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The Energy Analysis and Evaluation of the NEO-Hanok

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ABSTRACT

Plenty of efforts have been made in the traditional architecture of Korea, Hanok, to develop various elements such as restoration, the introduction of new design, and energy-saving while systemic setups on standard and evaluation of eco-friendly energy design of Hanok are lacking. If we evaluate energy performance based on current standards without reflecting unique features of Hanok on the system, Hanok will be included in the very low grade among the residential buildings being included in the approval system of eco-friendly architecture or the unique features will be modified and the burden of increased construction cost. Therefore, this study is to prepare the basic reference for the introductory evaluation system by evaluating the energy performance level of NEO-Hanok based on the current building energy rating system.

The result for NEO-Hanok based on the building energy rating system, we propose the rating standard with scorecard elements of NEO-Hanok by considering the necessity of identity and standard for NEO-Hanok. As a result of infiltration test to check the tightness, it was measured as 10.81 times/h (50 ACH). As we switch from the main insulation for the wall from the glass wool 64k(0.035W/mk) to rigid polyurethane foam first class first unit (0.024W/mk), the result was slightly increased from the first demand quantity rating yield 249.8 kWh/㎡·yr to 235.0 kWh/㎡·yr. Current certificate system is focused more on the heating load than the cooling load, it is disadvantageous for Hanok, which has less cooling energy consumption in summer. The rating result from the target building study is level 4.

KYEWORDS

Building Energy Efficiency Rating System,
NEO-Hanok,
rigid polyurethane foam

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1. Introduction

1.1. Background and Purpose

Korean government announced a plan from 2017 to drastically enforce the design standard to decrease the heating and cooling energy consumption by 90% compared to 2009. Also, if you are, currently, using private funding for the construction cost related to the energy performance improvement, the Ministry of Land, Infrastructure, and Transport and Green Remodeling Creation Center are assisting in paying the interest.[1] This shows that Korea is also making an effort to reduce the green-house gases along with the trend all over the world. However, they are lack of systemic devices for eco-friendly design standard and evaluation for traditional architecture Hanok while tremendous efforts have been made nowadays to develop various factors in architecture including restoration, introduction of new designs, and energy reduction. Majority of current buildings evaluated by many eco-friendly buildings certificate system are made of concrete, plastic frame windows and doors, and good insulator that is weak for fire. Also, the level of infiltration must be in high level to obtain the certificate level. However, eco-friendly building certificate system run by the government is not considering the evaluation and certificate about Hanok. Unless unique features of Hanok get reflected in this system or they made a new energy performance standard for Hanok, Hanok will be graded in the low level in the category of residential buildings

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1) The Ministry of Land, Infrastructure and Transport, "Announcement of improvement plan for building energy", National Policy Mediation Meeting, 2014.3.13

included in the eco-friendly buildings certificate system in the future and unique features of Hanok will be damaged or the construction cost for Hanok will be high.

Therefore, the present study was designed to prepare the basic resources by evaluating the energy performance level of NEO-Hanok with the current building energy efficiency grade certificate ratings standard through the interpretation of building energy of NEO-Hanok.

1.2. Methods and Range

As you may see from the materials used in making Hanok, Hanok is the most representative house made of various organic matters and lumbar. However, current eco-friendly building certificate system in Korea evaluates based on the architecture made of modern insulation, doors and windows, machines, and concrete. Also, ventilation ratio of apartment buildings about infiltration is 0.7 per time, which gives hard time for Hanok to meet this standard. This evaluating method is disadvantageous for Hanok to maintain the eco-friendly construction techniques. Therefore, we are to make basic resources for evaluating standard on NEO-Hanok after evaluating the changes in performance based on partial elements based on the energy efficiency ratings certificate system standard for buildings, which is one of the actively effective eco-friendly certificate systems in Korea. The steps for the study are as follows.

First, consider the possibility of evaluation for NEO-Hanok by analyzing the evaluation standard, definition and purpose of the energy efficiency ratings certificate system standard for buildings, which is one of the actively effective eco-friendly certificate systems in Korea.

Second, establish the concept of NEO-Hanok and set the standard for evaluation as an evaluating object.

Third, select the target building, and analyze the influence of evaluating items (insulator, doors and windows, infiltration, shading angle, maintenance) by evaluating the energy performance level within current system of the building.

