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TRAFFIC ROAD VIBRATION ENVIRONMENT AND ITS PROPAGATION TO RESIDENTIAL AREA IN JAPAN

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ABSTRACT

Vibration arising from road vehicles propagates through soil resulting in a ground vibration in their neighborhood. Such ground vibration as well as psychologically adverse effects on the inhabitants around its source. This paper describes a measurement example conducted on a elevated road of Shiga prefecture in Japan. A many vibro-meters were set up close to being footing also ground surface and residence houses to measure the ground vibration at its source. Certain houses are apt to resonance with ground vibration resulting in an identified vibration give rise an additional adverse effect.

1 - INTRODUCTION

This bridge herein addressed is situated on the central part of Shiga on Meishin Mortor way. Complains were often heard about the hazard and demand was extremely high for a reduced level of vibration. Acceleration of ground vibration arising from a large vehicle running across the bridge was measured to determine the effect of vibration itself on structures in near-by areas.

The upper structure spanning between piers P1 and P2 of the Ishiyama elevated bridge herein addressed was born at its either end by a pair of cantilever beam extending from each pier. A flexible joint was installed at the end of each beam to support the structure. The vibration originating in the impact produced by a vehicle passing over the joint as registered in nearby areas was assumed to have been relatively low in intensity, possibly because it propagated not directly through the piers but indirectly through the cantilever beams and their supporting members. The plane view of the test site is shown in Fig. 2.

Complaints have been brought forward from the neighbors in the area that their homes and buildings were subject to a higher level of vibration than before the work was completed. Typical of those suffering from inconveniences arising from vibration were the Matsuno-so (a hotel), the homes of the Tokunaga's and Kawasaki's. Protest was particularly strong from Matsuno-so that the guests were complaining of such inconveniences as rattling shoji's (Japanese sliding doors) and sleeplessness both arising from vibration which was strongly felt on its third floor in particular. The Kawsaki's also reported of rattling doors in their home. The increased level of vibration, as attested by these complaints, was thought to have arisen from the design of the renovation work whereby elastic bearing were installed on the piers, and therefore, the vibration was directly transmitted to the ground through them.

2 - RESULTS AND OBSERVATIONS

2.1 - Survey at the kawasaki's home

Vibration acceleration levels were measured of the vibration at three points: at the base of pier P2, in front of entrance of the kawasaki's home and in a Japanese-style room on its second floor. For reference, records were also taken of the vibration acceleration levels at the base of pier 3, at a corridor, and a

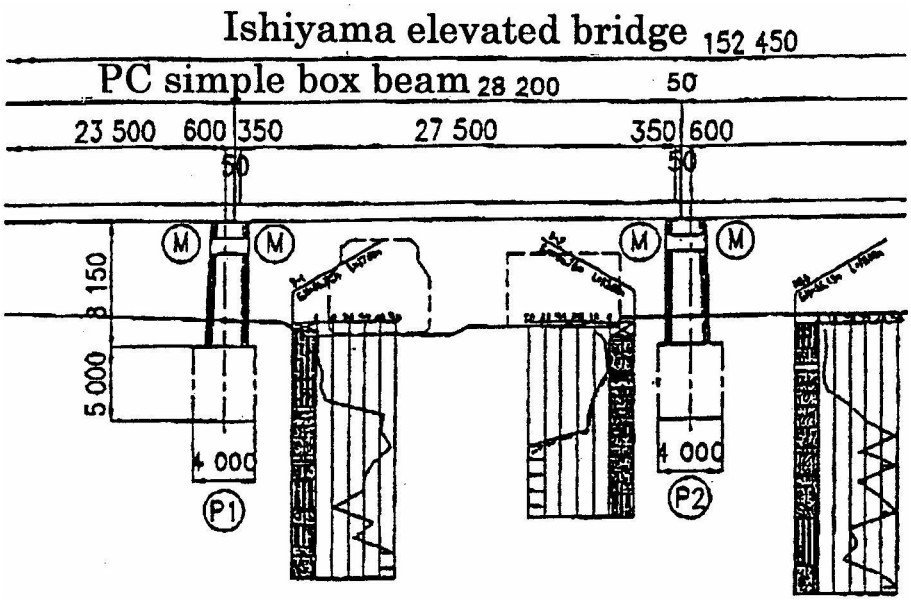

Figure 1: General view of the bridge after the work.

bedroom on the second floor, in their home. Frequency analysis was conducted of the Y and Z components of the vibration wave as recorded.

