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A Process of Value Assessment for Building Components of Hanok Residence

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***Abstract*— This study focuses on a process of Value Engineering (VE) for Hanok, Korean traditional residence, and its major building components. The purpose of this study is to support designer or builders with objective clues for decision-making by VE, especially when a preliminary design needs changes and feedbacks for the next steps toward design development and/or construction processes. For this research, Hanok elements were reviewed first in overall, and six major components have been selected for performing VE analyses: wall, roof structure, Giwa that is Korean traditional roof tiles, openings, Ondol that is Korean traditional floor-heating system and fence system. The wall system among those was used for a target to be examined in this paper, because this element affects the value of Hanok mostly in aspects of function and cost. For this research, popular applications using Information and Communication Technologies (ICT) such as Green Building Studio (GBS) have been utilized for simulation for value assessment. With VE analyses, it is turned out that the performance level of Hanok elements can determine its quality and this process will support objective data with concrete database to be used throughout the building process including design, construction and maintenance phases. Also, it would be possible that designer can make decision quickly by offering necessary plans and element details, while builder would be able to reduce cost and shorten construction period by the whole VE process.**

Keywords*— *Korean Traditional Residence; Value Engineering; Management; Simulation; Sustainability

I. Introduction

Recently, Korean traditional residence called Hanok is being taken for great attentions with many advantages in aspect of the beauty, the environmental sustainability, its eco-friendly, and so on. Because of those reasons, Korean government is planning a few national projects to supply demands of users. Nevertheless, Hanok construction is not yet systematic, since its building process tends to depend on constructers' experiences and old customs. So, it is nessary to implement objective databases and standards for value assessment to make decision easily during the design and construction processes. This paper aims to suggest a process of Value Engineering (VE) process to be applied to Hanok building elements.

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Through the procedure, a database for value evaluation can be constructed, and designers and constructers may use it in case preliminary planning needs changes, quantity of construction materials are required to be exactly expected, any sudden decision-making should be performed, and so on. The construction period and cost can certainly be reduced by taking alternative decisions in timely manner.

This study focuses on VE process during the design step, although normal VE is used for the whole construction phases. As the research background, previous researches about Hanok elements are reviewed to find the target for performing VE, and the wall system, one of the most important elements in Hanok, has been chosen for value evaluation.

Figure 1. Overall Flow of the Study

As the first step to apply for a VE process to the wall system, SketchUp, a 3D modeling software, has been used to make a Hanok model, and the target for this was selected from a real unit built at the Eunpyeong district in Korea. Then major factors for VE such as energy efficiency including monthly/annual energy demand and energy cost are with multiple simulations by Green Building Studio (GBS).

TABLE I. ANALYSIS TOOLS AND TARGET FACTORS

Tools	*Factors*
Sketch Up	3D Modeling Factor Detail
Green Building Studio	Monthly/Annual Energy Demand Energy Cost

This paper will review a VE evaluation report as the simulation results including energy demand and cost in comparison of traditional mud wall and redeemed wall system. Designer or constructer can refer to report for preliminary plan alterations by the process.

II. Concept of Value Engineering

A. *Background Study*

VE is a systematic method to improve the 'value' of goods or products and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. It is a primary tenet of value engineering that basic functions be preserved and not be reduced as a consequence of pursuing value improvements.[1]

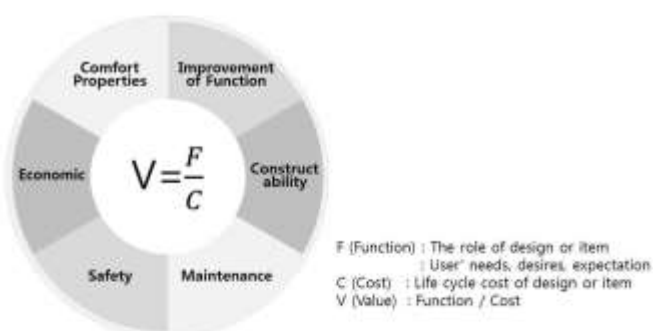


Figure 2. Concept of Value Engineering

In architecture, VE process consists of pre-study phase, analysis phase, and implementation phase. Pre-study phase is a step that task-performer receives a project and arranges the information for the next step. On analysis phase, VE information decided in the previous step is used to make alternatives by using systematic processes and application methods, and evaluations are proceeded after that. Implementation phase is carried out by establishing a detailed plan that contents generated in the previous step are to be applied to design and systematic decision-making. Information acquired from VE analyses is accumulated and can be used for other projects using VE process in the future. VE in the design area, one of the value engineering scopes, is performed by experts to check design contents especially about economic feasibility and validity on the actual field with functional and alternative indexes.

