INVESTIGATION OF TRAFFIC-INDUCED VIBRATION AT
McDADE INC., REAL ESTATE OFFICE IN DEARBORN

MICHIGAN
HIGHWAY RESEARCH LABORATORY SECTION

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INVESTIGATION OF TRAFFIC-INDUCED VIBRATION AT McDADE INC., REAL ESTATE OFFICE IN DEARBORN

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This report covers the results of an investigation of traffic-induced vibrations at the McDade Inc. Real Estate Office, 25121 Ford Rd (M 153), Dearborn. The study was requested in a letter of July 7, 1972 from the Right-of-Way Division.

Background Information

Right-of-way parcel CC-82081B, C-718, located at the above mentioned address, is in condemnation, and preparation for trial. The structure located on the site consists of an older residence, with a commercial addition on the front. The newer portion of the building is approximately 36 ft wide (west to east), made of brick with a glass front. The roof is of prestressed concrete planks spanning the full width of the building and is cantilevered out about 4 ft over the sidewalk. The present edge of eastbound Ford Rd is about 40 ft from the building and at approximately the same elevation (no cut or fill). The proposed widening of Ford Rd will place the new roadway about 20 ft from the building, and at nearly the same level as the present roadway.

The owner of the building is protesting that the new roadway will be so close that increased vibration due to truck traffic may cause damage to the structure. He is especially concerned about the heavy roof planks and the front cantilevered portion of the roof. Employees in the building expressed fear of working in the front part of the building, even under present conditions, because of the close proximity of the heavy traffic on the roadway. There is considerable noise from unmuffled and empty gravel trucks passing by. The traffic lane of the eastbound roadway has some surface roughness in front of the building, which results in increased ground vibration when trucks traverse the bumps, and also in loud noise when empty dump trucks bounce. The large glass windows in the front of the building respond quite readily to the vibration and noise.

Vibration Measurements

Vibration measurements were made at the site on July 26, 1972. Two 2-1/2-g accelerometers were used to make simultaneous measurements of ground vibrations at 20 and 40 ft from the edge of the roadway. Accelerometers were mounted on steel stakes driven into the ground. Comparative measurements were also made between the vertical acceleration of the ground and the roof of the building at mid-span. A few readings were also taken on a front window. Output from the accelerometers was recorded on a two-channel oscillograph. The trace was run at low speed to record vibrations caused by many trucks in the traffic stream. Fifty-seven vibration events due to vehicles were chosen from the trace for evaluation, and the maximum acceleration peak noted for each event. Results of the tests are shown in Table 1. The following actions were recorded to provide a rough basis of comparison:

a) (Accelerometers in horizontal position as per events 1 thru 30). A man tapping his foot on the sidewalk 1 ft away from the accelerometer stake generated a signal of 0.007 g.

b) (Accelerometer in vertical position as per events 31 thru 45). A person walking along the sidewalk about 2 ft from the instrument generated 0.013 g.

c) (Accelerometer in vertical position on roof as in event 46 thru 54). A man walking on the roof caused 0.018 g acceleration, and by jumping lightly on the roof the signal was raised to 0.058 g. Closing the office door moderately, generated 0.020 g in the roof.

d) (Accelerometer held horizontally against the window pane adjacent to the door, as in events 55 thru 57). Door shut lightly caused 0.110 g in window; slamming door, not very hard, raised signal to 0.850 g.

The response generated by vehicles traversing the small bumps in front of the building was not unusually large when compared with results of previous tests at other sites. The pavement roughness was not bad at the site, with only minor deterioration on the surface of the roadway. However, the sheer volume of traffic at this location, the close proximity of the traffic to the building, and the ridiculous, unnecessary noise from unmuffled gravel trucks on the roadway, combine to make the situation unpleasant and objectionable to those unwillingly subjected to the situation.

To interpret the results of the vibrations from a structural point of view, reference is made to chapter 50 of Harris and Crede (1), which deals with accelerations in the ground: "Early tests indicated that for typical small dwelling units, a peak acceleration of 0.1 g corresponded to a caution limit which might mark the beginning of minor plaster cracking, etc., and that 1 g was a limit above which significant structural damage could be expected."

Langefors in Sweden, Edwards in Canada, and Bumines in this country have made experiments correlating peak particle velocity in the earth with damage to structures. Their results agree quite closely with one another, and are in general agreement with the acceleration criteria of Harris and Crede.

Comparison of the tabulated acceleration values with the limiting values from Harris and Crede, shows that the vibrations present at the site are far below the amount required to cause structural damage. However, this does not tell the entire story, since the human body is an extremely sensitive device when subjected to vibration, and values far below structurally significant levels are known to be objectionable to many people.

Humans can feel vibrations of 0.0001-in. deflection; and motion of 0.001-in. at 20 cycles per second is annoying. Vibratory accelerations are "noticeable" well below 0.01 g; at 0.04 g they are "unpleasant" and above 0.25 g are classified as "intolerable" at certain frequencies.

In a September, 1967 presentation to the American Road Builders Association Annual National Highway Conference, titled "Blasting Vibrations, Their Effects on Buildings and People," John F. Wiss cautioned that although earth particle velocities of more than 4-in. per sec are required to cause minor structural damage, contractors should not exceed approximately 0.5 in. per second if they wished to avoid complaints from neighboring citizens. The 0.5 in. per sec velocity would correspond roughly to accelerations in the vicinity of 0.01 g.

