A STUDY ON EFFECTS OF ENERGY SAVING BY APPLYING COMPLEX INSULATION INTEGRATED THE SOFT MATERIAL IN APARTMENT HOUSE

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ABSTRACT

As environmental issues are rapidly gaining more and more interest globally, various measures and standards are being set to minimize the use of energy in the architecture field, which consists about a fourth of the total use of energy. Korea, like other developed countries, is also aiming to make zero-energy buildings mandatory(by 2025) implementing various measures such as energy efficiency rating system and energy performance certification systems to gradually minimize energy consumption in buildings.
Most residential buildings of Korea are constructed using box frame using concrete walls as bearing walls and the formation of the structure is done by steel reinforced concrete. Legally obligated insulation design is mainly based on internal insulation structure with easy construction method. This design is constructed by installing an insulating material on the interior of structure. Rigid urethane with light weight and excellent waterproof property is most widely used as an insulating material in residential buildings. But rigid urethane insulating material has a concern of creating a gap when attached to the surface of concrete with uneven finishing surface due to lack of flexibility. In order to resolve such problem, this study intended to develop a complex insulating material. This material integrates an insulating material with a soft material, which acts as a buffer between the wall with uneven finishing surface and the insulating material.

KEYWORDS

Energy saving, Flexible insulating material, Airtightness, Reduction of condensation

1 INTRODUCTION

As environmental problems are coming to the fore throughout the world, diverse methods to minimize energy consumption in the construction sector, which takes up about 1/4 of total energy consumption, are being implemented. As in developed nations, Korea is also implementing various standards to minimize energy consumption in buildings. With the objective of obligating 2025 zero-energy building, energy consumption efficiency rating system and building energy performance certification system are being promoted to gradually minimize energy consumption in buildings. As a part of such methods, the law obligates buildings to have insulation design to cope with temperature changes during four seasons, regulating thermal transmittance of each part and thickness of insulating material in buildings. Most of buildings in Korea have reinforced concrete structure. Legally obligated insulation design is mainly based on internal insulation structure with easy construction method. This design is constructed by installing an insulating material on the interior of structure. Rigid urethane with light weight and excellent waterproof property is most widely used as an insulating material in residential buildings, and it is used together with stiffeners such as gypsum board and iron plate to compensate for fragility. Rigid urethane insulating material has a concern of creating a gap when attached to the surface of concrete with uneven finishing surface due to lack of flexibility. In such gap, thermal loss can reduce insulation performance and convection phenomenon may create an unpleasant environment with condensation and inhabitation of molds. In order to resolve such problem, this study intended to develop a complex insulating material. This material integrates an insulating material with a soft material, which acts as a buffer between the wall with uneven finishing surface and the insulating material.

2 DEVELOPMENT OF INSULATING MATERIAL

Most of insulating materials used in buildings are rigid flat type materials with lack of flexibility. There is a limitation in close construction when the material is being attached to the concrete surface. The condensation phenomenon which occurs in the gap between concrete and insulating material reduces insulation performance and can create an unpleasant environment with molds.

Figure 1: Examples of Condensation phenomenon

A soft part was added in rigid insulating material to prevent occurrence of such gap. Polyethylene with elasticity and waterproof property was reviewed as the soft part. Polyethylene is chemically and physically cross-linked foam having excellent thermal insulation, buffer effect, durability and chemical resistance. Due to its light weight and easy processing, polyethylene is being widely used in civil engineering, construction, automobile interior materials, and convenience goods. Structure and outer skin of the foam can be processed according to the use, and the material shows excellent formability. The material can be used semi-permanently because of excellent durability, and the independent foam material has low thermal conductivity and desirable thermal insulation. The foam particle with high modulus of elasticity allows reduction of negative energy, excellent dimensional stability after heating, and stable dynamic modulus of elasticity and loss factor. Accordingly, there is little concern of deformation after construction with passage of time. Also, the material is flexible and not crushed by impact, allowing close construction.

Figure 2 : soft and flexible polyethylene

Rigid urethane insulating material has low thermal conductivity and excellent insulation performance. Soft polyethylene has excellent adhesion, which reduces the condensation phenomenon occurring in the gap between the wall and insulating material. The form of complex insulating material that integrated soft and flexible polyethylene with rigid urethane insulating material is as follows.

