

# A STUDY ON THE DESIGN CONSIDERATIONS OF A PREFABRICATED FLOOR HEATING PANEL REGARDING FOR REMODELING OF AN AGED APARTMENT

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## ABSTRACT

In Korea, there is growing interest in the remodeling of aged apartment buildings. Traditionally, the heating panel in Korea is a wet type floor heating panel that utilizes radiation. But if a wet type floor heating panel is installed in an aged apartment during its remodeling, some problems may occur. They include failure to secure enough ceiling height, to reduce level of floor impact noise and possibility that the load on the existing structure is increased. In other words, a wet type floor heating panel may not be in compliance with the Korea building codes when it is used in remodeling of such apartment structures. Therefore, a prefabricated floor heating system which is thin and lightweight is suggested as an alternative to a wet type floor heating panel. In this research, first, the building codes that restrict, directly and indirectly, the prefabricated floor heating panel for an apartment remodeling were investigated. Second, the available thickness of panel was calculated so that it complies with the building code, and it was found that there is a need to develop a new prefabricated floor heating panel that can be installed in an aged apartment to be remodeled. Third, the design parameters of a floor heating panel were classified and determined according to their role to design reasonably within the available thickness by studying the standards and technical documents.

## KEYWORDS

Prefabricated floor heating panel, Remodeling, Aged apartment, Design parameters

## INTRODUCTION

In Korea, apartments that were built in the 1970's and 1980's are aging and so, the aged equipments need to be replaced with new ones. As the national income has increased, the demands of residents of apartments with respect to their living spaces are becoming higher and more diversified. In order to satisfy their needs and demands, there has been growing interest in remodeling in Korea recently.

Remodeling is a method of replacing the building infilling such as the floor plan, interior finishing and equipments without having to change any part of the structure such as columns and beams. That is, the height of a story and the load that the structure can stand remain the same.

One of the objects of remodeling is the heating system of an apartment. Traditionally, the heating system that is used in Korea is the radiant floor heating panel. It is generally installed as a wet type. As a wet type floor heating panel is integrated with a slab, there are difficulties in terms of repairing and changing it. In addition, a wet type floor heating panel has disadvantages in terms of complying with the Korea building codes when it is used in remodeling of aged apartments. If a wet type floor heating panel is installed without change when the heating panel of an aged apartment is remodeled, some codes may not be met. In addition, it is possible that the ceiling height may not be sufficiently high or the load on the structure may be increased.

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As described previously, a wet type heating floor panel has some risks in remodeling of an aged apartment. Therefore, a prefabricated floor heating system which is thin and lightweight is focused on as an alternative to a wet type heating floor panel. But it is insufficient that the study of how a prefabricated floor heating system for apartments to be remodeled is designed in order to have appropriate thickness and weight and provide thermal comfort as much as a wet type heating floor panel. In this research, first, the building codes that restrict, directly and indirectly, the prefabricated floor heating panel for an apartment remodeled were investigated. Second, the available maximum thickness of panel was calculated to comply with the Korea building code. We found that a new prefabricated floor heating panel that can be installed in an aged apartment remodeled need to be developed. Third, the parameters to design within the available were classified through studying the standards and technical documents.

## INVESTIGATION OF KOREA BUILDING CODES

When the floor heating panel is designed, there are some factors to be considered including comfort, preference, economical efficiency, constructability and building codes. Among them, the Korea building codes must be first taken into account and they must be in compliance with.

In this section, we will discuss about the Korea building codes that must be considered during the design stage of the panel which is used in remodeling of aged apartments.

### The code of U-value of building components

This code is about U-value of building components which is representative of thermal performance. Table 1 shows U-values of floor structures according to various conditions such as region, location at building and so on. It was established with the intent to save energy by reducing the heat loss through building components.

Although the regulation of thermal performance is just one, simple, not strict and not detail, a reasonable thermal design of the panel is very important because thermal performance of the floor heating panel is directly correlated with a resident's comfort.

