ICSV14
Cairns • Australia
9-12 July, 2007

ACOUSTIC PERFORMANCE OF FIRST GENERATION APARTMENT HOUSES IN KOREA

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Abstract

Traditional life style in Korea has been established for thousands of years in detached houses. However, apartment houses have been introduced in the urban areas to serve the need of industrialization since the 1970's. To give a more rapid supply, building performance such as acoustic quality was not a significant matter at the stage of building. Furthermore the acoustic quality is getting worse as time goes by, the building is getting older and the urbanization is progressing more. They have two or three bedrooms, areas mostly from 65 ㎡ to 85 ㎡. There are usually 6 to 8 units in a floor, which are arranged linearly. 150mm to 200mm thick transverse load bearing walls and longitudinal beams structurally support the building. There had not been an anti earthquake design code in Korea. There are complaints about the acoustic quality of the old, first generation apartments in Korea. A recent survey shows that there are five major aspects. They are floor impact noise, heavy weight floor impact noise, plumbing noise, sound transmission between units in the same floor, and traffic noise. Surveys on the acoustic complaints, measures of the current performance on the five major acoustic aspects, and a comparison of the results with the residents' expectations and with legal considerations are performed in this study.

1. INTRODUCTION

Rapid growth of Korean industries causes that speed of urbanization. Mass housing system like apartment houses is the only alternative to accommodate the people who should live in the vicinity of the urban area. Traditional life style in Korea has been established for thousands of years in detached houses and kids' playing outdoors. It is relatively longer and more important living inside the apartment, and followed by more noise from footstep, plumbing devices, and airborne sound.

As far as the performance is concerned, mass is the matter from the beginning rather than the living quality like acoustic environment. As time goes by, it is getting worse according to the aging of the facilities. Partly due to the complaints from residents living in those old apartment houses, mainly due to the higher living standard and the growth of total housing

accommodation, over 100%, the demand on a better acoustic environment is getting higher and higher. Some of acoustic features are reflected on the Korean Building code.

The acoustic performances of recently built apartments are far higher than the first generation apartments. As a matter of course, the differences in the acoustic quality between the old and new ones are bigger than ever. Some of the old apartments are demolished and rebuilt, and some of the others are remodelled. But there are still many, waiting for any reform, mostly encouraged to execute a remodelling to minimize the possible damage on the urban environment. Demolishing and rebuilding is relatively simple as far as the acoustic quality is concerned. It may be treated as a new building project. But it is not in the case of remodelling. It should be based on the current building condition.

To execute a successful remodelling, in the acoustical viewpoint, it is essential to be aware of the current situation. What are the residents' major discomforts? How low are the current acoustic performances? How high should the targets on those items be, in referring to the Korean Building code or something? Can they be reachable? This study deals with the questions mentioned above. Surveys on the complaints of residents living in the first generation apartments were carried out. An acoustical assessment model was proposed, which was based on the result from the survey. Measurements and assessments were performed according to the model.

2. SURVEYS ON RESIDENTS' DISCOMFORT ON THEIR ACOUSTIC ENVIRONMENT

2.1 Subjects

Two blocks of 20 years old apartment houses were investigated. Residents, whether landlords or tenants, currently living in the apartments, were asked to take interviews and/or fill in answer sheets of a questionnaire. 122 samples were collected after one full day survey.

Table 1. Two blocks of apartment houses selected for the survey.

	Block A			**Block B**		
Date of completion	May 1986			Oct. 1986		
Profile	No. of Floor	No. of Unit	Unit Area ㎡	No. of Floor	No. of Unit	Unit Area ㎡
	12	384	85, 150	12	192	110, 180
	15	480	110	15	720	85, 110
No. of Unit	864			912		
Structure	RC load bearing wall			RC load bearing wall		

2.2 Contents of the questionnaire and interview

Besides the basic items on the subjects' profiles, questions on the floor impact noise, floor airborne noise, plumbing noise, noise from next door units, and other noise sources such as traffic noise were included in the questionnaire and interview. Contents of the questionnaire are presented in table 2.

