The 2016 World Congress on
The 2016 Structures Congress (Structures16)
Jeju Island, Korea, August 28-September 1, 2016

Experiments on Compressive Strength of UHPC Applied for Thermal Break Insulator

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ABSTRACT

A thermal bridge is an area of a structure which has a significantly higher heat transfer than the materials closed by so that It is a main cause of condensation. To avoid condensation of structure and reduce energy losses, effective prevention is critical. Thermal brake insulator acts as a thermal barrier blocking this heat loss when placed between the floor slab and the wall. Therefore, structural function of thermal break insulator is important and UHPC (Ultra-High Performance Concrete) can be a good solution because of high strength the material has.

In this study, the compressive strength of UHPC was measured and compared to strength of normal mortar in order to apply UHPC for thermal break insulator that is invented to prevent thermal bridge. In the near future, most reasonable model of UHPC for thermal break insulator will be developed.

1. INTRODUCTION

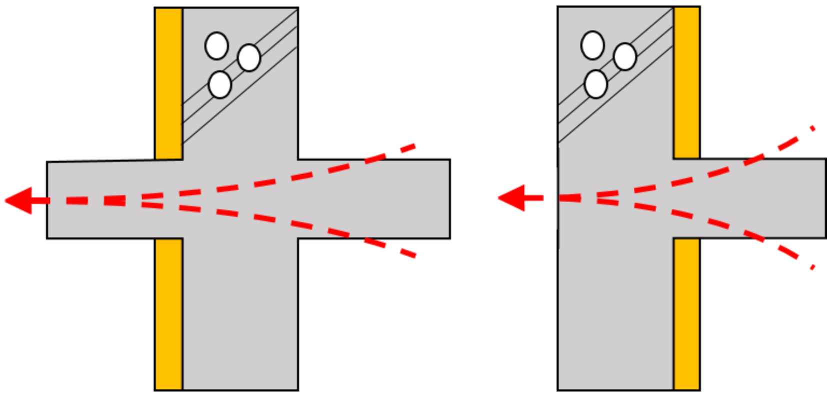

Fig. 1 Thermal bridge of slab

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Heat-insulation is an important component in house construction and the demand for buildings is increasing and it will grow more in the next years. There are several regulations covering different general guidelines that must be considered in order to decrease the energy demand in buildings. One of the main ones consists in increasing the insulation of the building envelope with the aim of minimizing heat losses. As a result, a proper treatment of thermal bridges becomes more relevant because their relative effect on the overall thermal demand of the building increases.

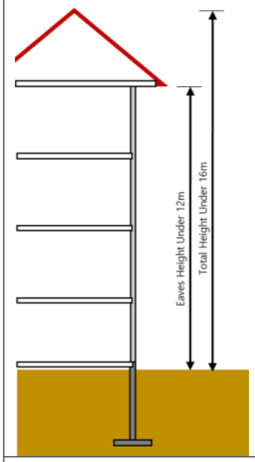
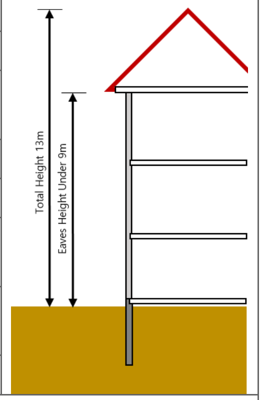
A thermal bridge is an area of a building which has a significantly higher heat transfer than the materials closed by. If one of the materials is more conductive, then the heat that would normally be confined within the building escapes, finding a path along the more heat conductive material. Some references spell it out with cold bridge but this research marked it as thermal bridge because the key role of insulator we studied is prevention of heat loss. One of the worst area of heat loss through a thermal bridge is where the floor cuts into the wall allowing heat to be transmitted to the outside. Because the surface temperature of the area thermal bridge occurs is relatively low, it is a main cause of condensation. To avoid condensation of structure and reduce energy losses, right understanding about thermal bridge and effective prevention is critical.

Thermal brake insulator acts as a thermal barrier blocking the heat loss. In this study, the thermal brake insulator with block shape which is used to increase the energy efficiency when placed between the floor slab and the wall. That is why the structural function of thermal break insulator is important and UHPC can be a good solution because of high strength of material. In that context, the compressive strength of UHPC was measured and the test results are compared to strength of normal mortar in order to assess the applicability of UHPC to thermal break insulator. The main goal of this project is to check the applicability of UHPC to thermal break insulator. Therefore, UHPC serves as durable element to protect the load-bearing from mechanical impact.

CODE STUDY

For the thermal break insulator, mechanical property of a product is essential. The insulator is used like a masonry block, the structural properties specified in the “Korean lightweight foam concrete block structure design criteria” had to be fulfilled in the construction design. Therefore, the compressive strength of UHPC had a direct relation to the mechanical property of the product. The compressive strength of the insulators according to the criteria is not to be less than 2.94Mpa. In case of more than two-storey masonry buildings, since the wall thicknesses of the first floor can vary with the other wall thicknesses, different types of thermal brake insulators must be used for each floors. Three compressive strength of a product were selected consulting the building code in this study so that It could be selected as compressive strength required or thicknesses.