Table 1 U-value of a floor structure according to various conditions (W/(m<sup>2</sup>K))

			Central region	Southern region	Jeju-do
Floor of occupied space at the lowermost story	Facing outdoor directly	With the floor heating system	≤ 0.35	≤ 0.41	≤ 0.47
		Without the floor heating system	≤ 0.41	≤ 0.47	≤ 0.52
	Facing outdoor indirectly	With the floor heating system	≤ 0.52	≤ 0.58	≤ 0.64
		Without the floor heating system	≤ 0.58	≤ 0.64	≤ 0.76
Floor between stories	With the floor heating system		≤ 0.81	≤ 0.81	≤ 0.81
	Others		≤ 1.16	≤ 1.16	≤ 1.16

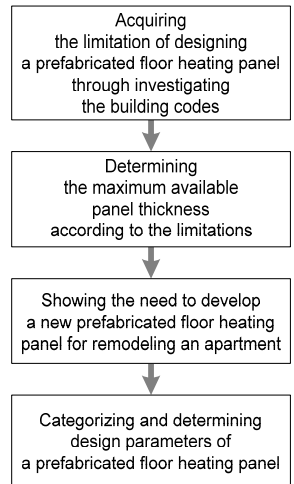


Figure 1. Flow chart of the study

### The code of ceiling height in house

The minimum ceiling height of occupied space restricted in the code is 2200mm. The apartments in Korea that were built in the 1970's through the 1980s mostly have a height of 2600mm. Considering the restricted minimum ceiling height, the floor heating system and other plumbing pipe systems must be installed with a height of 400mm.

### The requirement of a sprinkler installation at an apartment which is above eleven-story

According to the fire service law revised in November 2005, an apartment that is eleven-story or higher must have a sprinkler system in every floor. As the targets of remodeling, aged apartments of Korea are more than eleven-story, they must be installed a sprinkler system when they are remodel.

An installation of the present sprinkler system does need a 150mm plenum.

### The regulation of floor impact noise

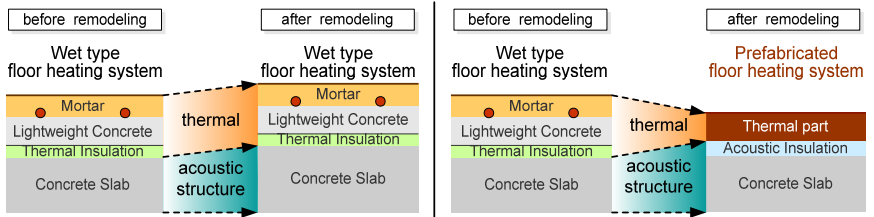
In the past the floor impact noise did not matter. As the standard of living has improved, the demand better sound insulation has increased. Noises have become a source of arguments among neighbors. As a result, the regulation of floor impact noise was newly established and implemented. This regulation states that light floor impact noise - floor impact noise by relatively light and solid impulse - must be less than 58dB and heavy one - floor impact noise by relatively massive and tender impulse - must be less than 50dB. This regulation must be kept when an apartment is remodeled with changing the floor area.

In Korea the floor impact noise of one specific floor structure is tested at the standard laboratory. If the test result satisfies the regulation, that floor structure is certificated as 'the standard floor impact noise insulation structure', and an apartment installed with a certificated floor structure is considered to be in compliance with the regulation relating to floor impact noise.

When an apartment is remodeled, the thickness of a wet type floor heating system must exceed 210mm so that it can reduce the floor impact noise up the level stated in the regulation (Figure 2-(a)). As an apartment to be remodeled has a fixed story height, if a floor heating system thickens, the ceiling height decreases and the load that building structure stand increases.

In case of an apartment to be remodeled, one way to comply with the regulation of floor impact noise and securing the ceiling height without changing the thickness of slab is by installing the prefabricated floor heating panel. This prefabricated floor heating panel must be more lightweight and thinner than a wet type floor heating panel system and have a structural system that reduce the floor impact noise (Figure 2-(b)).

Most of the codes investigated restrict the total thickness of a floor heating panel. The first key consideration to a panel design is to find the available panel thickness for an aged apartment.