(1) Vibration acceleration level

Shown in Table 1 are the levels as measured of acceleration in three directions at various locations mentioned above. The level is seen to have been about 57 to 62 dB as recorded at the base of pier P2 in any of the three directions. While travelling to the point in front of the entrance of the house, the vibration is observed to have decreased in level by about 10 to 11 dB. Upon reaching the second floor, however, it increased in level to around 60 dB. While the increase is seen to be the largest in Y direction, as large an increase is also observed in Z direction. Because of this phenomenon, the level recorded in the Japanese-style room was actually higher than at the base of pier P2. A vibration was distinctly felt in this room at a frequency of about 3 to 5 Hz in Y direction and the sliding doors was heard to rattle also at a frequency of 3 Hz.

Direction	Acceleration level Lva (dB)			Change in Lva (dB)	
	Pier P2	In front of the entrance	In a room on the 3rd floor	From Pier P2 to the entrance	From the entrance to the room
X	60.1	46.8	53.3	− 13.3	+ 6.5
Y	56.6	47.7	67.4	− 8.9	+ 19.7
Z	63.0	45.2	54.5	− 17.8	+ 9.3

Table 1: Measurement result at Kawasaki's home.

(2) Frequency analysis

Fig. 3 shows the vibration acceleration levels recorded at three different locations at different frequencies. The vibration registered in the Japanese-style room is seen to have been predominantly in a frequency range over 20 Hz.

2.2 - Survey at the Matsuno-so

Level was recorded of the acceleration at three points; at pier P2, in front of the entrance and in a room on the third floor. The first set of data were taken in three directions; X, Y, and Z. It was subsequently decided, however, to do away with the measurement of vibrations in X and Z directions, as their levels were found to be well below human perception.

(1) Vibration acceleration level

Levels as measured of acceleration are shown in Table 2 below. The level recorded in the room addressed was over 67 dB, and as high as 70 dB at times. The amount by which the level was amplified in the building was as large as 20 dB. This is much higher than the amount of amplification within a typical

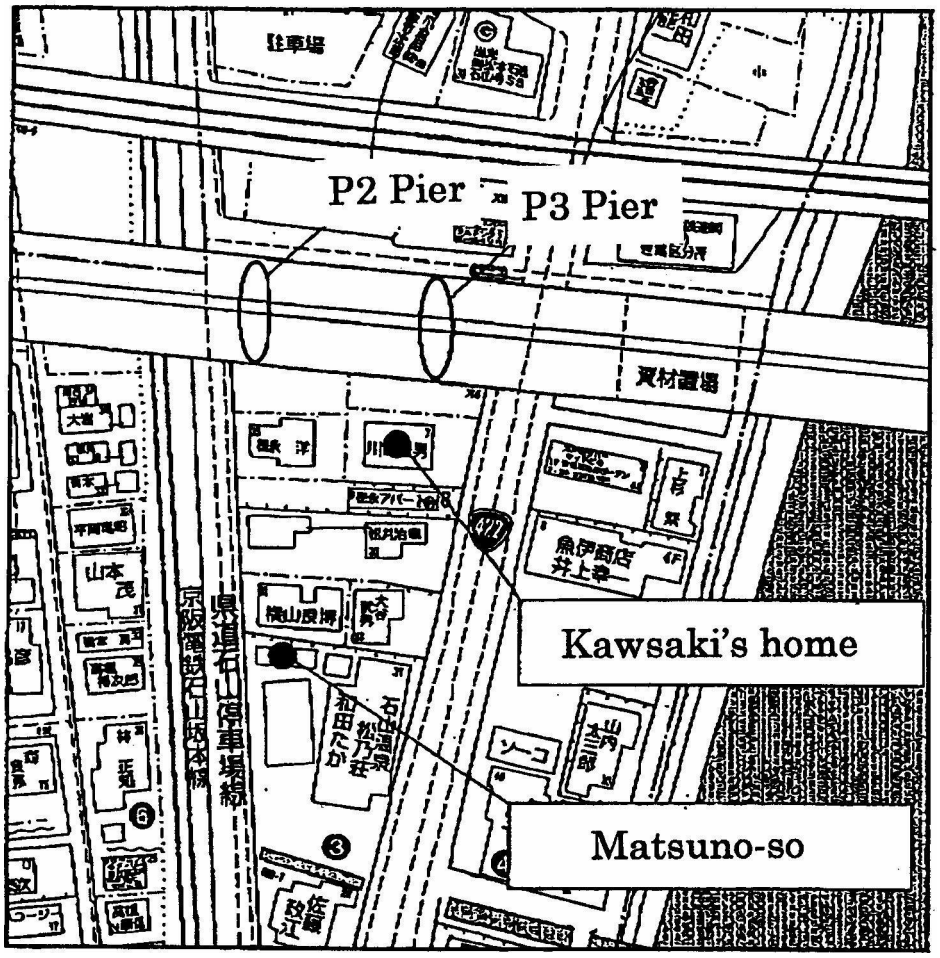

Figure 2: Plane view of the test site.

wooden house, which is somewhere between 5 and 15 dB. The vibration was distinctly felt there, the major component being in Y direction at a frequency around 3 Hz. Movement was clearly seen of the doors on the partition in the corridor, glass doors of the stereo-set rack and the curtains both in the room.

