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ANALYSIS OF FOOTSTEP NOISE IN DAILY LIFE OF AN APARTMENT HOUSE

S.NAKAMURA, M.KOYASU and H.OCHIAI

Kobayashi Institute of Physical Research
Kokubunji, Tokyo, Japan

INTRODUCTION

It is reported that one of the most serious causes of noise problems in apartment houses is the jumping of children on the floor of the living room.

It could possibly be said that a case such as this should be regarded as the result of the apartment dwellers' manners rather than the fault of the building construction. Since there is no necessity for the impact sound insulation of the floor structure to exceed too much the requirements for "the normal conditions of daily life".

Then, what can be considered "the normal conditions of daily life"? What relation exists between the acoustical phenomena and the reaction of people living beneath the floor in question? Though all these questions are very simple they appear to be not well answered.

As well known, the usual method for testing the impact sound insulation properties of floors is to utilize the results of the measurements of quasi-steady noise generated by the tapping machine in order to judge whether the insulation is sufficient to satisfy human requirements towards the sporadic actual footstep noises. It was indeed a very smart idea to relate these two matters, quite different each other in nature. However, one should not overlook the fact that the established correspondence between two phenomena is based on so many empirical factors (perhaps for instance cultural backgrounds) and also that the correspondence should be regarded valid only within applications to the certain extent.

We have intended to examine the actual "normal state" of footstep noise generating in Japanese apartment houses.

Among the factors concerned with these noise problems, the frequency of the occurrence of footstep impacts and the distribution characteristics of the peak noise levels depend very much on the composition of the family and their manner of living. This is the one of the reasons why the study of this field is very difficult.

The purpose of our investigation was focused to evaluate the actual circumstances of this kind of noise in daily living and to show the relation between those and the nature of the dwellers or their mode of life.

PILOT FLAT AND PROPERTIES OF FOOTSTEP NOISE

In order to study the properties of the phenomena and to establish the method of the measurement, an inhabited pilot flat was chosen in a collective housing area which was completed four years ago. Fig.1 shows the skimatic of the flat. The flat situates on the fourth floor of a five-storied building. Parents and their two daughters, average composition of a family in this housing area, living there. As norma; Japanese living, they do not wear shoes in the rooms and walk around or sit down directly on the tatami floor.

Since it is impossible to measure the footstep noise in the lower flat, an acceleration pickup was fixed on the concrete slab of the floor structure in the living room as shown in Fig.2. The position of this measuring point looks being placed aside, but in fact it is just below the main walk way of the occupants because the position of the furniture.

Figs.3 and 4 are examples of the results given from the pilot studies of the floor vibration measurement. These show clearly that the ordinary footsteps are the major source of floor vibration and this depends closely on the mode of behaviour of the dwellers. In addition the floor vibration (=noise) generated by footsteps is so impulsive and sporadic that a new type of apparatus is to be developed which requires the statistical measurement considering the factors mentioned above.

As shown in Fig.5, there are two different kinds of footstep noises on such floor structures. One is the usual type of shock vibration caused by footstep impacts, and the other is the so-called grating noise.

Since the latter is caused by the mutual displacement and touch of wooden members of the floor structure, it depends very much on the condition of the individual floor. In case of our pilot flat this type of noise is prominent when very soft steps are performed towards some certain points in the living room.

MEASURING APPARATUS

The block diagram of our measuring apparatus is as shown in Fig.6. It is a kind of peak level selector with counters, as it is intended to count the number of the occurrences of footstep noise of a certain period in terms of its peak value. The sound level of the noise acceleration pickup and the peak value of that is detected by a set of window comparators (the present plan, 10dB step three channels) which

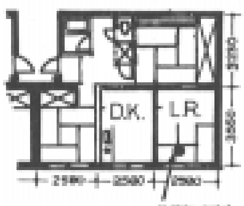


Fig.1

Fig.2

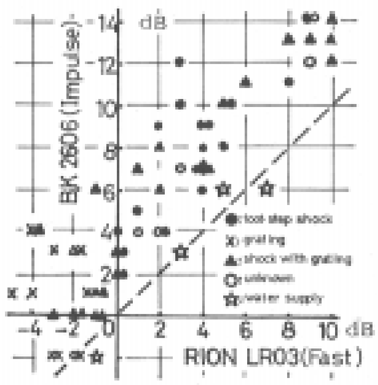


Fig.4

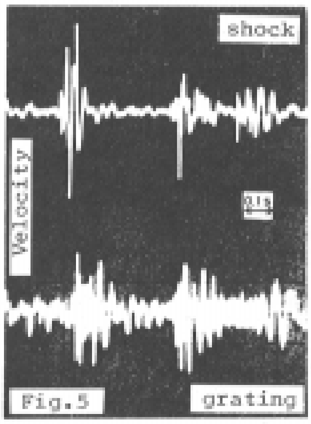
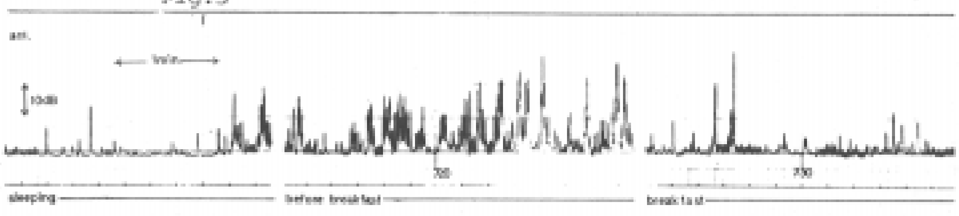


Fig.3



are connected to the respective counters .