(a) Remodeling with a wet type floor heating system

(b) Remodeling with a prefabricated floor heating system

Figure 2. The comparison between a wet type and a prefabricated floor heating system

# Determination of available floor heating panel thickness

## Calculation of available panel thickness

Subtracting plenum thickness in order to install the sprinkler system, slab thickness and ceiling height from a given story height, available thickness of the prefabricated floor heating panel(PFHP) is put out. As stated above, the story height of a Korean aged apartment is generally 2600mm. The thicknesses of slab are 135, 150, 165, 180 and 210mm. The ceiling height is at least 2200mm. The sprinkler system is needed 150mm. Taking these dimensions into account, the available thickness of a floor heating panel,  $T_{p,max}$  can be calculated (see Table 2).

Table 2 Available panel thickness according to slab thickness

	135mm slab	150mm slab	165mm slab	180mm slab	210mm slab
Schematic Image					
	$T_{p,max}$	115 mm	100 mm	85 mm	70 mm

## Analysis of certificated floor structures in terms of panel thickness

There are some floor structures developed by various manufacturers and certificated by the Korea Government. They are called 'the standard floor impact noise insulation structures'. Most of them are wet type floor heating panels; one is a prefabricated floor heating panel. All of them have some devices like soundproofing material, vibration absorber, a raised floor system and so on which reduce the floor impact noise level. They must be installed in the floor with specific slab thickness in order to take full advantage of their noise insulation performance. Table 3 shows the specific slab thickness of some certified floor structures and panel thickness. And it shows whether the panel of the certified floor structure can be installed in apartments with various slab thickness and can work well in terms of noise insulation. As you see in Table 3, there is no certified floor structure which can be installed in the apartment with above 165mm slab thickness which is remodeled. There is hardly the structure which can be installed in below 150mm slab thickness. Although it can be installed, it is not reliable that panel can reduce the floor impact noise level. Therefore it is needed to develop a new prefabricated floor heating panel that can be installed in an aged apartment remodeled.

Table 3 Availability for a remodeled apartment in terms of thickness and noise insulation performance of certified floor structure(as of January, 2006)

Certified floor structures as of 2006	Specific slab thickness <sup>1</sup> (mm)	Panel thickness (mm)	Availability for a remodeled apartment and noise insulation performance of certified floor structure				
			135mm	150mm	165mm	180mm	210mm
A	150	97.5	○	●	X	X	X
B	150	110	X	X	X	X	X
C	150	112	X	X	X	X	X
D	180	116	X	X	X	X	X
E	180	120	X	X	X	X	X

- : available for a remodeled apartment in terms of thickness and capable for insulation of heavy floor impact noise
- : available for a remodeled apartment in terms of thickness and unreliable insulation of heavy floor impact noise
- X : unavailable for a remodeled apartment in terms of thickness

<sup>1</sup> This thickness is a specific slab thickness in which the panel must be installed to take full advantage of its noise insulation performance

# CLASSIFICATION OF DESIGN PARAMETERS OF FLOOR HEATING PANEL

To design a prefabricated floor heating panel within available thickness reasonably, the components of the panel should be classified as design parameters. In this research, some European standards and technical documents were studied and design parameters were categorized according to their roles.

## Study of international standards and technical documents

The existing European standards of floor heating panel are EN15377, EN1264, Nordtest vvs 127, etc. These standards treat a wet type floor heating panel and a panel for lightweight structures such as wood. In addition, they provide steady-state calculation methods for determination of the heating capacity and a method for design heat flow intensity and a procedure for determining the design supply temperature. In other words, they do not deal with the prefabricated floor heating panel on concrete slab and do not provide a method for determining the dimension and properties of layers which is composed of the panel.

Then some predicted design parameters were listed up and checked with reference to these standards and technical documents-EN15377, EN1264, Nordtest VVS 127 and Ch.6 Panel Heating and Cooling of ASHRAE System and Equipment Handbook (see Figure 3). In the beginning, prospective design parameters are classified according to their locations in the panel. The parameters of the International standard and the technical document are used to calculate the heating capacity.