Table 2. Two blocks of apartment houses selected for the survey.

Contents	
Address, sex, age, family status, unit type, period of residence	
Degree of Satisfaction	Current situation, reason for the discomfort, further demand
Floor impact noise	Floor impact noise, heavy weight floor impact noise, major noise sources, reason for the discomfort etc.
Floor airborne noise	Airborne noise between floors, noise from ducts , major noise sources, reason for the discomfort etc.
Plumbing noise	Noise from pipe runs, fixture, appliances, pumps etc.
Unit to unit airborne noise	Noise from the next door units, reason for the discomfort etc.
Other noise sources	Traffic noise, community noise, noise from other sources etc.

Figure 1. Interview and questionnaire

2.3 Results

2.3.1 General degree of satisfaction and items on discomfort

About a quarter of the subjects have certain amount of discomforts. It depends partly on the actual physical environment, and the difference in the sensitivity on noise. Heavy weight floor impact noise and plumbing noise are definitely the major parameters that affect the discomfort of the residents.

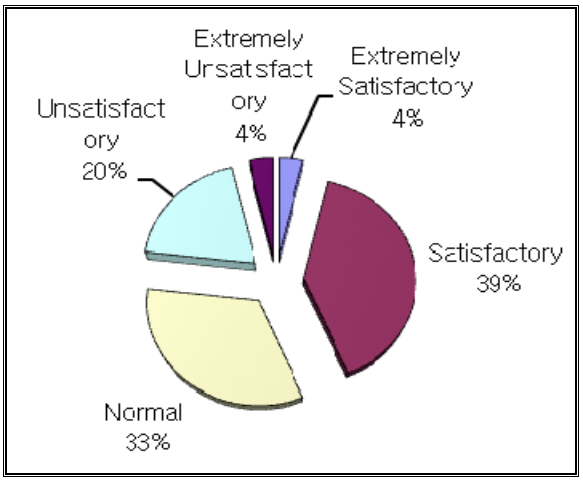

Figure 2. General degree of satisfaction

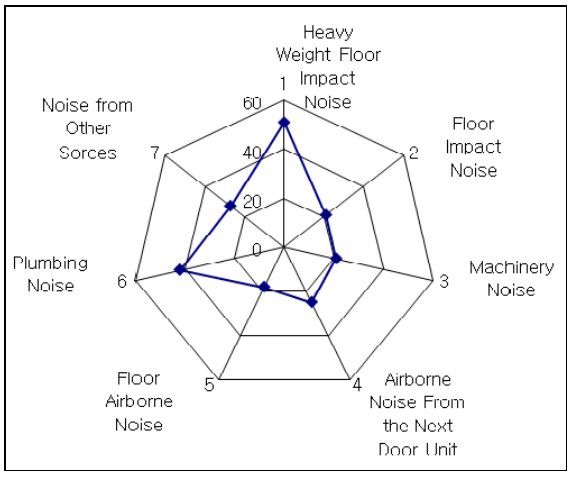

Figure 3. Items on discomfort

Table 3. Number of marking on the discomfort features

Parameters	Number of marking/122	Rate of marking(%)
Heavy weight floor impact noise	**51**	**41.8**
Floor impact noise	21	17.2
Machinery noise	21	17.2
Airborne noise from next door units	25	20.5
Floor airborne noise transmission	18	14.8
Plumbing noise	**42**	**34.4**
Noise from other noise sources	27	22.1
Miscellaneous remarks	Pets barking/growling noise, Doors closing noise, Ringing interphone bell, Footstep noise at stairs etc.	