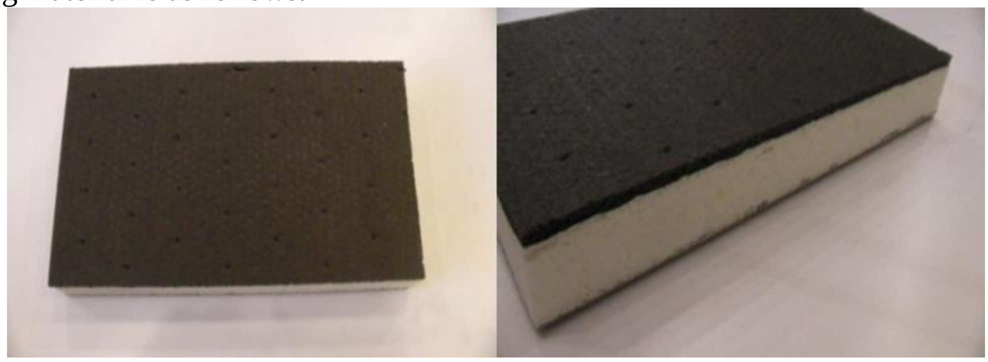


Figure 3 : The Developed insulating material

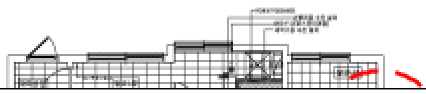
3 PERFORMANCE ASSESSMENT ON THE DEVELOPED INSULATING MATERIAL

To assess performance of the developed complex insulating material, insulation performance and occurrence of condensation were reviewed. Insulation performance assessment was conducted by comparatively analyzing thermal performance and heating load of the complex insulating material with air tightness and existing insulating materials using a computer program. For review of condensation, the developed complex insulating material was constructed in the condensed space to measure and monitor temperature and humidity.

3.1 Insulation Performance Assessment

For assessment of insulation performance, thermal performance and heating load were evaluated using a simulation program. The most general type of apartment house in Korea with the size of 84 ㎡ was selected as the simulation model, and the simulation program was based on Physibel and TRNSYS.

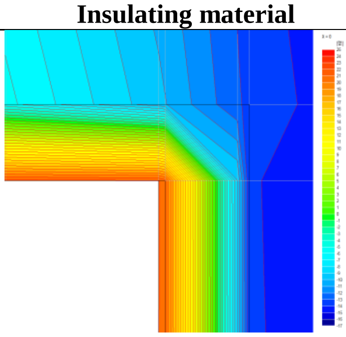
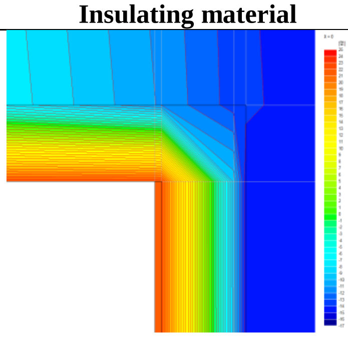
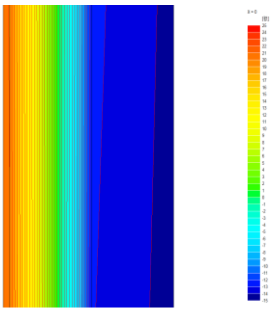
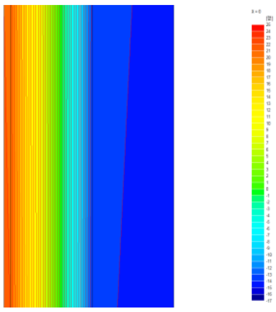
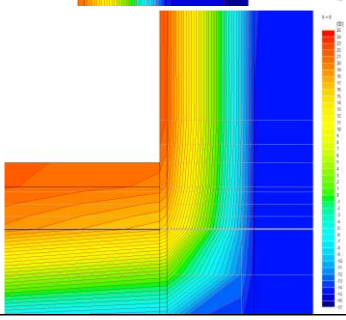
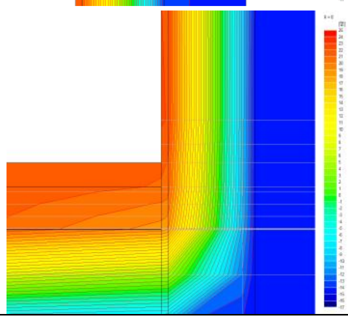
Table 1 : Simulation conditions

