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Just noticeable difference of rubber ball impact sound

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In order to measure low frequency impact sound in concrete and wooden structured apartment building rubber ball was proposed by Japan and Korea. Previous studies on rubber ball impact sound showed that physical propertied of rubber ball similar with real impact such as jumping and running of children. Rubber ball was standardized in ISO 10140-5 and ISO 16283-2. Studies on single number quantity (SNQ) for rubber ball is conducted. In addition, classification on rubber ball impact sound is needed for the evaluation and labelling of low-frequency impact sound. In this study, subjective evaluation on just noticeable difference (JND) of rubber ball impact sound was conducted. The presented rubber ball impact sound was recorded in real apartment buildings. JND results of this study and previous studies discussed for the proposition of classification difference.

1 Introduction

Low frequency impact sound is one of the major noise source in apartment buildings. In some countries, civil disputes or civil suits on floor impact sound in their apartment buildings were occurred. Mid and high frequency impact sound such as dropping goods or high heel walking can be reduced by floor covering and resilient materials in the floor structures. However, isolation of low frequency impact sound is difficult because low frequency impact sound propagates as structure borne sound. In order to measure and evaluate low frequency impact, rubber ball was standardized in ISO 10140 series and ISO 16283-2 [1, 2]. It was reported that the rubber ball has similar physical and subjective characteristics with child's running and jumping [3]. Recently, researches on single number quantities of rubber ball are conducted and the result show that A-weighted maximum impact sound pressure level and arithmetic mean from 63 Hz to 500 Hz in octave band has good relationship with subjective loudness and annoyance [4, 5, 6].

In ISO/TC 43/SC 2/WG 29, acoustic classification scheme for building is standardizing. Acoustics classification scheme has 6 grades from A to F with 4 dB step [7, 8]. Classification scheme on rubber ball impact sound was not proposed. However some research results on classification on rubber ball impact sound was proposed [4]. In this study, subjective evaluation on just noticeable difference (JND) of rubber ball impact sound was conducted to check the level difference between grades. The presented rubber ball impact sound was recorded in real apartment buildings. JND results of this study and previous studies discussed for the proposition of classification difference.

2 JND (Just Noticeable Different) Experiment

For JND experiment, rubber ball impact sound sources were recorded in real apartment buildings with reinforced concrete and wooden structures. Totally 15 rubber ball impact sound sources were used in JND experiment. 9 rubber ball impact sound sources were recorded in reinforced concrete structured apartment building with resilient material on the floor structures and 6 were recorded in wooden structured residential buildings.

Recorded rubber ball impact sound sources were represented through 4 loud speakers (Genelec 8030) and one subwoofer (Genelec 7060) to insure low frequency impact sound. JND experiment was conducted in listening chamber which was constructed similar with living room in typical apartment units (see Figure 1). Recorded rubber ball impact sound sources were set up as reference sources. To make comparison sources, sound pressure level of reference sources was changed as 2 dB step until 6 dB (- 6 dB, - 4 dB, -2 dB, + 2 dB, + 4dB, +6 dB). Reference sound sources were presented and then 6 kinds of comparison sources of each rubber ball impact sources were presented. Subjects were asked to respond they can distinguish level difference between reference and comparison source as Yes or No. 30 subjects were participated in JND experiment. Most of subjects were in their 30's and 40's and have experience living in apartment buildings.

Figure 1: Listening chamber where JND experiment was conducted

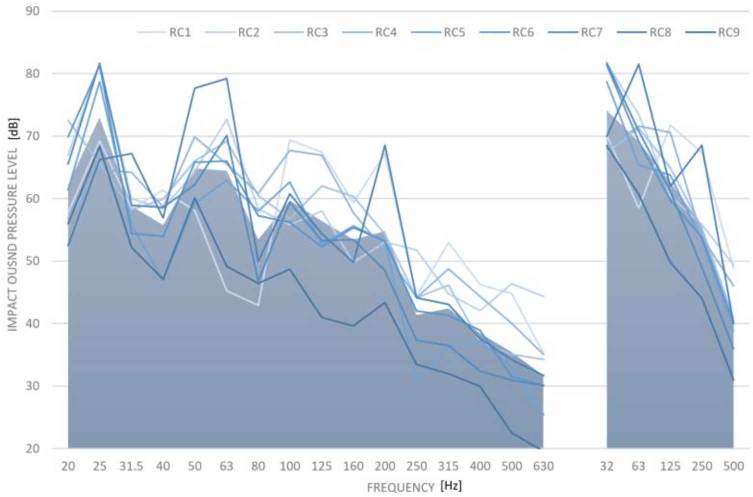

Figure 2: Frequency characteristics of rubber ball impact sound recorded in reinforced concrete structured buildings