2.4.2 Heavy weight floor impact noise

Floor impact noise, especially from the standard heavy weight impact source described in KS F 2810-2, is the most frequently marked discomfort parameter. There are questions to the subjects about the degree of satisfaction for the floor impact noise transmitted from upstairs, and on the possible discomfort of the residents living underneath for the heavy weight impact noise generated by themselves. It is quite interesting that there is an obvious difference between the must be identical, answers for the two questions. They are suffering the noise from upstairs, and they think the resident underneath may be better because they do not make impact noise like the people upstairs. This means that the impact noise insulation performance of the floor is worse than what they think it to be. There is another distinct feature in the response. Though being discussed later, according to the measurement, the impact noise level in fact is higher in bedrooms than in the living rooms. But the answer shows that the subjects feel louder in living rooms than in bedrooms. This means that annoyance is a more important factor in acoustic discomfort than loudness.

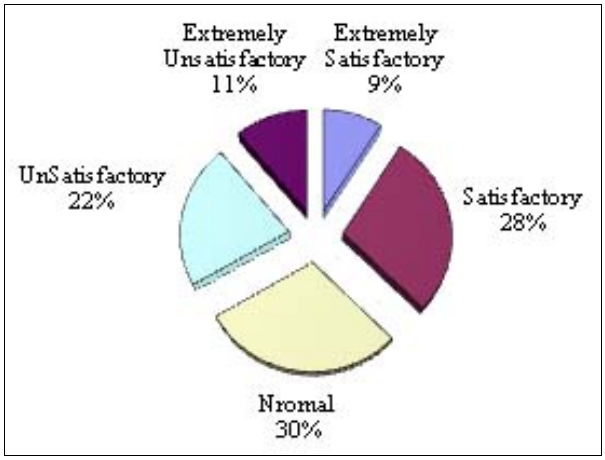

Figure 4. Degree of satisfaction about the heavy weight impact noise from upstairs unit

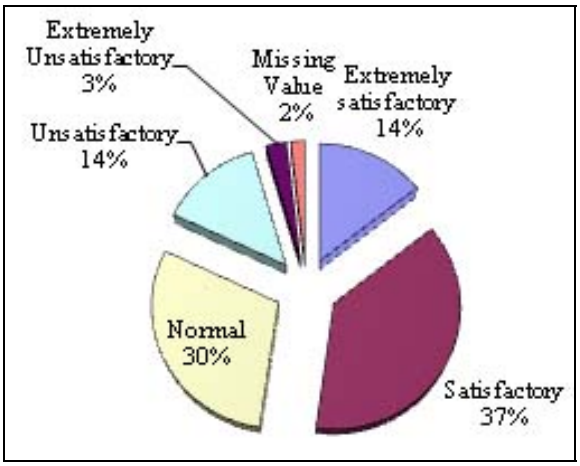

Figure 5. Guess the degree of satisfaction of the residents living underneath

4.1.3 Plumbing noise

Plumbing noise is the second frequently marked discomfort. A quarter of the subjects marked

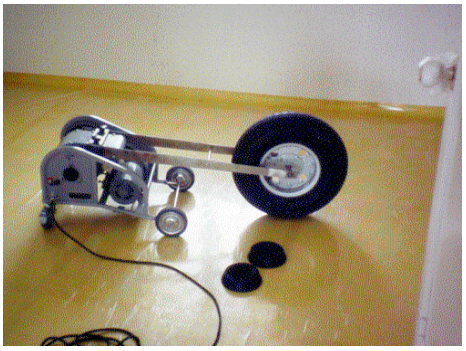

Figure 6. Standard heavy weight impact source(KS F 2810-2)

