Control of Low-Frequency Footstep Sound & Vibration Transmission Through a Wood-Framed, Concrete-Topped Floor

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NATURE OF THE PROBLEM

The owners of certain units within a new wood-frame condominium building in Victoria were experiencing excessive low-frequency noise and vibration due to the footsteps of the occupants of the units above. This problem was occurring even though the floor system (which consisted of a 38mm concrete topping layer over 16mm plywood sheathing on 38 x 235mm wooden joists, R28 Batt insulation in the joist cavities and a ceiling of 16mm GWB suspended on 22mm resilient channels) had been field tested at FSTC 56 and FIIC 77 to 80 (carpeted areas) and met the maximum deflection (stiffness) requirements of the 1992 B.C. Building Code. It was, however, concluded that the problem (which included very low-frequency thudding noise and the perception of vibration in objects as well as in the floors of the units below) was due to the insufficient stiffness of the basic floor section, particularly in the living room/dining room areas where joist spans were longest.

PROPOSED SOLUTION

After consideration by the building's structural engineer of the options available to stiffen the floor section, it was decided to remove the existing GWB ceiling and "glue and screw" 38 x 89mm wood studs to the bottoms of the wood joists to form "I-beam"-like structures. The 16 mm GWB ceiling would then be reapplied on resilient channels with a second layer of 13mm GWB attached and foam spacer strips inserted between the edges of the suspended ceiling and the walls to minimize "flanking transmission" between wall and ceiling GWB surfaces.

TEST OF EFFECTIVENESS OF STIFFENING

To test the effectiveness of the proposed stiffening measures, before-and-after noise transmission tests were planned for one living room/dining room area. Since the floor section had proved acceptable under the standard FIIC test and since the problem was primarily at frequencies below the 100 Hz. lower limit of the standard test, it was decided to employ a "controlled walker" test instead, so as to better simulate the real source of the disturbance.

One-third octave band average sound spectra were recorded (using a Larson-Davis Model 2800 Real Time Analyzer) at two positions in the lower unit while a "standard person" (an approximatley 75 kg male) walked diagonally back and forth across the length of the carpeted living room/dining room of the upper unit. This test was then repeated after the corrective work was completed using the same walker wearing the same street shoes and walking in nominally the same fashion.

FOOTSTEP NOISE REDUCTION DUE TO STIFFENING

The results of the before and after tests of footstep noise levels in the lower condominium unit are summarized in the table below. When analyzed in one-third octave bands, it is seen that the noise reductions achieved varied widely, from as much as 15 to 18 dB in the 8, 50, and 63 Hz. bands, to as little as 2 to 3 dB in the 16 and 20 Hz. bands. It is of interest to note that, unfortunately, the smallest improvement occurred in the frequency band (16 Hz.) containing the highest unweighted noise level. This variation in effectiveness is to be expected since the primary result of the stiffening treatment would have been to alter the natural modes of vibration of the floor and therefore redistribute their natural, resonant frequencies. Since the force created by footsteps is by nature impulsive, the spectrum of the force input into the floor will be quite broad band. Energy will then be available to excite natural modes of vibration even though they may have generally been shifted upwards in frequency by the stiffening of the floor section. The non-resonant response of the floor (at frequencies away from its natural modes), however, will tend to be reduced due to the overall increased stiffness of the section.

In terms of the perception of the noise situation within the lower unit, the A-weighted footstep noise levels were reduced by 6.9 and 8.4 dBA at microphone positions 1 and 2 respectively. Subjectively, there was a marked improvement in the overall impression of very low-frequency sound being radiated from the ceiling. In particular, during the "before" tests, sub-audible sound radiated from the ceiling overhead was distinctly "feelable" as a "pressure wave". During the "after" tests, this sensation was no longer evident. The unit's owner now perceived much less vibration and his CD player no longer skipped when his neighbour walked across the floor above

Microphone Position	Test Condition	Footstep Noise Levels (dB) in One-Third Octave Frequency Bands (Hz.)											
		8	10	12.5	16	20	25	31.5	40	50	63	80	100
1	Before	49.8	56.7	69.2	76.1	71.2	64.2	58.2	57.6	61.1	52.5	42.9	37.0
	After	39.4	49.6	60.6	72.5	64.7	57.7	47.4	47.6	46.8	37.2	35.7	31.3
	Reduction	10.4	7.1	8.6	3.6	6.5	6.5	10.7	9.9	14.3	15.3	7.2	5.6
2	Before	51.6	60.3	68.1	71.1	67.8	63.3	63.6	62.1	59.9	58.0	44.7	35.4
	After	33.8	48.1	54.8	69.3	64.4	57.9	53.8	54.4	44.9	41.7	38.6	29.5
	Reduction	17.8	12.1	13.3	1.8	3.4	5.3	9.8	7.7	15.0	16.4	6.1	5.9

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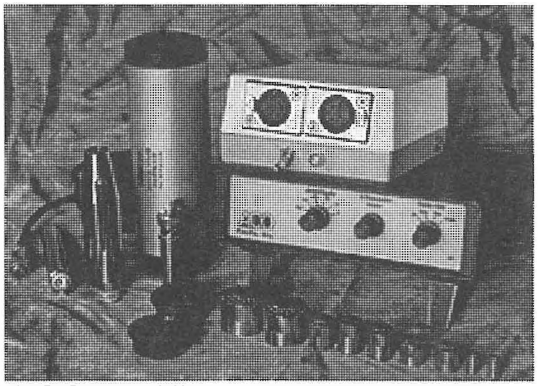

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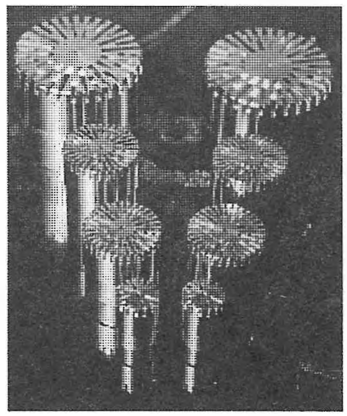

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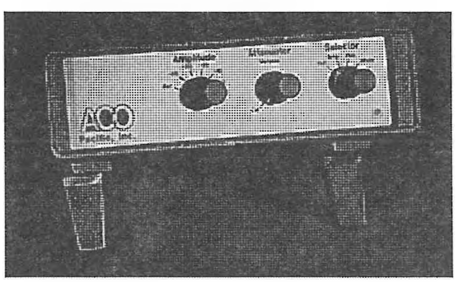

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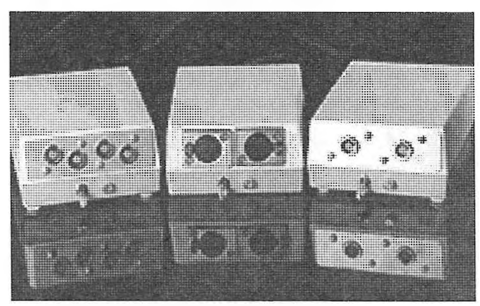

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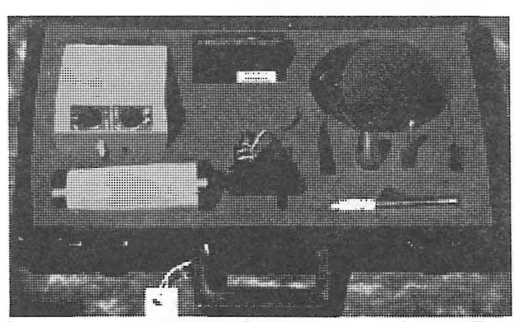

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