The decrease in its level as the vibration traveled the distance (about 60 m) from pier P2 to the entrance varied from in one direction to another; it was approximately 18 dB in Z direction and 9 dB in Y direction, the latter being only about half as much as the former.

Direction	Acceleration level Lva (dB)			Change in Lva (dB)	
	Pier P2	In front of the entrance	In a room on the 2nd floor	From Pier P2 to the entrance	From the entrance to the room
X	61.3	50.3	57.4	− 11.0	+ 7.1
Y	57.4	47.3	59.9	− 10.1	+ 12.6
Z	61.6	50.2	62.3	− 11.4	+ 12.1

Table 2: Measurement result at Matsuno-so.

(2) Frequency analysis

Shown in Fig. 4 are the acceleration levels over a range of frequency. Peaks are clearly seen at around 3 Hz at which the level reached as high as 60 dB in the room addressed. The highest among the five levels recorded was 67 dB, this being 2.2 cm/s^2 when converted in Arms value which exceeds by far the standard permissible limit (for comfortable human habitation). The frequency of vibration actually felt there, being in the order of 3 Hz, is in good agreement with the data shown in Fig. 4.

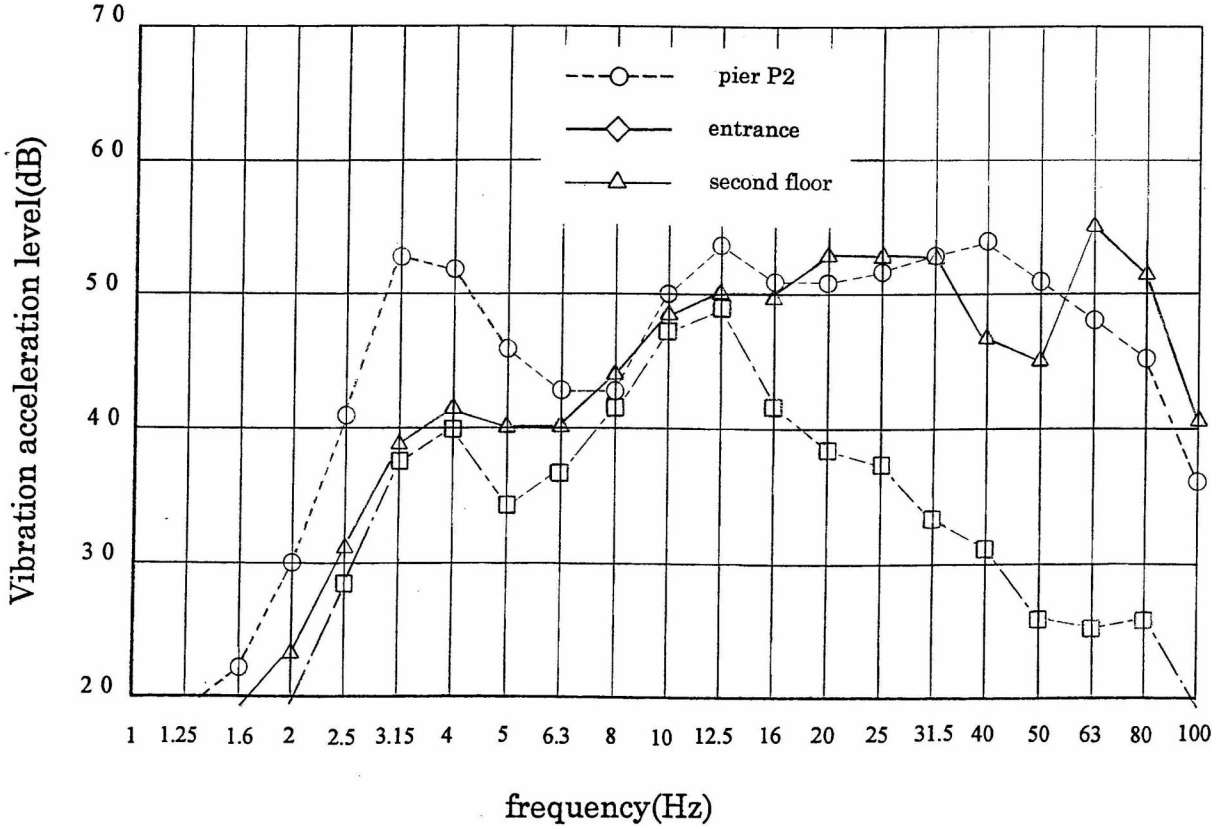

Figure 3: Result of frequency analysis (Kawasak's home, Z direction).