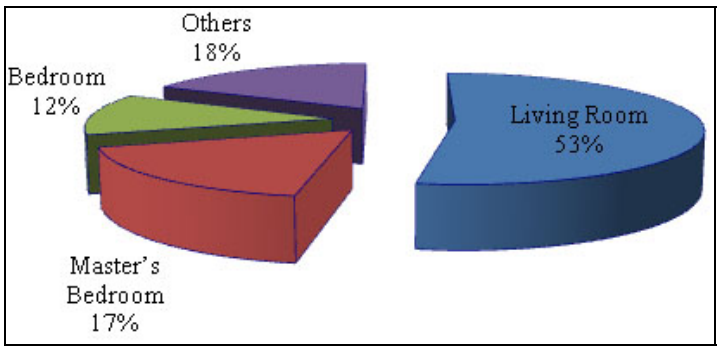

Figure 7. Loudest area marked by subjects

"unsatisfactory" area, but the extreme case is much lower than heavy weight floor impact noise. Unlike the expectation, the toilet flushing noise, water supply noise is the most discomfortable factor. Despite the fact that over 80% of the units have changed their own fixtures, they are still suffering from the noise. It is expected that there are some problems in design, pipeline isolation, water pressure and/or duct connection, etc.

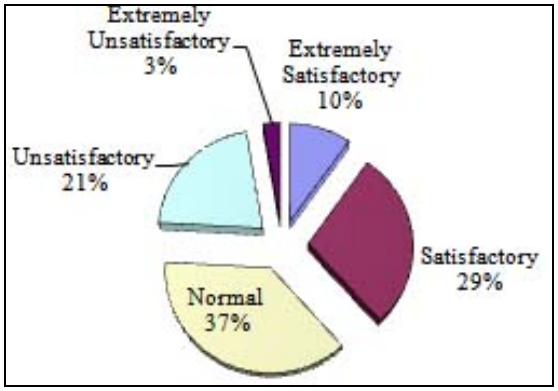

Figure 8. Degree of Satisfaction about plumbing noise

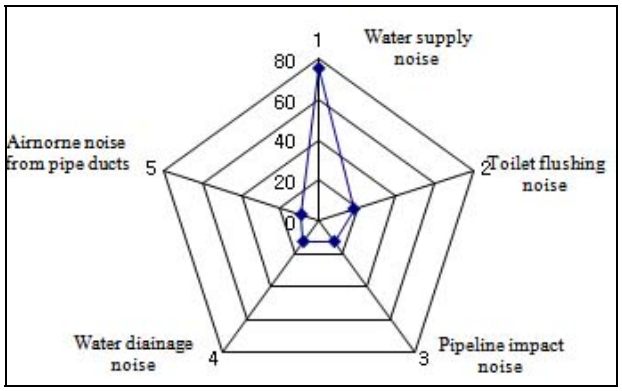

Figure 9. Most loud plumbing noise

3. BUILDING AN ACOUSTIC ASSESSMENT MODEL

As shown in the survey result, there are acoustic discomforts which affect the satisfaction of residents in old apartments. To quantify the actual performance, an acoustic assessment model is proposed.

Table 3. Acoustic Assessment Model

Parameters	Standards	Units	Targets	Remarks
Heavy weight floor impact noise	KS F 2810-2 KS F 2863-2	$L'_{I,Fmax,AW}$	≤ 50	Korean Building Code
Plumbing noise	Under processing	dBA	≤ 45	Exclude Bath
Unit to unit sound insulation	KS F 2808 KS F 2809	Dntw	≥ 48	
Floor impact noise	KS F 2810-1 KS F 2863-1	$L'_{n,AW}$	≤ 58	Korean Building Code
Traffic noise level (indoor)	Under processing	Leq(dBA)	≤ 40	Korean Building Code

4. MEASUREMENT ACCORDING TO THE MODEL

4.1 General

Measurements were carried out in the guest apartment at Jeju National University. The apartment houses were built in 1979 and have never been changed. Measuring equipments are two types of standard impulse sources, omni directional loudspeaker, and the actual plumbing fixtures as sound sources, Oros and Svan912 as analysers. The unit plan and the measurement points are presented in Figure 10.

