Survey of Vibration Periods in Multi-Storey Buildings

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TECHNICAL NOTE

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PREPARED FOR Record Purposes

SUBJECT SURVEY OF VIBRATION PERIODS IN MULTI-STOREY BUILDINGS

A program of measuring the natural periods of buildings was undertaken for the purpose of checking and evaluating the adequacy of formulae for calculating the natural periods given in the National Building Code of Canada. This note describes the method of measuring the natural periods and gives the results obtained in the various buildings. The full evaluation of the results will be carried out in future publications.

The natural periods are a unique characteristic of a building. Besides their obvious use in design calculations, the initial natural periods of a building are useful to know should some future event such as an earthquake, blast or planned alteration change the stiffness or mass properties of the building. Such changes would then be reflected in shifts in the natural periods of the structure.

EXPERIMENTAL METHOD

The natural period of the building was determined from the ambient vibrations monitored near the top of the building. Generally two "Larson" servo-drive accelerometers (5 V/g sensitivity) were placed at opposite ends of the building. The direction of the sensitive axis was oriented so that by adding the signals either translational motion or rotational (torsion) motion was obtained. The signal from the accelerometers was amplified (generally with 40 dB) and filtered. The low-pass filter setting was chosen, by trial and error, just above the natural frequency. The signals were then added and displayed on a Hewlett-Packard strip chart recorder. Before each recording run, the entire electronic assembly was calibrated so that when the accelerometers were facing each other essentially zero output was obtained.

The experimental procedure proved quite satisfactory and enabled a complete set of measurements for one building to be taken in one to two hours. A diagram of the experimental setup is shown in Fig. 1, and a sample of a typical record obtained is shown in Fig. 2. Along with the ambient vibration results, man-excited vibrations were also recorded.

RESULTS

The results of the measurements of natural periods of buildings are presented in Table1. Each building is given a code letter which can be employed in referencing the experimental data in possible future publications. "Transverse" is generally the short direction, and "longitudinal" the long direction of the building. Where ambiguity might arise the approximate compass orientation of building motion is given.

In addition to the ambient vibration results, the natural frequency was also determined from the decay curve of man-excited oscillations. These values are identified by an asterisk (*).

The accuracy of the results depends essentially on the speed control of the recorder and on the adjustment of the electronic instruments. Since a system calibration was carried out before each test, the possible source of error originating in the electronics is effectively eliminated. The speed of the recorder is generally controlled to 2 - 3%, and the results can, therefore, be expected to have that level of accuracy.

ACKNOWLEDGEMENT

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TABLE 1

AMBIENT VIBRATION PERIODS OF BUILDINGS IN OTTAWA

Code Letter	Length ft	Width ft	Total Height ft	No. of Storeys N	Bldg. Type	Date of Measurement	Transverse T_1 Sec.	Transverse T_2 Sec.	Longitudinal T_1 Sec.	Longitudinal T_2 Sec.	Torsion T_1 Sec.	Torsion T_2 Sec.
A	182.5	55.3	206.0	24	C - S	Oct. 24 - 25, 1973	1.61		1.15		1.56	
B	154.0	57.2	231	27	C - S	Oct. 24 - 25, 1973	1.51* 1.49	0.37	1.37	0.38	1.48	0.39
C	131	50.6	196.2	22	S - C	Oct. 24 - 25, 1973	1.27	0.34	1.20* 1.18	0.33	0.98	0.29
D	131	50.6	196.2	22	S - C	Oct. 24 - 25, 1973	1.27	0.325	1.19* 1.16	0.316	0.98	0.29
E(+)	219	54.9	231.8 (193.5)	24 (20)	C - S	Oct. 24 - 25, 1973	1.39	0.375	1.01* 1.02	0.32	1.26 1.35	0.36
F	131.3	94.0	249.5	27	C - S	Nov. 1973	1.32	0.405	1.24	0.375	1.32	0.40
G	171.5	54.2	265.3	27	C - S	Nov. 1973	1.46	0.38	1.17	--	1.09	--
H	101.7	83.0	263.5	23	C - S	Nov. 1973	(E-W) 1.67* 1.66	0.420	(N-S) 1.48	0.36	0.970	0.25
J	180.0	110.0	359.6 (339.9)	30 (29)	S - F	Nov. 1973	(E-W) 3.48	1.20	(N-S) 4.20	1.4	4.82	1.53
K					S - C	Oct. 1972			1.01			
L	112.5	88.0	118.6 (109.0)	13 (12)	M	Jan. 16, 1974	(E-W) 0.415		(N-S) 0.44			

( ) Dimensions in parentheses are those measured from ground level.