2. Energy efficiency rating certificate system for buildings

2.1. Definition and purpose of certificate system

Energy efficiency rating certificate system for buildings, a system for the value of the buildings to be recognized and provided with objective information such as energy performance and quality based on the composition of environmental architecture, started with the purpose of providing fresh internal environment and economic effects through energy saving by providing objective and accurate information about the energy used in the building to save energy.[2] Also, eco-friendly certificate system to expand the cognition about energy saving and investment on energy saving techniques.

2.2. Certificate standard and ratings

Based on the 2013-248 notification by the Ministry of Land, Infrastructure, and Transport, energy efficiency ratings certificate ratings for buildings are divided into total 10 ratings as shown in <Table 1>, and it is composed of residential buildings and non-residential buildings. Residential buildings are houses and apartment buildings (except for dormitory), and non-residential buildings are the buildings except for residential buildings.

Total primary energy supply is a result reflecting the correction factor by use, and it may be different from the actual total primary energy supply.

2.3. ECO2(evaluation tool for building energy)

ECO2 (evaluation tool for building energy) is a certificate evaluation tool for building energy efficiency ratings developed by applying international standard such as ISO 13790 with the base of DIN V18599. It is a

$$\text{Primary energy requirements per square meter} = \frac{\text{Heating energy requirements}}{\text{Floor area of heating energy}} + \frac{\text{Cooling energy requirements}}{\text{Floor area of cooling energy}} + \frac{\text{Hot water heating energy requirements}}{\text{Floor area of hot water heating energy}} + \frac{\text{Lighting energy requirements}}{\text{Floor area of lighting energy}} + \frac{\text{Ventilation energy requirements}}{\text{Floor area of ventilation energy}}$$

Fig. 1. Building energy efficiency rating standards

2) Korea Energy Management Corporation, “Introduction of certificate system”www.kemco.or.kr, 2014

Table 1. Certified Ratings

rating	Residential Buildings	Non-Residential Buildings
	Per unit area per year Primaryenergy requirements (kWh/㎡·year)	Per unit area per year Primaryenergy requirements (kWh/㎡·year)
1+++	Less than 60	Less than 80
1++	60 - 90	80 - 140
1+	90 - 120	140 - 200
1	120 - 150	200 - 260
2	150 - 190	260 - 320
3	190 - 230	320 - 380
4	230 - 270	380 - 450
5	270 - 320	450 - 520
6	320 - 370	520 - 610
7	370 - 420	610 - 700

program, produced to evaluate overall about the heating, cooling, hot-water supply, lighting, and energy of ventilation as <Table 1>, performs interpretation of semi-normal status using Monthly Calculation Method as a basic evaluation logic. You may input Building shapes, HVAC system, and renewable energy systems, then calculate the energy demand by using regional monthly average weather data[3]. Calculated results are the annual total primary energy supply per unit area.

3. Consideration about NEO-Hanok

3.1. Definition of Hanok

According to the 2nd amendment 16th article, the definition of the building act enforcement decree 『 "Hanok"is a structure of wooden pillars, beams, and roof trusses. Hanok is architecture and annex with Korean traditional methods finished with Korean roof tiles, rice straws, lumbar, and soil.』 Hanok means architecture built with our own traditional techniques and styles from the prehistoric time. It means 'residential house' in a narrow scope, and 'entire Korean traditional architectures in a broad scope. However, every region adapts different ways of defining 'Hanok' as shown in <Table 2>. This is because each region evaluates different main points in the definition of Hanok.

Table 2. Hanok by local law[4]

law & ordinance (traditional style)	roof tile	struc ture	beauty	mater ial
Goryeong	○		○	
Seoul, Suwan, Gyeongju, Jeonju	○	○	○	
Wanju	○	○	○	○
Damyang, Goheung, Yeongam, Jangseong, Hampyeong	○	○		○
Yeoju, Muan, Jeonnam, Gangjin, Gokseong, Gwangyang, Gurye, Naju, Mokpo, Boseong, Sunchun, Sinan, Yeonggwang, Wando, Jangheung, jindo, Haenam, Hwasun, Kyungnam	○	○		