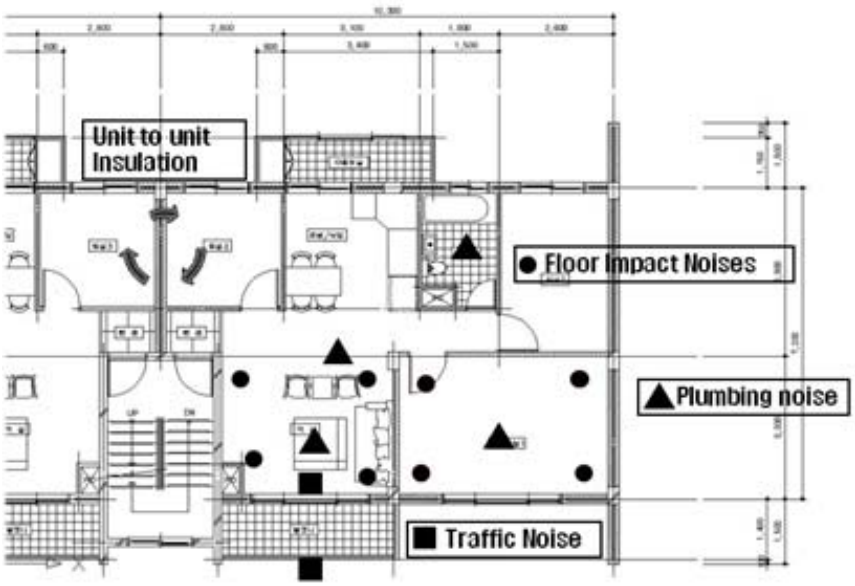

Figure 10. Plan and the measurement points

4.2 Results

Overall general results show that there are deficiencies in the performance at heavy weight floor impact noise and plumbing noise. Unit to unit sound insulation and traffic noise level both inside and outside are quite satisfactory in this case, while floor impact noise with standard tapping machine is at the marginal level. To ensure the current profile, details on the two parameters are investigated further.

Table 4. Overall result of the measurement

Parameters	Targets	Results	Remarks
Heavy weight floor impact noise	$L'_{I,Fmax,AW} \leq 50$dB	Living Room 51dB Master' Bedroom 56dB	1dB to 6dB to be improved
Plumbing noise	SPL$\leq$ 45 dBA	Living Room 47.4dBA Master' Bedroom 49.2dBA (Bath 63.2 dBA)	2.4 dBA to 4.2dBA to be improved
Unit to unit sound insulation	Dntw $\geq$ 48	52	OK
Floor impact noise	$L'_{n,AW} \leq$ 58 dB	Living Room 58dB Master' Bedroom 55dB	OK
Traffic noise level (indoor)	Leq$\leq$ 40dBA	Far below 40	OK

4.2.1 Details on heavy weight floor impact noise

The rating scheme of heavy weight floor impact noise in KS F 2863-2 is the comparison of the measured value with the reference curve, from 63Hz to 500Hz in octave bands. The octave band value at 500Hz of the shifted reference curve is a single number, which allows less than 8 dB's deviation throughout the frequency bands compared. The reason why the value measured in the master's bedroom is higher may be interpreted by the degree of slab's conjunction with walls. It affects especially to the lower frequency bands transmission. It is noted that the levels at 500Hz are almost the same, whilst much higher at 63Hz and 125Hz. Floating floors with resilient dampers, increasing the stiffness of slabs, and special treatment of the ceiling and its plenum may be an alternative to improve the performance.