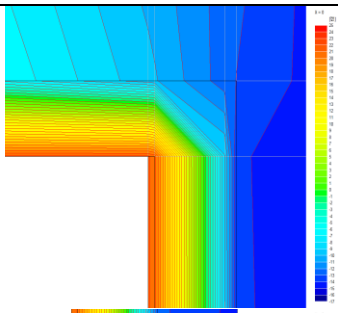
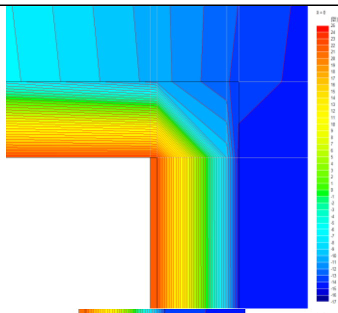
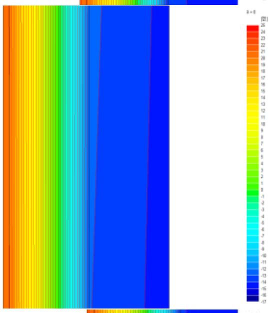
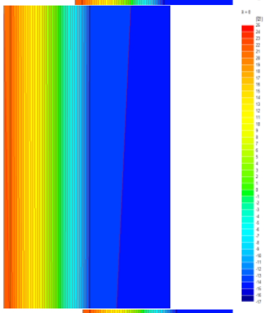
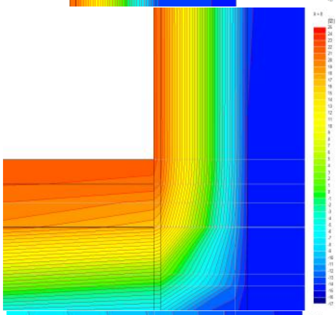
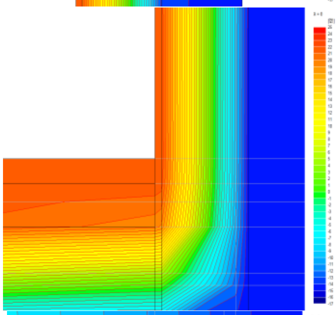
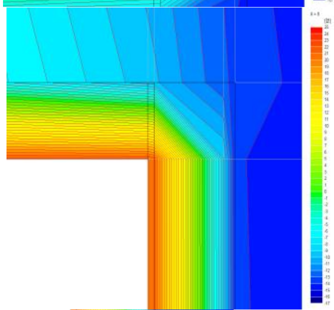
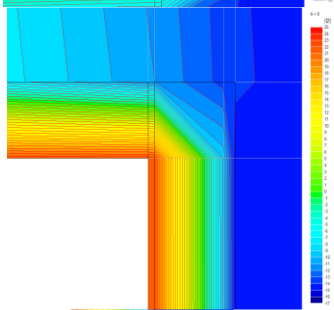
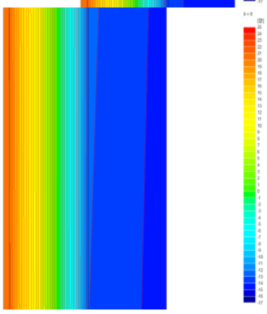
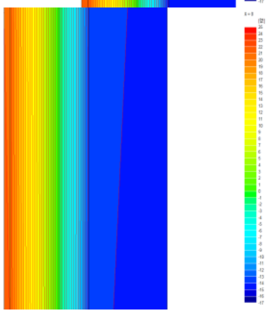
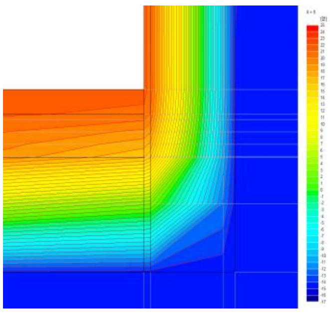
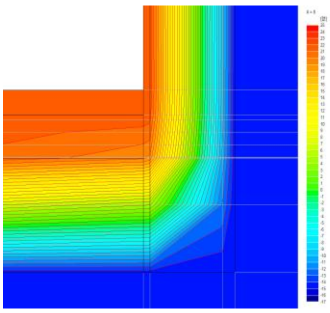
Model	Division	Design conditions
	Indoor Temperature	22℃