3.2. Concept of NEO-Hanok

As the standard of living in modern society has got higher, more people want to enjoy their leisure time. Hanok, which is made of classical grace and dignity and eco-friendly materials, has high level of satisfaction from the customers. Last year, more than 5 million visitors visited Jeonju Hanok Village, so there was a shortage of lodgings.[5] It shows tremendous interest in Hanok from Koreans and foreigners because you may experience traditional atmosphere of Korea from Hanok. However, since Hanok is a form of timber house, it is very cold in winter and you have to put up with inconvenience of living due to a number of columns. Also the expensive construction cost as much as average KRW 10,000,000 to 20,000,000 per 3.3㎡ is a big burden to regular consumers. Therefore, the Hanok made up for these faults is called modern Hanok, green Hanok, NEO-Hanok, improved Hanok, or city type Hanok. Among these names, the contest exhibit promoted by National Hanok Center and the Korean Housing Corporation run by Korean government is calling it as Neo-Hanok. Thus, the naming for the new form of Hanok is being decided as NEO-Hanok. Therefore, NEO-Hanok is the universal name for the Hanoks with modification in modern society. Even if NEO-Hanok is a form of timber house, massive production is possible due to the developed modern technique, and reduction in cost has been brought by weight reduction of the materials, modern insulator and doors and windows. Also, using the boilers instead of floor heating system, convenience of winter heating system is

3) Kwonjanghyeok. "Comparison on the Annual Energy Demand by Building Energy Assessment Tool and Dynamic Energy Simulation" 2012

4) Jeonbonghee, "Definition and Scope of hanok" 2011

5) Kimkwangoh, "The power of Hanok Village", 2013

achieved. Therefore, NEO-Hanok is a modern house, and a part of modern architecture.

3.3. Setting the range of NEO-Hanok

The standard for selecting rating objects in domestic certificate system is based on the number of homes and total floor area. However, setting the standard to get NEO-Hanok involved in the certificate system needs to be approached from different aspect from the existing rating standard. Since NEO-Hanok is a form of architecture, if NEO-Hanok is an object building in selecting the rating objects in eco-friendly certificate system for NEO-Hanok. Also, it is not a problem of use and magnitude but form. Thus, setting the objective standard to determine what kind of houses are NEO-Hanoks to get NEO-Hanok involved in the certificate system and classify NEO-Hanok as a separate rating object. Understanding on the feature of NEO-Hanok is necessary to make right and objective decision about the standard. NEO-Hanok is a combination of traditional Hanok and modern architecture. As you can see from <Fig.2>, as the percentage of traditional Hanok elements gets bigger, the building is closer to Hanok and as the percentage of modern architecture gets bigger, the building is closer to modern architecture. Looked at from that point of view, if certain portions of traditional Hanok elements and modern architecture combine together, they are defined as NEO-Hanok. However, we need a method to draw a clear line in rating system through quantifiable analysis. Therefore, the standard to determine if it is NEO-Hanok based on the ratio is as follows.

1) Select the characteristic elements to classify the traditional Hanok from Modern architecture, separately.
2) Decide independent score for the selected elements.

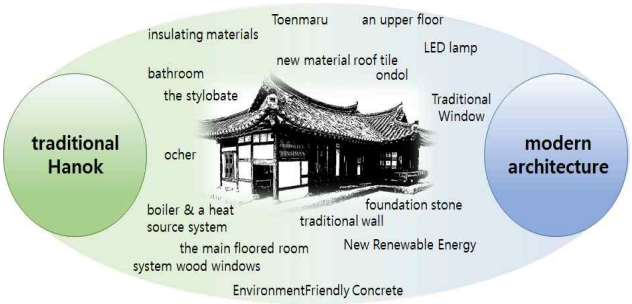

Fig. 2. Combination of elements of the NEO-Hanok

3) Determine if it is NEO-Hanok based on the total calculated points.
4) Even if the object meets the standard points, it will be eliminated from the rating objects for NEO-Hanok unless it meats the essential basic elements.

3.4. Evaluation for selecting object building for NEO-Hanok

Set the range in following 3 categories and provide the detailed items and accordant point to determine the rating objects for NEO-Hanok.