As this apparatus is designed to meet the very limited purpose, a somewhat tentative way has been taken to process the input voltage signal. That is, the voltage signal from the vibration pickup is transmited to the level selectors without being squared or rectified, and some of the level selectors produce rectangular pulses. Since its duration is enlarged by τ , the counter dose not work if a succeeding one exists within the interval τ as shown in Fig.7.

Taking $\tau = 0.5s$, the number given by a certain counter corresponds approximately to the number of the occurrences of footstep noise the peak level of which exceeded the certain prescribed value.

The working voltage of a window comparator is calibrated by a stational sinusoidal wave signal which stands for a certain value of sound level, for instance 40dB(A). Though it is the rms value, the nominal value of the working level of the comparator is adopted from it without any corrections.

RESULTS

Figs.8 and 9 are the examples of the results measured by our apparatus of the previous type. The difference in the working levels between the neighbouring channels is 2.5dB.

On the right side of the maximum, the curves can be regarded the accumulative characteristics of the footstep noises which start from the measured number of the occurrence of the highest peak level.

On the left side, however, they reduce down instantly to the smallest value to be counted because of quasi-steady ground noise so that this part is not available for our present study.

The method of illustrating the results shown in the figures, is convenient also for studying the distribution characteristics of footstep noise by comparing their carious shapes.

Those shown in Fig.8 are the result measured in 30 seconds, that was intended to examine the actual state of footstep noise for the simplest condition, which is, a man (weight:74 kg) walking around continuously during the measuring period. It is shown in Fig.8 again

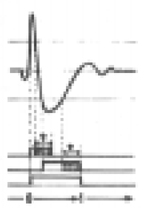


Fig.7a

Fig.6

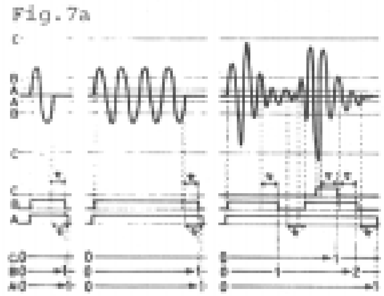


Fig.7b

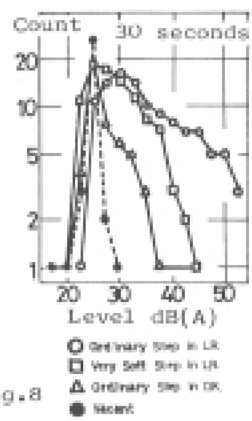


Fig.8

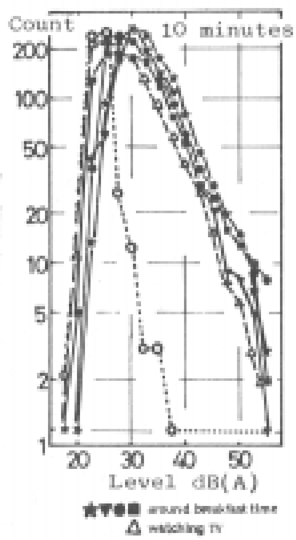


Fig.9

that the footsteps of the dweller are a very important source of the floor vibration possibly generating the noise, annoying the neighbour in the lower flat and that, in general, there are many conditions contributing to footstep noise.

As shown in Fig.9, the measuring period was enlarged to 10 minutes and was taken from daily life when the family there was acting in its usual way. The period "before breakfast" is one of the busiest times in a day. The results indicate very much a few differences among the actions of dwellers in the same situation in everyday life.

On the contrary, when then are watching television, the number of occurrences of footstep noise becomes noticeably less than that in the morning. However, it is interesting to show a very little difference in the distribution characteristics between these two cases in spite of the difference in the number of the occurrences.

Those shown in Fig.10 are the result measured in 24 hours with the apparatus of the present type reformed according to our experiences of the former studies. Since the shape of the resultant accumurative curves is simple as shown in Figs.8 and 9, the number of level selectors is reduced by expanding the working level difference between channels up to 10dB.

The broken lines in the figure show the results of the measurements made for the different flat just above the pilot flat. The dwellers but an aged woman of that flat are mostly out in the daytime.

These curves also indicate that each family has its own pattern of "normal living condition of daily life", and are reflecting evidently the difference in mode of life and that in characteristics between families.

As for the measuring method, it is recommended that 50dB(A) as the lowest working level for the series of the level selectors should be taken, since the counted number at the working level 40dB(A) contains a innegligible amount of the counts caused by the vibration transmited from the other flats.

During the measurements in 24 hours, readings in the counted number were taken for several times as much as possible. The results in Fig.11 also express very well the difference of the conditions.

As mentioned above, our tentative measuring method is found to be able to evaluate the actual condition of footstep noises in daily life, though there are still some problems remaining unsolved, for instance the sound radiation characteristics of the concrete slab in the low frequency region and the appropriate value of the time constant of the level selectors.

In the present stage of the study of this field, it is needed very much to compile many date given by the field measurements of this kind.

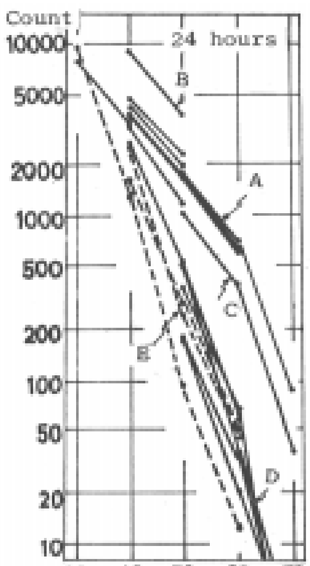


Fig.10 Level dB(A)

A:ordinary day
B:visit of daughter's friend
C:out in the afternoon
back late at night
D:out in daytime
back late at night
E:ordinary day (5F)