·60	6·40	
·008	·0032	·013	·029	·051	0·08	·20	·30	1·30	2·90	5·10	8·00
·006	·0024	·010	·022	·038	·06	·10	·20	0·96	2·20	3·80	6·00
·004	·0016	·006	·014	·026	·04	0·09	·20	·64	1·40	2·60	4·00
·002	·0008	·003	·007	·013	·02	·04	0·08	·32	0·72	1·30	2·00
·001	·0004	·0016	·0036	·006	·01	·02	·04	·16	·36	0·64	1·00
·0008	·0003	·0013	·0029	·005	·008	·02	·03	·13	·29	·51	0·80
·0006	·0002	·0010	·0022	·004	·006	·01	·02	0·096	·22	·38	·60
·0004	·0002	·0006	·0014	·0026	·004	·01	·016	·064	·14	·26	·40
·0002	·0001	·0003	·0007	·0013	·002	·004	·008	·032	0·072	·13	·20
·0001	·0000	·0002	·0004	·0006	·001	·002	·004	·016	·036	0·064	·10

TABLE ACCELERATION IN TERMS OF GRAVITY 'g'

(Based on Table 7. Thoenan and Windes. Bull. U.S. Bur. Min. 442)

SCALE OF ACCELERATION IN TERMS OF GRAVITY 'g'



VIBRATION TEST, FLINDERS

SEISMOGRAPH POSITIONS

(Not to Scale)

PLATE I

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics. G344-68

VIBRATION TEST, FLINDERS GUNNERY

TEST No. 1 SAMPLE RECORD