1) Essential basic elements

Essential basic elements are selected 3 elements that should be included in NEO-Hanok. The first is wooden structure. Wooden structure means major structural part is made of woods. The standard to classify houses is based on the major materials that support the weight of the building. Hanok is a wooden structure made of pillars, beams, and cross beams. If major components of Neo-Hanok were made of concrete, it would lose the unique feature of Hanok, which is wooden structure. Therefore, it is one of the essential items. The second element is the form of traditional shape of roof in Hanok. In modern architecture, we use light-weight new material Korean roof tiles instead of mud and Korean soil roof tile to reduce the roof weight, with lead to the reduction of roof weight and construction time, tremendously. However, if the type of roof is modified, it is hard to keep the unique atmosphere of Hanok. The reason why the type of roof has not been modified even if the plane floor has been changed due to the modern life patterns is related to the above. Therefore, changes in materials are acceptable but the type of root must be included in the range of traditional Hanok. The third basic element is to obtain the tightness. Tightness is an essential performance element must be included in the building with thermal control. Buildings with poor tightness bring a big load of heating and cooling system. However, Hanok is a building made of organic matters. Therefore, it gets humid and affects bad influence on the maintenance unless enough ventilation is secured. Therefore, a study is performed to find the minimal number of infiltration in Hanok to set the standard. Thus,

we did not apply tightness of 0.7 times/h, which is applied during the current preliminary certification, but we actually performed tightness test and evaluated actural tightness as a standard.

2) Elements of traditional Hanok

we have selected 8 elements that are considered important in terms of composition of Hanok, which are Ondol (Korean floor heating system), the main floored room, traditional wall(wall line, lintel, more than 90% total wall line area), the stylobate, foundation stone, traditional window(more than 90% of traditional window area), ocher (more than 60% of total wall line area(, and floor (toenmaru, an upper floor). 1 point is given for each element.

3) Elements of modern architecture

We have selected elements eco-friendly, high efficiency in reducing energy for the elements of modern architecture. The components are new renewable energy, modern bathroom, environment friendly concrete, LED lamp (more than 90% of total light energy consumption), insulating materials, system wood windows, boiler and a heat source system, and new material roof type. The characteristics of these components are selected in 8 detailed items, and total 8 points are given.

If the total score is beyond 5 points out of 8 points, it is considered that the house is enough to function as a traditional Hanok and modern dwelling.

<Table 3> is the scorecard elements of NEO-Hanok by summing up the contents above.

Table 3. Scorecard elements of NEO-Hanok

The necessary basic elements		
	Division	Score
1	wooden structure	Pass
2	traditional Hanok roof	Pass
3	air leakage	Pass
Three kinds must pass		
traditional Hanok		
	Division	Score
1	ondol, Korean floor heating system	1
2	the main floored room	1
3	traditional wall	1
4	the stylobate	1
5	foundation stone	1
6	Traditional Window	1
7	ocher	1
8	floor(toenmaru, an upper floor)	1
Total (above the 5 score)		8
modern architecture		
	Division	Score
1	New Renewable Energy	1
2	bathroom	1
3	EnvironmentFriendly Concrete	1
4	LED lamp	1
5	insulating materials	1
6	system wood windows	1
7	boiler & a heat source system	1
8	new material roof tile	1
Total (above the 5 score)		8

4. Object building

4.1. Selecting object buildings

Myungji University built Hwagyungdang as a research business run by Myungji University with the support from the Ministry of Land, Infrastructure, and Transport from 2010 to improve brand value and performance with reduction of construction cost. As people have different tastes on dwelling, newly improved traditional Hanok called 'NEO-Hanok' is being introduced. For the generalization of NEO-Hanok, NEO-Hanok should secure the generalization of NEO-Hanok through the reduction in construction cost and succeed traditional style of Hanok.[6] Hwagyungdang is the most well known building that is introduced to the public as one of the most recent project that the government is promoting for the study of NEO-Hanok. The use of Hwagyungdang is classified as a meeting and cultural facility, but it is expected that flat ground makes it possible to live in there and double storied structure puts more utilization in the building. Also, it is just a demonstration for the study. Therefore, it shows easy access to obtain the information for the construction, which makes it as a target building.

4.2. Outline of target building

4.2.1 Outline of the building

The name of rating object building is Hwagyungdang (target building from below). It is located in Seoul, Eunpyung-gu, Jindwan-dong, 125-29, and being used as a meeting and cultural facility. It is composed of 361.68㎡ of

6) Kimwangjik, "Construction report of experimental hanok(Mock-up)", 2012 pp. 56~64

lot area, 71.10㎡ of building area, and 142.2㎡ of architectural area.