## Final decision of design parameters of the prefabricated floor heating panel

By investigating these two parameters-the prospective design parameters and the parameters of the European standard and the technical document-each other, some of prospective design parameters are selected.

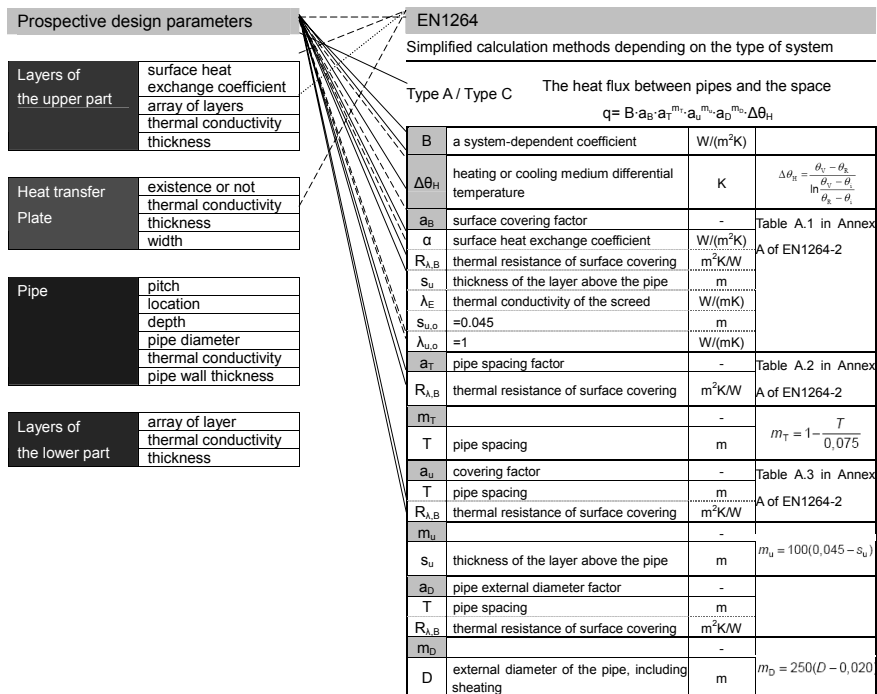


Figure 3. A match-up of the prospective design parameters to those in the standard EN1264

And the design parameters are reorganized. First, the components of the panel were divided according to their roles. The roles are distribution of heat, source of heat and prevention of heat loss. Layers of the upper part and heat transfer plate belong have a role of heat distribution. A pipe is the source of heat. The role of layers of the lower part is to prevent heat loss prevention caused by their location in the panel. The components are classified into two kinds. One is an essential component and the other is a selective components. Each dimension and property of the components is the final design parameter which will be determined in design process (see Table 4).

Table 4 Final design parameters of prefabricated floor heating panel

Role	Component	Dimension or Property
Distribution of heat	Flooring	Surface heat exchange coefficient
		Thermal conductivity
		Thickness
	Upper medium	Thermal conductivity
		Thickness
		Heat transfer plate
Source of heat	Pipe	Thermal conductivity
		Thickness
		Width
		Spacing
		Depth
		Diameter
Prevention of heat Loss	Lower medium	Wall thickness
		Thermal conductivity
	Thermal insulation	Thermal conductivity
		Thickness
		Thickness

■: essential component

□: optional component

## DISCUSSION AND CONCLUSIONS

In this study, we studied the current situation relating to the remodeling of aged apartments in Korea and the Korean building codes. In this situation, the available thickness of a prefabricated floor heating panel was calculated. We found that the development of new prefabricated floor heating panel for remodeling of

and aged apartment is necessary. Lastly the design parameters of panel were determined. Presently, we are in the process of developing a method to decide materials and dimension of a panel.

As pointed out above, there is not a type of a prefabricated floor heating panel on a concrete slab in the standards. As a result, this kind of panels cannot be reasonably designed and appropriately evaluated its thermal performance. After researching this subject in related to a prefabricated floor heating panel, we will suggest a type of the prefabricated floor heating panel in the standard based on the results of the research.

## ACKNOWLEDGEMENTS

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