# Implementation of the Floor Impact Noise Monitoring System through the Field Test-Bed Operation

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**Summary**

The present study attempted the first try to control floor impact noise problems using ICT facilities called floor impact noise monitoring system which are consisted of sound and vibration sensors, wireless communication gateway and the main server with analyzing software. The systems were applied to the 300 dwelling units at three apartment complexes in Korea for three months. The operating algorithm was made satisfying with the current regulations in Korea. During the real-time implementations of the system, warning sound was rumbled to the dwelling units where excessive impact noise was occurred. After the implementation, questionnaire survey was executed to investigate the resident satisfaction measurement.

As a result, it was found that the system is operated well in real time pursuantly with the algorithm and regulation. It was also revealed that the analyzed results of the system are in coincident with the measured levels. Also, it was appeared that excessive noise occurrence was reduced 14% comparing with the initial state. And residents replied that noise concerned stress was reduced about 20% in average. As a conclusion, reliability of the floor impact noise monitoring system was verified and the standard specification of the system was fixed for the system commercialization in future.

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## 1. Introduction

Korea has high density of population, considering the size of the territory. Thus, high-rise residential buildings have been built during the last two decades. In addition, because of the improvement of the standard of living along with continuous national economic growth, the interest in well-being and the expectation of quiet life for comfortable and pleasant residential environment have also been increasing. However, Korea has the life style of sitting on the floor, floor impact sound has been occurring more and more frequently. Eventually, neighbourly disputes have been a serious social problem. Lately, damage and disputes from noise between floors have been much more increasing.

The purpose of the present works is to reduce the number of disputes and to give secure aural environment in the multi-dwelling apartments. The present work was the first trial supported by Korean government in order to reduce the dispute cause by floor impact noises using ICT facilities called floor impact noise monitoring system.

## 2. System Algorithm

The system consists of sound and vibration sensors, wireless communication gateway and the main server with analyzing software. At least, one outlet which contains both a sound microphone and a vibration meter was installed at the center on the ceiling of the living room.

The operation procedure of the monitoring system is displayed in Fig.1. When impact noise occur, the sensors catch the signals and transmit the signals to the server through the home gateway. Then, the server will analyze the signal and if the measured sound levels exceed the standard, it delivers alarm to the dwelling unit where impact noise was originally made. The algorithm of the system was made following the regulation of the impact noise standards of Korea (refer to Table 1&2). Figs 2&3

show the basic and modified algorithm of the system and the example of the system outputs.

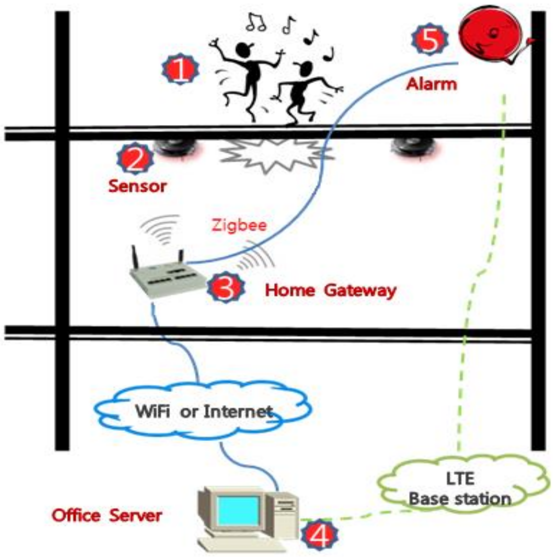


Fig. 1 Operation procedure of the system.

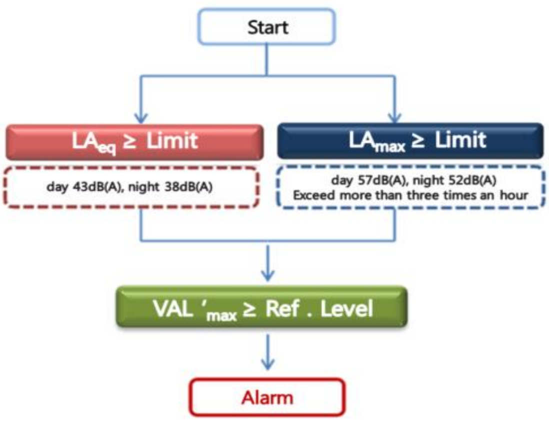


Fig. 2 Basic algorithm of the system.