Fig. 3. Target building Foreground

4.2.2 Rating methods

<Table 4> is the scoreboard of certification object proposed in this study for NEO-Hanok. After evaluating the certification objects based on <Table 4>, if they meet essential basic elements, and scored 6 points in traditional Hanok elements and 5 points in modern architecture, they are considered as rating objects of NEO-Hanok.

4.3. Conditions for simulation

The target building is located in the central areas, and has a full south aspect. It has the gambrel roof with ㄱshape floor plan in 2 different floors. In terms of area of evaluation, 1st floor is composed of bedroom (10.8㎡), bathroom (3.6㎡), living room and kitchen (32.13㎡), stair room (3.96㎡), utility room(5.94㎡), and dining room and tearoom (8.91㎡). 2nd floor is composed of total 13 rooms, which are bedroom (18.72㎡), bathroon 2 (4.32㎡), room (8.64㎡), stair room (3.96㎡), bathroom(3.96㎡), temporary kitchen and aisle (13.68㎡), and loft (17.82㎡). The loft on the 2nd floor is a lantern ceiling with exposure of rafters, and the rest is finished with ceiling. The height for 1st floor is 2.4m, 2nd floor is 2.22m, and the loft for 2nd floor is 2.9m. The heat source equipment is gas boiler, and the efficiency of the boiler is 91.1%. Cooling system has not been installed. After the infiltration test through the blower door test of the target building, it is estimated as 10.81 times/h.

The material property of the target building was set as

Table 4. Scorecard per element of the Target building

The basic elements necessary		
	Division	Score
1	wooden structure	Pass
2	traditional Hanok roof	Pass
3	air leakage	Pass
Three kinds must pass		
traditional Hanok		
	Division	Score
1	ondol, Korean floor heating system	
2	the main floored room	
3	traditional wall	1
4	the stylobate	1
5	foundation stone	1
6	Traditional Window	1
7	ocher	1
8	floor(toenmaru, an upper floor)	1
Total (above the 5 score)		6
modern architecture		
	Division	Score
1	New Renewable Energy	
2	bathroom	1
3	EnvironmentFriendly Concrete	
4	LED lamp	
5	insulating materials	1
6	system wood windows	1
7	boiler & a heat source system	1
8	new material roof tile	1
Total (above the 5 score)		5

Table 5. Component-specific properties of the target building

type	material	(mm)	(W/m·K)	(㎡·K/W)	(W/㎡·K)
wall A	cement board	9	0.58	0.0155	0.246
	plaster board	12.5	0.21	0.0595	
	glass wool 64K	70	0.035	2	
	cellulose	70	0.04	1.75	
	ocher	12.8	0.173	0.0740	
wall B	cement board	9	0.58	0.0155	0.407
	plaster board	12.5	0.21	0.0595	
	glass wool 64K	75	0.035	2.1429	
	ocher	12.8	0.173	0.0740	
wall C	cement board	9	0.58	0.0155	0.414
	plaster board	12.5	0.21	0.0595	
	glass wool 64K	75	0.035	2.1429	
	plaster board	9.5	0.21	0.0452	
floor	cement mortar	57	1.4	0.0407	0.222
	air entrained concrete	100	0.19	0.5263	
	pressing out heat reserving board	100	0.034	2.9412	
	PE film*2	0.16	0.21	0.0008	
roof	tiled roof	50	0.75	50	0.336
	plywood	35	0.15	35	
	glass wool 64K	89	0.035	89	
win	argon Low-e double glass Window	solar Energy Transmission Ratio:0.522			2.1
win	double glass window	solar Energy Transmission Ratio:0.696			2.8
door	wood door				2.4

<Table 5>. Most of wall composition and the size of doors and windows were set as the actual working drawing, and applied the specifications of windows used in residential buildings. The components that are not recognized in the program or influencing the thermal transmittance value were excluded and analyzed it by replacing it with average performance values.

4.4. Floor plan[7)]

<Table 4> and <Table 5> are the floor plans for the target building. Even if the use of the target building is a cultural and meeting facility, it is considered as modern residential design with undetached bathroom and kitchen.