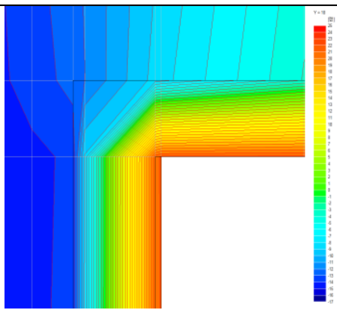
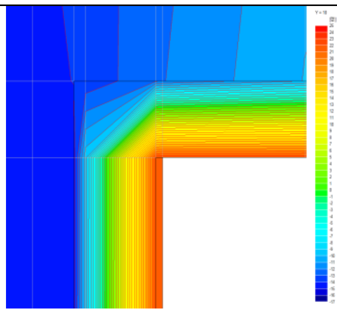
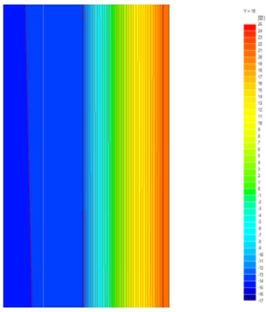
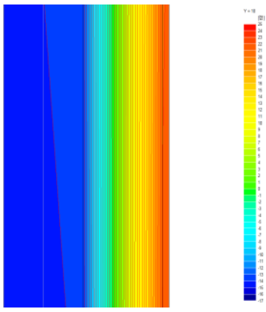
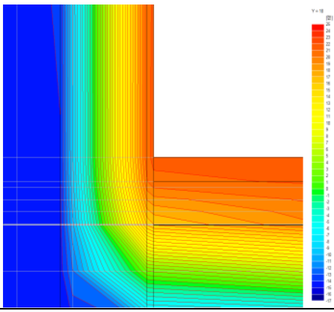
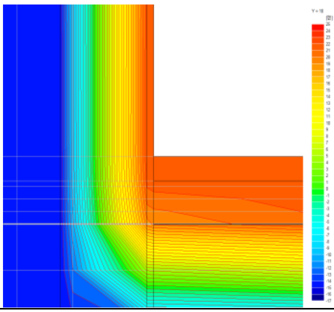
	Outdoor Temperature		15℃
	U-Value of wall	A	0.11[W/m·K]
		B	0.12[W/m·K]
		C	0.11[W/m·K]
		D	0.11[W/m·K]

For the thermal performance simulation, heat flow performance of existing urethane insulating material was analyzed first. The developed complex insulating material was applied to the same structure to perform thermal performance assessment on the uppermost, reference and lowermost floors. Performance of the developed insulating material was reviewed by comparatively analyzing the data obtained.

Table 2 : Simulation Results

Division		Urethane Insulating material	Developed complex Insulating material
A	**Uppermost Floor**		
	Reference Floor		
	Lowermost Floor		

B	**Uppermost Floor**		
	Reference Floor		
B	**Lowermost Floor**		
	Uppermost Floor		
C	**Reference Floor**		
	Lowermost Floor		

D	Uppermost Floor		
	Reference Floor		
D	Lowermost Floor		

As a result of simulating the uppermost, reference and lowermost floors of Cases A, B, C and D, construction using the developed complex insulating material compared to existing insulating material was interpreted to show a difference of about 1℃ to 1.5℃~1.8℃ on top of the uppermost floor, wall of the reference floor, and bottom of the lowermost floor. Accordingly, when insulating materials with same thickness are applied, construction with complex insulating material was found to reduce heating energy due to change in temperature of about 1℃~1.8℃.

Heat load of the developed insulating material was assessed. Using the same model as in thermal performance assessment, the type of insulating material in the wall configuration according to the building part (exterior wall, uppermost floor, lowermost floor, etc.) was differentiated to evaluate heating load of each household.