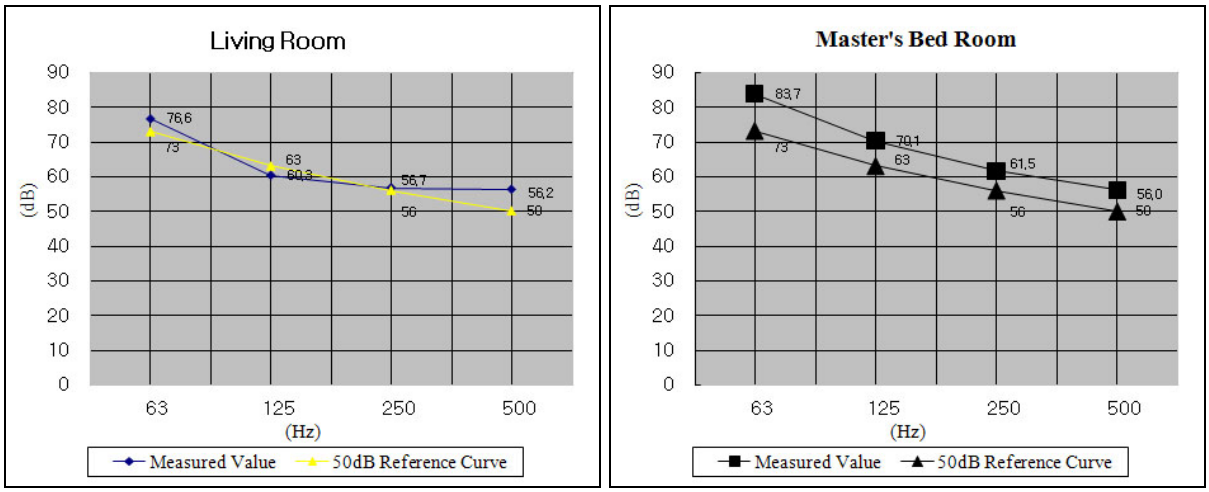

Figure 11. Comparison of the measured value with 50dB reference curve(target)

4.2.2 Details on plumbing noise

Measurement is carried out according to the report from a working group, which has been preparing a new Korean Standard. It will be announced in late 2007 or 2008. Noise from three different noise sources should be measured at least in three different positions. For all the noise sources, at almost all the microphone positions, the level is higher than the target value, 45dBA. Lower water supply pressure, low tank toilet, isolation of pipelines to the building, pipe jacketing, isolation and direct flushing to the duct of the toilet, and insulation of airborne noise through duct and door are the possible alternatives to reduce the noise.

Table 4. Overall result of the measurement

Noise Sources			SPL in dBA's at microphone positions		
			Bath	Living room	Master's bedroom
Bathtub	Supply		68.5	49.9	48.9
	Drain		59.0	44.7	45.7
Washbowl	Supply		67.2	49.0	48.6
	Drain		55.9	38.7	45.9
Toilet	Same unit	Supply	62.4	44.7	47.2
		Flush	63.2	47.4	49.2
	Underneath unit	Supply	54.8	-	33.6
		Flush	56.4	-	45.3

5. SUMMARY

For executing a successful remodelling of old first generation apartments, in the acoustical viewpoint, it is essential getting to be of the current acoustic situation. What are the residents' major discomforts? How low are the current acoustic performances? How high should the targets on those items be, in referring to the Korean Building code or something? Can they be reachable?

This study deals with the questions mentioned above. Surveys on the complaints of residents living in the first generation apartments were carried out. There are various acoustic items for the residents to feel uncomfortable. Among them, heavy weight floor impact noise and plumbing noise are the most frequently marked issue. An acoustical assessment model was proposed, which was based on the result from the survey. It is composed of floor impact noise, heavy weight floor impact noise, plumbing noise, sound transmission between units next door, and traffic noise.

Measurements and assessments were performed according to the model. Overall general results show that there are deficiencies in performance at heavy weight floor impact noise and plumbing noise. Unit to unit sound insulation and traffic noise level both inside and outside are quite satisfactory in this case, while floor impact noise with standard tapping machine is at the marginal level.

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ACKNOWLEDGEMENTS

This research is part of a research project (Grant No. C105A1050001-05A0505-00310) in the program of "Construction Core-Technology Research & Development", sponsored by Korea Institute of Construction & Transportation Technology Evaluation and Planning (KICTTEP). The financial support is gratefully acknowledged.