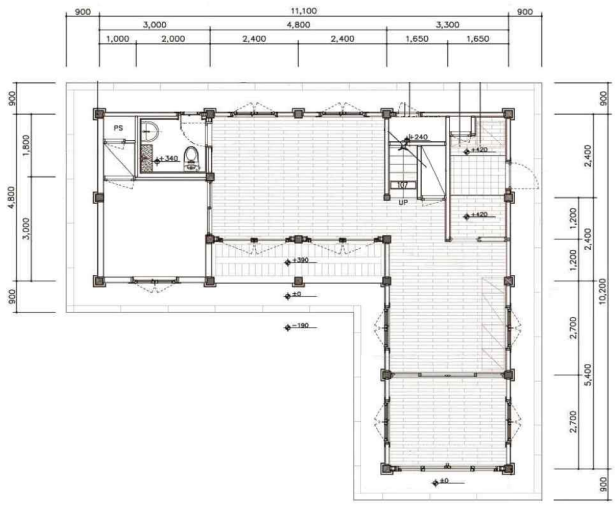

Fig. 4. 1st Floor Plan

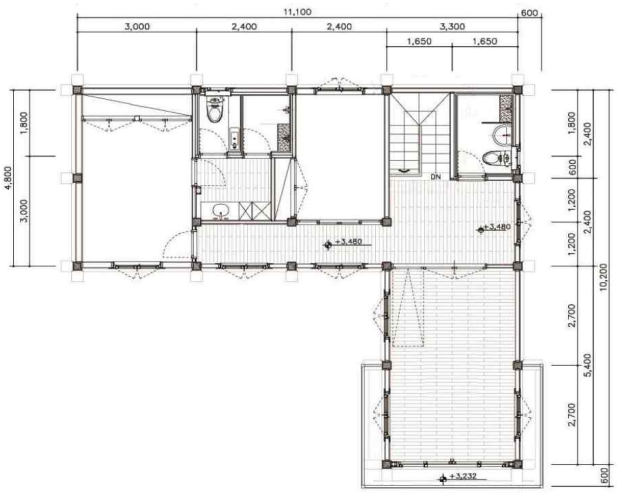

Fig. 5. 2nd Floor Plan

5. Evaluation result of energy performance

5.1. Evaluation of energy performance for target building

The results of energy simulation through ECO2 are as follows.

<Table 6> is the analysis result for monthly heating and cooling energy demand. Y-axis represents energy demand, Monthly heating and cooling energy demands were high from November to March, and January shows the highest energy demand. Since cooling system was not installed, cooling energy was not calculated.

<Table 7> is a graph shows annual energy demand and requirements by adding the renewable, heating, cooling, hot water, lighting, and ventilation. Based on the fact that heating energy takes up the biggest energy consumption, most energy consumption is on the heating. The energy

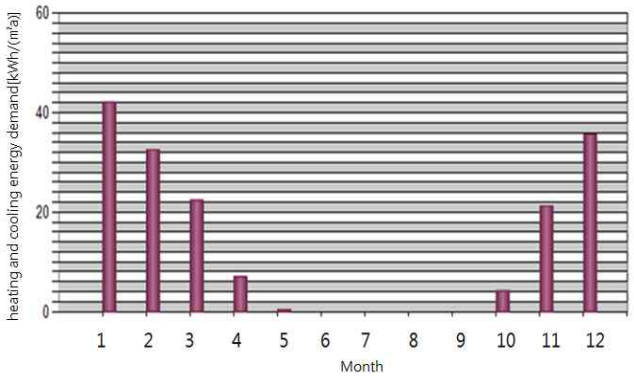

Fig. 6. Monthly heating and cooling energy demand

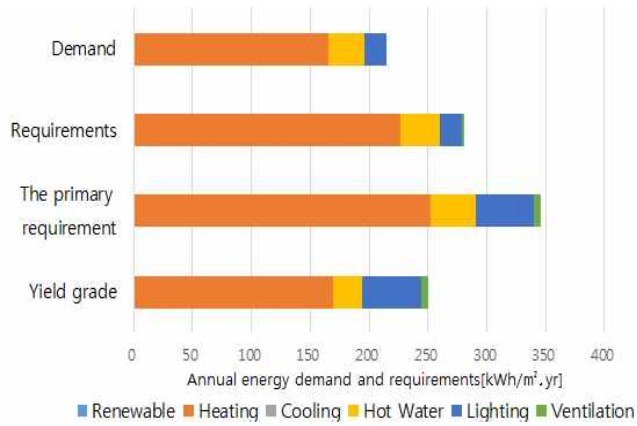

Fig. 7. Annual energy demand and requirements

7) Demonstration Hanok, research topic for Hanok techniques development at Korea Agency for Infrastructure Technology Advancement, (Resource : Myunji University School of Architecture Hanok technique development research team, 2014)