1. The natural frequency of the piers is about 3 to 5 Hz, and the shock
   Vibration generated within this range of frequency is transmitted to the ground with no substantial damping.

2. The vibration further propagates to neighboring areas through the soil with no appreciable reduction, the natural frequency of which being approximately in the same range as that of the piers.

3. The natural frequency of Kawsaki's house and that of Matsuno-so are also in this range. Furthermore the vibration, on reaching these buildings, is amplified by resonance as it propagates to the second and third floors, resulting in as high an intensity as felt by the residents.

4. The amount by which vibration is amplified due to resonance as recorded in these buildings is larger than those registered with typical wooden houses. This appears to arise from their particular structural design; the buildings may be given to resonance in Y direction with the incoming vibration, possibly because they are narrower in that direction than in X direction.

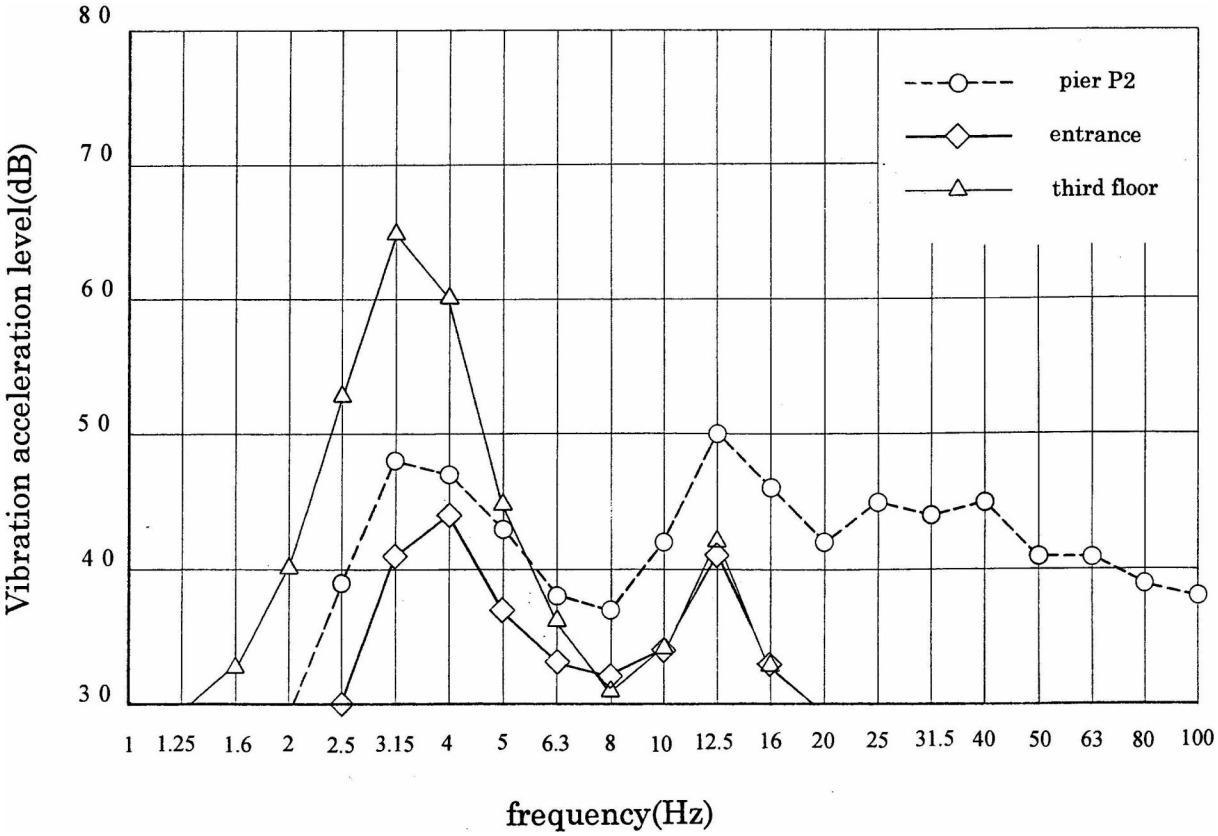

Figure 4: Result of frequency analysis (Matsuno-so, Y direction).