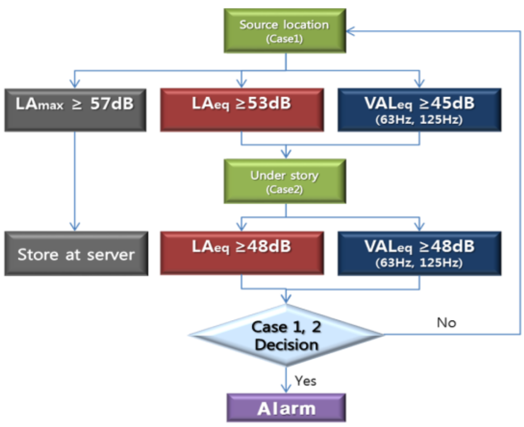


Fig. 3 Modified algorithm of the system.

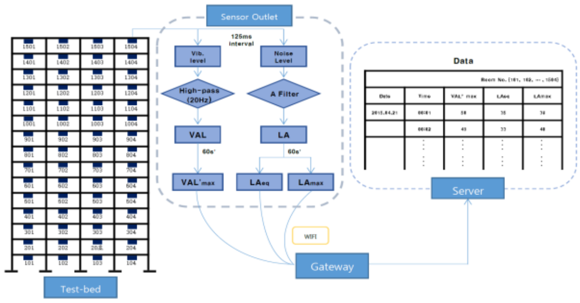


Fig. 4 System configuration.

## 3. Implementation of the System

The systems were applied to the 300 dwelling units at three apartment complexes in Korea for three months. At first, floor impact noises of the three Test-bed apartments were measured following ISO standard using standard noise sources (KS F 2863-1 & KS F 2863-2) The floor impact noise insulation performances were evaluated following the Korean standard regulations as listed in Table 3.

Table 1 Standard for light-weight impact noise.

| Grade | Grade Criteria (dB) |
|---|---|
| 1st | L'n,AW ≤ 43 |
| 2nd | 43 < L'n,AW ≤ 48 |
| 3nd | 48 < L'n,AW ≤ 53 |
| 4th | 53 < L'n,AW ≤ 58 |

Table 2 Standard for heavy-weight impact noise.

| Grade | Grade Criteria (dB) |
|---|---|
| 1st | L'i,Fmax,AW≤40 |
| 2nd | 40≤L'i,Fmax,AW≤43 |
| 3nd | 43≤L'i,Fmax,AW≤47 |
| 4th | 47≤L'i,Fmax,AW≤50 |

Before the implementation, a series of several experiments were undertaken to investigate the performance verification including laboratory test for sensors, mock-up test for system operation and field test for system performance evaluation. The operating algorithm was made satisfying with the current regulations in Korea. During the real-time implementations of the system, warning sound was rumbled to the dwelling units where excessive impact noise was occurred. After the implementation, questionnaire survey was executed to investigate the resident satisfaction measurement.

Table 3 The floor impact noise insulation performances of the three Test-Bed apartments.

| | Test –Bed A | | Test –Bed B | | Test –Bed C | |
|---|---|---|---|---|---|---|
| | Noise Level | Grade | Noise Level | Grade | Noise Level | Grade |
| Light-weight ($L'_{n,AW}$) | 60dB | Below Grade | 56dB | 4 | 56dB | 4 |
| Heavy-weight ($L_{i,Fmax,AW}$) | 51dB | Below Grade | 50dB | 4 | 46dB | 3 |

## 4. Results

Fig. 5 shows the two measured records of sound levels of an existent apartment in Seoul using precision devices and a Test-bed apartment in Ulsan using system devices during the same time period. It shows that the noise patterns are similar with time. This means that the measurement devices used in the system is reliably working.

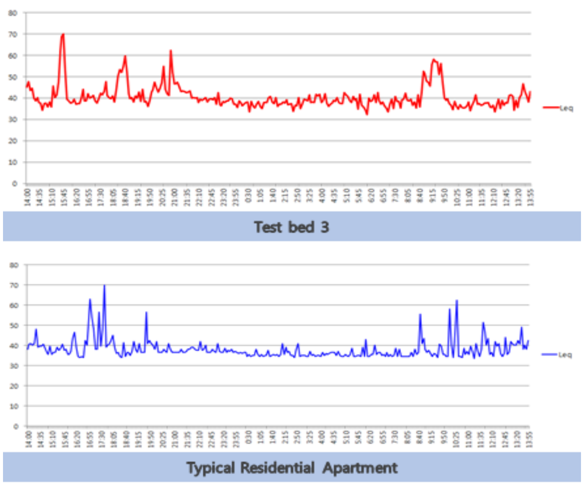


Fig. 5 Comparison of the noise data measured in the real residence with the data stored in the Test-bed.