Table 1 Structural design criteria for masonry walls [The Ministry of Construction and Transportation Notification No. 1997-376 Issue: lightweight foam concrete block structural design criteria]

- Compressive Strength – More than 30kg/㎠(2.94MPa)				
Structural Design		**Sort**	**Empirical Design Method (Without Structural Calculations)**	
	4floor belows	Floor	-	
	16m or less	Total Height	13m or less	
	12m or less	Eaves Height	9m or less	
	-	Basic Wind Speed	45m/sec or less	
	-	Min. Wall Thickness	200mm or less	
	h'/t (Max.)	**Wall**	**h'/t&L/t(Max.)**	
	20	Bearing Wall	20	
	18	Exterior Non Bearing Wall	18	
	36	Interior Non Bearing Wall	36	
	6	Cantilever	3	
* L : length between horizontal directional supports of wall , h' : effective depth of wall, t : effective thickness of wall				

2. MATERIALS AND METHODS

The Insulation used in this study is EPS based on expanded polystyrene of rigid cellular plastics thermal-insulation products sort no.2 with bead method for building thermal insulation according to KS M 3808. The UHPC used in this study was a variation of the basic mix of UHPC with a water/binder ratio of 0.23 and it has flowability of concrete exceed more than 250mm diameter with measurement tools presented in KS L 5111. That mix is used in several research projects at the Seoul National University. The dimension of specimens is 50mm*50mm*50mm.

Fig. 2 Insulation and Specimens with UHPC

Fig. 3 Mixing Process of UHPC

Fig. 4 Pouring and Curing Process

Several processes were performed to evaluate the mechanical property. Once preparing premix powder, it was mixed again with water and superplasticizer. When pouring was finished, curing had to be performed carefully. After pouring the UHPC, it cured 24 hours at room temperature, 20° degrees, and re-cured 72 hours at high temperature. High temperature curing of UHPC is performed in 90° degrees generally, but in this study, 60° degrees were used to high temperature curing in consideration of the deformation of the insulation at high temperatures. The interface between EPS and mortar was well-connected enough. The mechanical property tested was the compressive strength and the ratio of UHPC area needed to area of normal mortar was calculated with the test results. The compressive strength was calculated as the average value for the three specimens.

3. RESULTS

In order to increase the compressive strength, as well as, decrease the bulk of mortar several calculations with normal mortar and UHPC were performed (Table. 1). An influence of the different mortar to area was seen as a result.

Table 2 Comparison of Area Needed Between UHPC and Normal mortar

Mortar	Compressive strength of mortar (MPa)	Compressive strength of a product (MPa)	Number of mortar cylinder	Area of a cylinder (mm^2)	Mortar area (mm^2)	Ratio of mortar area (%)	Radius (mm)	Ratio of mortar area (%)	Ratio of radius (%)
Normal Mortar	35.80	6	20	502.73	10054.51	16.75	12.65	100	100
	53.71	9							
	59.67	10							
UHPC	190	6		94.74	1894.74	3.16	5.49	18.87	42.69
		9		142.11	2842.11	4.74	6.73	28.30	53.20
		10		157.89	3157.89	5.26	7.09	31.40	56.05

* Block Width:100mm, length:600mm, Product area:60000 mm^2

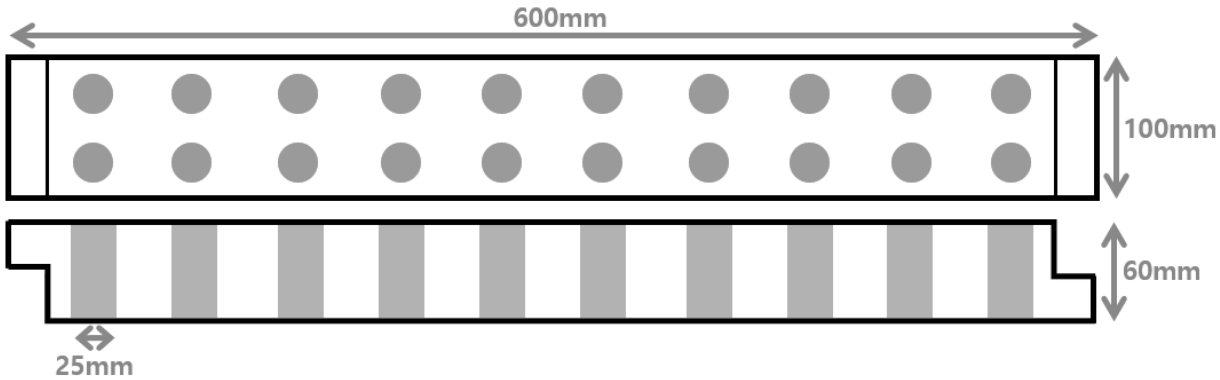


Fig. 3 Configuration of Thermal Break Insulator

The area of mortar is calculated with the simple calculation that is to divide ultimate load with compressive strength. Compressive strengths of a product were set up as 6,9,10MPa respectively, and all of it fulfill the Korean standard. Using UHPC instead of normal mortar decreased the area of mortar required about 70-81% and 44-58% of the radius of a cylinder is reduced when 20 cylindrical mortar is set.

4. CONCLUSIONS

The research showed that it is technically possible to manufacture thermal break insulator made with UHPC because UHPC has superior mechanical properties compared to normal mortar. Therefore, containing larger quantity of insulation, thermal break insulator with UHPC instead of normal mortar is more effective to reduce heat losses. And the compressive strength of product could be controlled by proportion of mortar and insulation. Furthermore, the study of thermal conductivity of thermal brake insulator UHPC applied has to be performed.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support of the Research Fund of the 2015 Agricultural Complex Activation Demand-Customized Technology Consulting Services Support Project by Korea Industrial Complex corp.

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