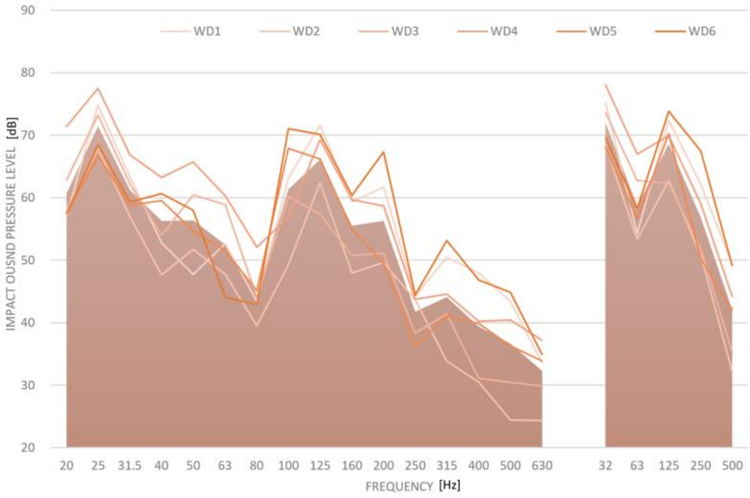

Figure 3: Frequency characteristics of rubber ball impact sound recorded in wooden structured buildings

Figure 2 and Figure 3 show frequency characteristics of presented reference sound sources in 1/3 and 1/1 octave band. Figure 2 is the frequency characteristics of rubber ball impact sound sources recorded in reinforced concrete structured buildings with resilient materials. Figure 3 shows frequency characteristics of rubber ball impact sound recorded in wooden structured buildings. Comparing average frequency characteristics, rubber ball impact sound in reinforced concrete buildings have much more component in 50 Hz ~ 80 Hz bands. Rubber ball impact sound in wooden structured buildings have higher than RC buildings in 125 Hz and 160 Hz bands. Rubber ball impact sound were presented two kinds sound pressure level. One is similar with recorded sound pressure level, another is 10 dB reduced sound pressure level in order to check JND variation with different presented sound pressure level.

3 Results of JND Experiment

Figure 4 and Figure 5 show results of JND experiment. As shown in Figure 4, about 65 % of subjects responded that they can distinguish 4 dB difference and more than 85 % of subjects can distinguish 6 dB difference. In addition, when the presented sound pressure level reduced about 10 dB, distinguishing percentage of level difference were decreased. Figure 5 shows JND experiment results of wooden structured buildings. About 65 % of subjects answered that they can distinguish 4 dB level difference. 90 % of subjects distinguished 6 dB level difference of rubber ball sound in wooden structured buildings. In the case of 10 dB reduced sound sources, more than 10 % of distinguishing percentage of level difference were decreased. When considering these results, about 2/3 of people can distinguish 4 dB difference of rubber ball impact sound. When rubber ball impact sound pressure level is increased, people can distinguish more easily the level difference. Comparing the results between RC and wooden structure buildings, distinguishing percentage difference of wooden structured buildings was larger than that of RC Structured buildings.

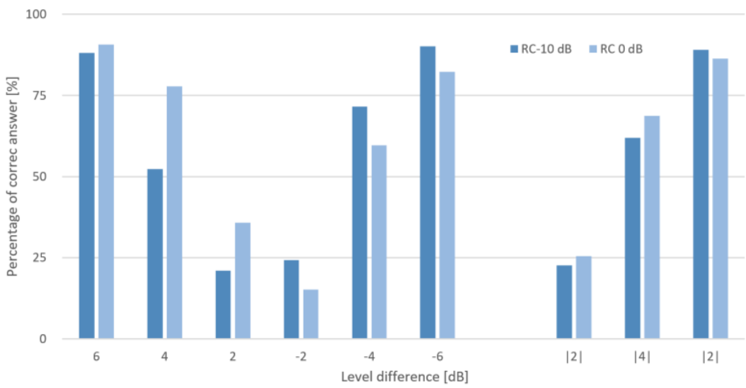

Figure 4: JND experiment result of rubber ball impact sound recorded in RC structured buildings