Fig.6 shows an example of the stored noise & vibration data including both floor impact and other noises in a vertically connected unit. Only when noise and vibration levels exceed the reference level in the two units at the same time the system decide the floor impact noise occurs and recorded the data in the sever.

As a result, it was found that the system is operated well in real time pursuantly with the algorithm and regulation. It was also revealed that the analyzed results of the system are in coincident with the real measured levels. Also, it was appeared that excessive noise occurrence was reduced 14% comparing with the initial state and residents replied that noise concerned stress was reduced about 20% in average.

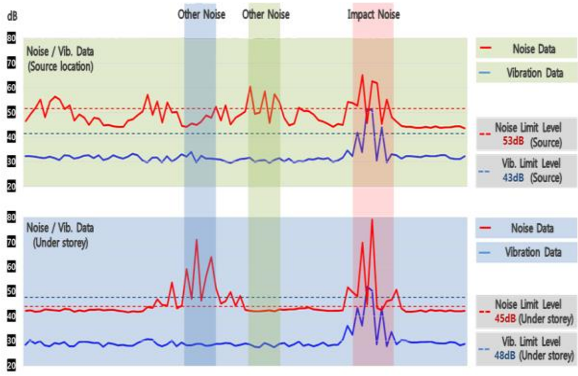


Fig. 6 Example of the stored noise & vibration data including both general and impact noises.

Also, the system was tested in order to verify the function of noise source localization since apprehension of the exact noise source and the correct alarm delivery to the noise source place are most important matters. The tests were done twice in the Test-Bed C using reference noise sources. At the 1st test, 12 rooms were randomly selected by an impactor. And impactor recorded the time of impact and the room number. Also, operator monitored the system and recorded the time of impact noise and the room number as well. However, among 12 trials, only 7 trials were in tune with noise sources and alarmed location at the 1st test.

2nd Test was undertaken after modifying the source location tracing algorithm few months later. At the 2nd test, 6 rooms were randomly selected by an impactor and the same procedures were executed as precisely as the 1st test. Totally 8 trials were done in 6 rooms and all the trials were in tune with noise source and alarmed location.

In parallel with implementation of the floor impact noise monitoring system, surveys were undertaken two times before and after operating monitoring system to the residents of the Test-bed apartments.

Regarding the frequency of the impact noise occurrence, residents replied that noise occurrence was reduced approximately 14%. It was presumed that the monitoring system is efficient for residents themselves to realize about the noise.

Also, it was replied that responses for being stressed are reduced approx. 20%. This denotes that residents seems like feel more free for being concerned about generating noises after operating the system.

There was also some effect on the alarming number of occurrence. After operating the system, the number of warning signal is reduced 10% in comparison with number of the pre-survey

## 5. Conclusion

The present work carried out the floor impact noise monitoring system using ICT technology with the sensor based devices to the real residential apartments. Implementation of the floor impact noise monitoring system was undertaken to 300 dwelling units for five months.

As a result, it was found that the system is operated well in real time pursuantly with the algorithm and regulation. It was also revealed that the analyzed results of the system are in coincident with the real measured levels.

As a conclusion, reliability of the floor impact noise monitoring system was verified and the standard specification of the system was fixed for the system commercialization in future.

### Acknowledgement

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### References

[1] Ministry of Environment, Annual Statistical Report of Environment, vol. 21. (2008).

[2] Ministry of Environment, Survey Report of the National Poll for Noise Awareness (2002).

[3] Ministry of Traffics & Construction, National Standards for Sound Insulation and Floor Impact Noise of Apartments (2004)

[4] KS F 2863-1, Method of Floor Impact Noise Measurement and Evaluation of the Performance of Noise Insulation : Standard Light-weight Impact Source

[5] KS F 2863-2, Method of Floor Impact Noise Measurement and Evaluation of the Performance of Noise Insulation : Standard Heavy-weight Impact Source

[6] C.H.Haan: Monitoring algoritm of the floor impact noise managing system. Proc. Acoust. Soc. Of Korea 2017.