Discussion

The vibration tests conducted in this experiment were quite limited, and do not provide complete answers. They do indicate increased vibration levels nearer the roadway, as is to be expected. They also indicate that if the present roadway were moved 20 ft closer to the building, vibration levels would be high enough to annoy people, although structurally insignificant. Initially, the new roadway will be smoother than the present one, which will tend to decrease vibrations caused by trucks at a given speed. However, the improved roadway undoubtedly will result in increased speeds of vehicles, which tends to increase vibration caused by vehicles traversing a given pavement profile. Future deterioration of the pavement surface could result in further complaints from neighboring residents.

Conclusions

The test results have shown vibration values far below the magnitude required to cause structural damage, even at 20 ft from the edge of the present pavement. Vibrations of the roof planks were quite low. Front window acceleration due to traffic was below that caused by normal use of the building.

However, the vibrations measured were within ranges known to be objectionable to some people, and the table shows that higher values are obtained nearer the roadway.

REFERENCE

1. Harris and Crede, "The Shock and Vibration Handbook" Vol. 3, Mc-Graw-Hill, New York, 1961.

TABLE 1
SUMMARY OF VIBRATION MEASUREMENTS
AT McDADE REAL ESTATE OFFICE

Event	Accelerometer Orientation		Location of Accelerometer		Truck Heading	Peak (g) Acceleration	
	No. 1	No. 2	No. 1	No. 2		No. 1	No. 2
1	Horiz	Horiz	20-ft from rd edge	40-ft from road edge, NE corner of building	E	0.005	0.003
2	Horiz	Horiz	"	"	E	0.004	0.003
3	Horiz	Horiz	"	"	E	0.006	0.004
4	Horiz	Horiz	"	"	E	0.004	0.004
5	Horiz	Horiz	"	"	W	0.003	0.003
6	Horiz	Horiz	"	"	W	0.006	0.003
7	Horiz	Horiz	"	"	W	0.003	0.006
8	Horiz	Horiz	"	"	E	0.012	0.010
9	Horiz	Horiz	"	"	E	0.005	0.002
10	Horiz	Horiz	"	"	E	0.009	0.010
11	Horiz	Horiz	"	"	E	0.011	0.012
12	Horiz	Horiz	"	"	E	0.008	0.009
13	Horiz	Horiz	"	"	E	0.009	0.008
14	Horiz	Horiz	"	"	E	0.010	0.007
15	Horiz	Horiz	"	"	W	0.006	0.004
16	Horiz	Horiz	"	"	E	0.012	0.010
17	Horiz	Horiz	"	"	-	0.006	0.005
18	Horiz	Horiz	"	"	-	0.009	0.008
19	Horiz	Horiz	"	"	-	0.009	0.007
20	Horiz	Horiz	"	"	-	0.007	0.006
21	Horiz	Horiz	"	"	-	0.006	0.005
22	Horiz	Horiz	"	"	-	0.005	0.004
23	Horiz	Horiz	"	"	-	0.006	0.004
24	Horiz	Horiz	"	"	E	0.013	0.016
25	Horiz	Horiz	"	"	-	0.008	0.008
26	Horiz	Horiz	"	"	-	0.014	0.012
27	Horiz	Horiz	"	"	-	0.015	0.010
28	Horiz	Horiz	"	"	-	0.010	0.012
29	Horiz	Horiz	"	"	-	0.009	0.009
30	Horiz	Horiz	"	"	-	0.008	0.006
					Avg	0.008	0.007

TABLE 1 (Cont.)
SUMMARY OF VIBRATION MEASUREMENTS
AT McDADE REAL ESTATE OFFICE

Event	Accelerometer Orientation		Location of Accelerometer		Truck Heading	Peak (g) Acceleration	
	No. 1	No. 2	No. 1	No. 2		No. 1	No. 2
31	Vert	Vert	20-ft from rd edge	40-ft from road edge, NE corner of building	E	0.016	0.008
32	Vert	Vert	"	"	E	0.014	0.005
33	Vert	Vert	"	"	E	0.014	0.007
34	Vert	Vert	"	"	E	0.009	0.004
35	Vert	Vert	"	"	-	0.014	0.007
36	Vert	Vert	"	"	E	0.013	0.008
37	Vert	Vert	"	"	E	0.015	0.012
38	Vert	Vert	"	"	E	0.024	0.013
39	Vert	Vert	"	"	E	0.017	0.008
40	Vert	Vert	"	"	E	0.012	0.005
41	Vert	Vert	"	"	E	0.009	0.004
42	Vert	Vert	"	"	E	0.007	0.004
43	Vert	Vert	"	"	E	0.009	0.005
44	Vert	Vert	"	"	E	0.008	0.004
45	Vert	Vert	"	"	E	0.023	0.008
					Avg	0.014	0.007
46	Vert	Vert	33-ft from edge of rd, C of bldg.	On roof, center of span, over a point about 37 ft from rd	W	0.009	0.010
47	Vert	Vert	"	"	W	0.009	0.008
48	Vert	Vert	"	"	W	0.007	0.009
49	Vert	Vert	"	"	W	0.005	0.008
50	Vert	Vert	"	"	E	0.012	0.009
51	Vert	Vert	"	"	-	0.009	0.004
52	Vert	Vert	"	"	-	0.008	0.005
53	Vert	Vert	"	"	E	0.015	0.009
54	Vert	Vert	"	"	E	0.015	0.011
					Avg	0.010	0.008
55	Vert	Horiz	"	On front window pane	E	0.008	0.095
56	Vert	Horiz	"	"	E	0.009	0.065
57	Vert	Horiz	"	"	W	0.004	0.045
					Avg	0.007	0.068