Table 6. Annual energy demand and requirements per type[kWh/㎡·yr]

type (energy)	Demand	Requirements	The primary requirement	CO_2 emissions	rating calculation amount
Renewable	0.0	0.0	0.0	0.0	0.0
Heating	165.7	226.6	252.5	46.3	169.0
Cooling	0.0	0.0	0.0	0.0	0.0
Hot Water	30.7	33.9	37.6	6.9	25.1
Lighting	18.3	18.3	50.2	8.6	50.2
Ventilation	0.0	2.0	5.5	0.9	5.5
Total	214.7	280.7	345.8	62.7	249.8

load and the demand quantity for lighting has no fluctuation. However, since the total primary energy supply had a tremendous increase by the primary energy conversion factor, the demand quantity for lightning was the highest following heating energy.

<Table 6> is a diagram shows overall analysis on the demand, requirements, the primary energy requirement, CO2 emissions, and rating calculation amount. The rating calculation amount calculated from the primary energy requirement by reflecting the modification factor is 249.8kWh/㎡·yr, which is grade 4 according to the rating of target building. Among these items, heating energy takes up approximately 67.7% of the total energy followed by 20.1% lighting, 10% hot water, and 2.2% ventilation. Since cooling system and renewable energy equipment were not installed, accordant loads were not generated.

5.2. Estimation of infiltration of target building

We estimated infiltration by using the Blower Door Test. Infiltration (ACH50) shows ventilation numbers when ± 50Pa is generated inside the building. The air volume is CFM50(ft^3/min) and define the value after checking it in 1 hour and divide it by internal volume. As a result, the infiltration ratio of entire volume except for the loft (family room) was 10.81times/h. In case of the loft (family room) had high volume of leakage, which made it impossible to estimate for not having the value 50Pa inside and outside. Based on the fact that all the windows and composition of the walls are identical, the lantern ceiling is the reason for the leakage.

Fig. 8. Blower Door Test

5.3. Analysis result by elements of the target building

We performed energy interpretation evaluation to find the influence of changes on the factors that affect energy performance based on the result of the energy performance analysis of the target building according to the changes in insulators, windows, infiltration, heating and cooling system, and renewable energy, and the results are as follows in <Fig 9> and <Fig7>.