Table 3 : Simulation Results

Division	Heating Load		Reduction Effect	
	Urethane Insulating material	Developed complex Insulating material	Heating Load	CO_2 Emission
Lowermost Floor	8,702kWh	7,765 kWh	10.8%	12%
Reference Floor	6,422 kWh	5,883 kWh	8.4%	9%
Uppermost Floor	8,187 kWh	7,418 kWh	9.4%	10%

When constructed using the developed complex insulating material compared to existing insulating material, predicted heating load was reduced by about 10.8% for the lowermost floor, 8.4% for the reference floor, and 9.4% for the uppermost floor.

Therefore, when insulating materials with same thickness are applied, heating load was reduced by about 8~10% by constructing the building using complex insulating material.

3.2 Experimental Construction for Occurrence of Condensation

To examine occurrence of condensation, an experimental construction of existing insulating material and the developed complex insulating material was conducted on a balcony wall of an apartment house on which condensation frequently occurs during winter season due to low outdoor temperature.

After cleaning the wall surface, the insulating materials were attached to the constructed part using glue. The joint part of insulating materials was filled and straightening work was carried out.

Figure 4 : Construction Process

Occurrence of condensation was reviewed by measuring internal, external and surface temperatures.

Table 4 : Measuring Results

Division		Average Temperature
Outdoor		-3℃
Indoor		18℃
Wall	**Urethane Insulating material**	9.6℃
	Developed complex Insulating material	12.3℃

As a result of monitoring, surface temperature of the wall with the developed complex insulating material was higher than surface temperature of the wall with existing insulating material under same external temperature. In addition, while the wall with existing insulating material had its surface contaminated by condensation, the wall with the developed complex insulating material did not show occurrence of condensation.

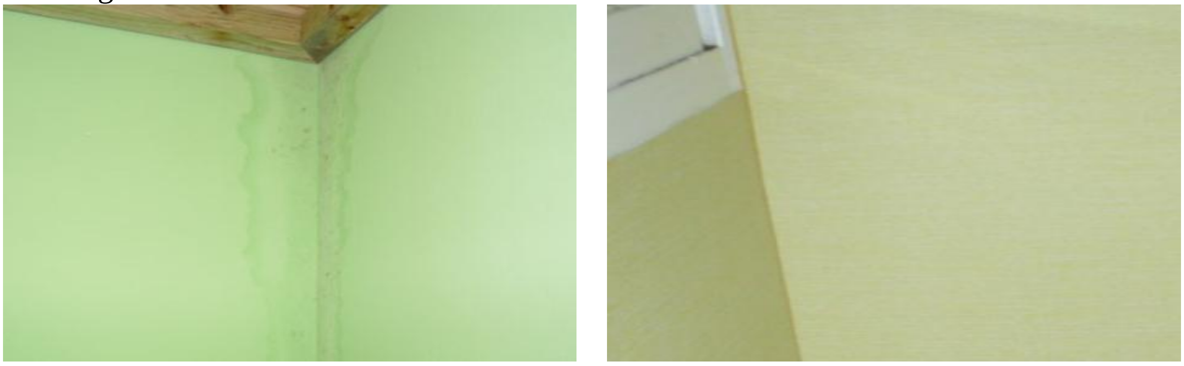


Figure 5 : Surface of Wall – Urethane Insulation material(left), Developed complex Insulation material(right)

4 CONCLUSIONS

In this study, a complex insulating material on which a soft part was added to a rigid insulating material was developed to secure air tightness between the wall and insulating material, and performance of the material was reviewed. To examine air tightness between the insulating material and wall, an energy analysis simulation based on computer program was performed for thermal performance and insulation performance of existing insulating material and the developed complex insulating material. Experimental construction and monitoring were carried out to observe occurrence of condensation, which can be caused by lack of air tightness. As a result of energy analysis simulation, thermal performance was improved compared to existing insulating material, and CO_2 emission was reduced by decrease in heating load. Also, as a result of constructing the complex insulating material to reduce condensation that occurs on the wall surface during winter due to difference in external and internal temperatures, the material was found to be effective in preventing condensation. However, since condensation occurs as a result of complex phenomena including temperature difference, humidity, lack of ventilation and defective construction, continued monitoring and additional experimentation on the constructed parts are deemed necessary to accurately verify performance of the developed complex insulating material.

5 ACKNOWLEDGEMENTS

MIN HEE SON, SI WOO LEE(YOUNGBO Chemical Co., Ltd.)

6 REFERENCES

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