(+) Somewhat irregular in plan dimension.

Building types: C - S: Reinforced concrete shear wall
S - F: Steel frame and braced core
S - C: Steel frame and concrete shear walls
M : Masonry

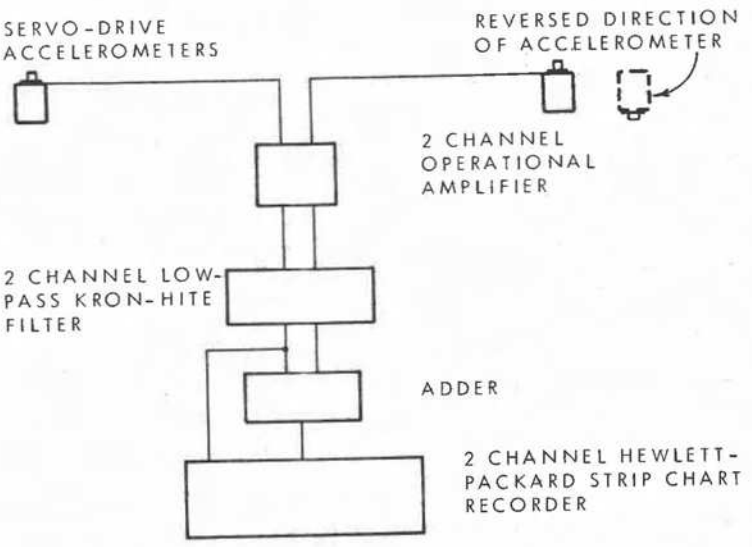

FIGURE 1
EXPERIMENTAL SET-UP

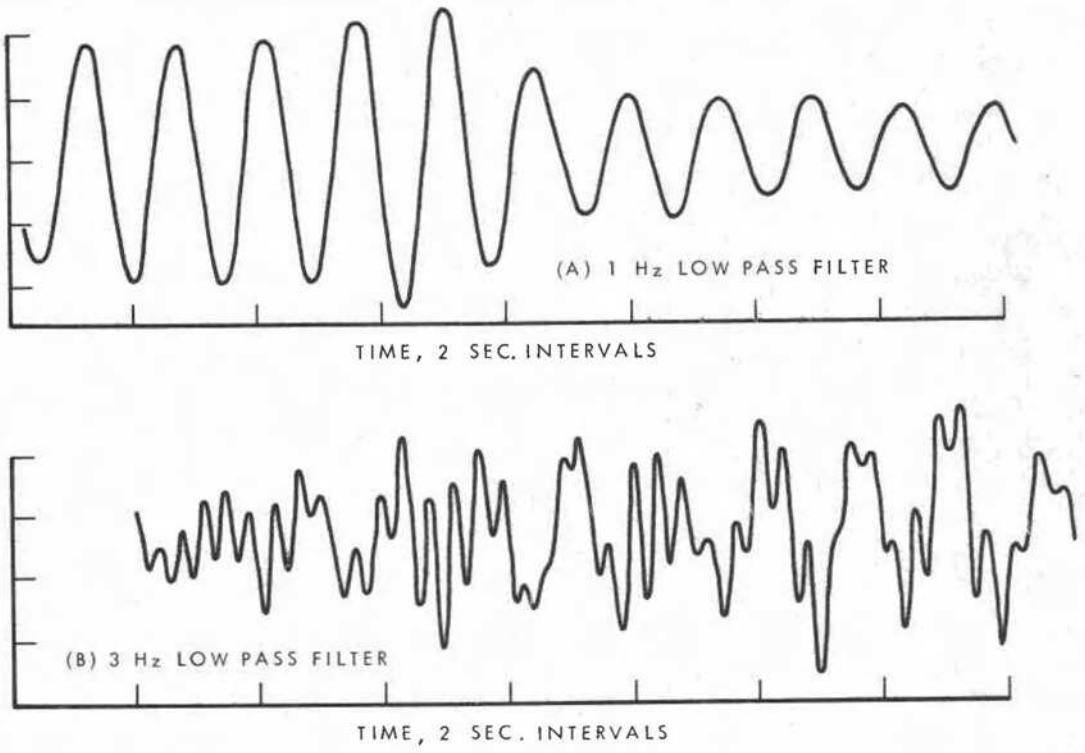

FIGURE 2
TYPICAL VIBRATION RECORDS