A shows the old performance result, rating calculation

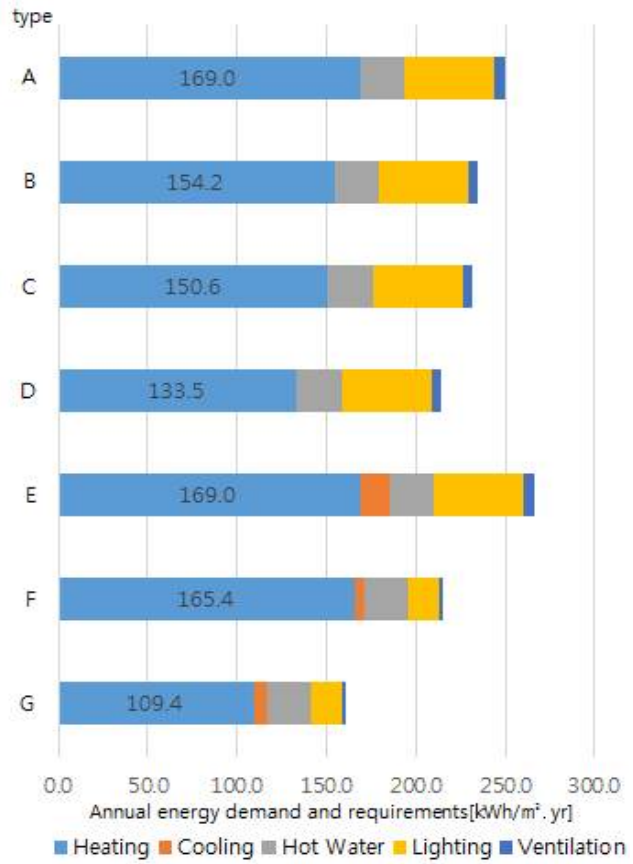

Fig. 9. Annual energy demand and requirements

Table 7. Change in performance by type

type	change point	rating calculation amount[kWh/㎡·yr]	existing performance comparison
A	before change state	249.8	0%
B	insulating material	235.0	5.9%
C	window	231.4	7.4%
D	air leakage	214.3	14.2%
E	air conditioner	266.0	6.5%
F	E + New Renewable Energy	214.8	14.0%
G	B + C + D + F	160.8	35.6%
H	awning	139.3	33.5%

amount for the primary energy is 249.8kWh/㎡·yr, which is level 4.

B is the result by switching the wall insulator from glass wool 64k to hard urethane heat reserving board 1st class No.1. As a result by checking the performance of pure insulator under non-insulation circumstance, heating load increased by 212.8% from 169kWh/㎡·yr to 528.7kWh/㎡·yr, which showed 609.5kWh/㎡·yr of rating calculation amount (primary energy consumption).

C is the value that uses argon Low-e 12mm quadruple layered window in the previous double layered window. For the various experiments, we removed entire window surface area, and make it only with the wall. As a result, it slightly increased to 234.8kWh/㎡·yr.

D is the result by applying 1.5 times/h, which is increased from the previous infiltration (ACH50) 10.81 times/h.

E is the result after installing the air conditioner (cooling capacity 20.46kW).

F is the result value graph after installing renewable energy (solar energy) to reduce the heating load and the cooling load from the addition of the cooling equipment. Module area for solar energy is 23㎡ with 45°tilt, and a contact type mono-crystal. The point of compass is due south. As a result, energy consumption decreased by 19.25% compared to the method E with the cooling equipment.

G is the result from applying all the methods from B~F. As a result, it is level 2.

H is the analysis result how the length of eaves affect the cooling and heating energy performance. Heating energy was increased by 11.7% from 109.4kWh/㎡·yr to 122.2kWh/㎡·yr and cooling energy was decreased by 52.5% from 6.7kWh/㎡·yr to 3.2kWh/㎡·yr after changing the length of eaves by increasing the entire horizontal shading angle. However, actual amount of increase compared to entire energy performance was increased by 9.3kWh/㎡·yr in heating energy.

6. Conclusion

In this study, we analyzed the possibility of introduction of eco-friendly building certificate system by interpreting energy after selecting the target building and setting the standard of decision for NEO-Hanok as a fundamental research for the building energy efficiency rating certificate system for NEO-Hanok. The results are as follows.

1) As types of NEO-hanok get various, identity and standard for NEO-Hanok is essential to introduce NEO-Hanok in the objects of energy efficiency rating certificate system. Thus, we propose score board of Hanok and modern architecture by elements.

2) Evaluation result of the target building through the energy efficiency rating certificate system is level 4 since calculated rating amount is 249.8kWh/㎡·yr by reflecting the modification factor from primary energy consumption amount.

3) The result by switching the wall insulator from glass wool 64k (0.035W/mk) to hard urethane heat reserving board 1st class No.1 (0.024W/mk slightly increased by 5.92% from 249.8kWh/㎡·yr to 235.0kWh/㎡·yr.

4) As a result of Blower Door Test to estimate the infiltration of the target building, the loft (family room) on the 2nd floor appeared to have infiltration. The reason for the infiltration is that the ceiling of the loft is a lantern ceiling that has an exposed rafter unlike other rooms.

5) The eaves of traditional Hanok bring tremendous energy reduction effect. Current evaluation systems focus on the heating load. However, a certain part of electric load during summer season is the cooling load takes up considerable portion. Based on current standard, as the length of eaves gets longer, cooling load gets decreased but the heating load gets increased with a bigger ratio. This result is considered that the cooling load of eaves of Hanok was not considered in the calculation.

In this study, a certain portion of composition in

Hawgyungdang simulation conditions by replacing the materials with general performance for generalization. Therefore, the performance of Hwagyungdag on the result is slightly different from reality. In later studies, it is considered that the studies on the energy performance rating must be performed to supplement these limitations.

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