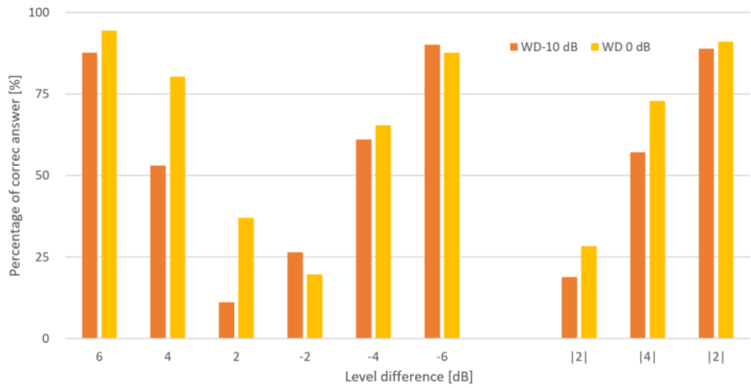

Figure 5: JND experiment result of rubber ball impact sound recorded in wooden structured buildings

Figure 6 shows the JND experiment results from previous study [9]. The experiment of previous study was conducted in small listening chamber and the rubber ball impact sound sources were presented through headphone. 10 subjects in their 20's were participated. As shown in Figure 6 distinguishing percentage was much higher than JND results of this study. One of the reason of higher distinguishing percentage is that subjects of previous study can easily concentrate on the presented sound source, because rubber ball impact sound presented through headphone. Also, the experiment was conducted in small listening chamber, therefore subjects might not have influenced by visual environment. When compare two results of JND experiments, JND results have similar tendencies (see Figure 7)

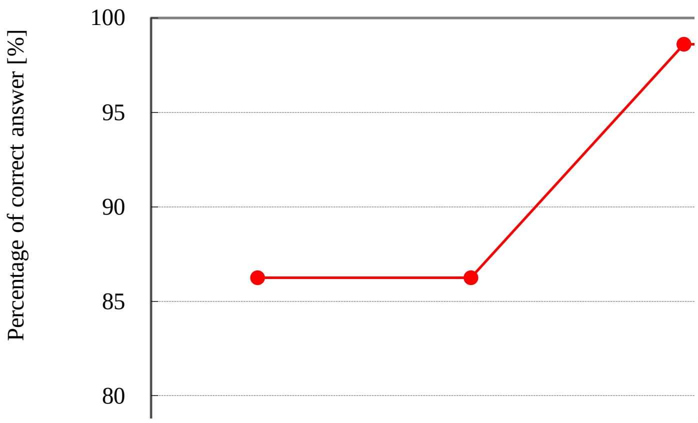

Figure 6: JND experiment result of previous study

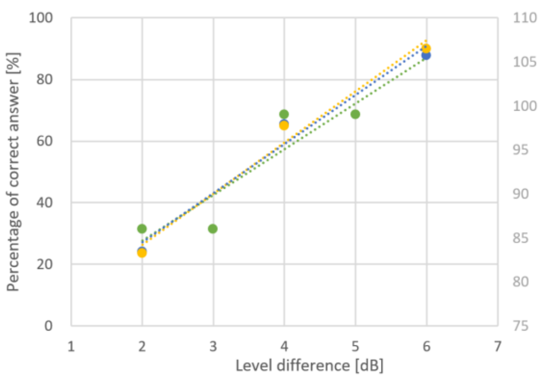

Figure 7: Tendency comparison JND experiment result of previous study

4 Summary

In this study, JND experiment of rubber ball impact sound was conducted. Rubber ball impact sound sources recorded in RC and wooden structured buildings and were presented in listening chamber through 4 loud speakers and sub-woofer. As a comparison sources, impact sound pressure level of reference sources was changed 2 dB step up to 6 dB. 30 subjects were participated. JND experiment result show that about 65 % of subjects were distinguished 4 dB difference and more than 90 % of subjects were recognized level difference. Also, the results of previous study showed that most of subject distinguish 4 dB difference. When making a classification scheme for rubber ball impact sound, level difference between grade can be 4 dB step.

References

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