In sum, VE toward architectural design is consecutively carried out through preliminary planning, design implementation and alteration steps. Ultimately, the purpose of design VE pursues improvement of project value and it needs organized efforts in aspects of cost and time, and other qualitative points of view as well.

B. *Effect of Value Engineering Process*

Design value assessment is one of VE processes for architectural projects. In this step, a digital spatial model for rating qualities is normally made by 3D tool and it helps expert find further necessary information and details for the design process. 3D models also enable expert to examine designs thoroughly and manage a field of construction and maintenance as the following businesses.

For example, Department of Transportation in the United States of America has applied a variety of design VE projects, and they includes 282 SOC (Social Overhead Capital) projects in 1996 with the subsidies by U.S. government and 1083 policy suggestions, and it counts 4 VE suggestions per project in average. Before the design VE, the presumed cost was 6.2 billion and 12million dollars, but after the design VE, it was significantly decreased to 5.6 billion and 368 million dollars. Finally, the cost could be saved for 10%.[2]

So, value engineering in the design process may offer high possibility to make better alternative designs and can accept change of other things, because the final design and the whole contents of the project are not yet decided. It is assumed that VE in the design stage is more effective and has possibility to reduce cost than the construction phase.

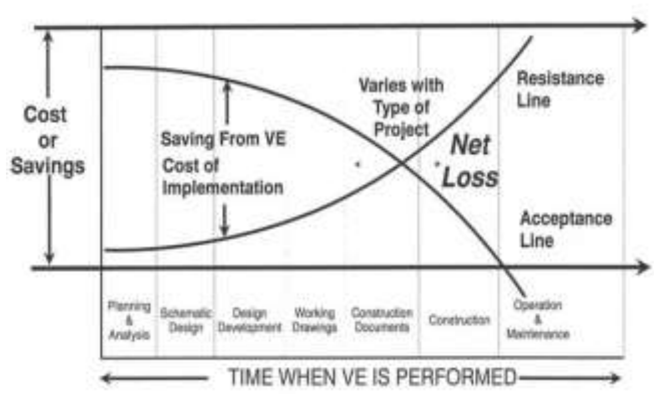


Figure 3. Effect of Value Engineeing

[1] Cooper, R. and Slagmulder, R., Target Costing and Value Engineering, 1st Ed., Institute of Management Accountants, 1997.

[2] Dongil Architectural Technology Laboratory in Korea, Value Engineering Practice, Construction Book, 2010.

III. Proposed Process of Value Engineering for Hanok

A. *Evaluation Factors for Hanok*

Hanok is different from western housing in terms of structure, space organization and major design components. Korean governmental research institutes and laboratories have studied about its elements to prove its values with objective data. Hanok VE process is difficult to define, because Hanok consists of many factors and those specialties. The primary factors were studied to estimate design VE on Hanok.

The major components for Hanok are classified under 6 elements such as wall, roof structure, Giwa that is Korean traditional roof tiles, openings, Ondol that is Korean traditional floor-heating system and fence system.

TABLE II. EVALUATION FACTORS FOR HANOK

		
Wall	Openings	Ondol
		
Roof structure	Giwa	Fence system

Especially, its wall system has a role as the façade of modern buildings and occupies a main portion of Hanok elements. So, wall system was selected as the target to proceed design VE and it is expected to indicate differences from cost of other factors.

B. *Application of Value Engineering Process to Wall Systems*

Design VE process is composed of the following procedures: survey, design VE analysis, function analysis, performance score deduction, cost index deduction, and VE assessment. From survey to performance score deduction is a scope of the evaluation associated with design plans which is comparative to prevenient contents, and evaluation phase is from cost index deduction to value engineering. In this study, VE process was carried out from cost index deduction to VE assessment phase focusing on cost according to energy efficiency.

Cost means total cost occurred in building life cycle and it contains all the costs on production, operation, destruction, and so on. There are some methods to calculate life cycle cost such as present value, year value, and last point value. One of the most correct method is present value that is converted from the future value, and this enables to calculate expecting cost into the present value. This method contains regularly and irregularly recurring costs occurred from building every year. In this study, the present value has been used to estimate building life cycle cost for 40 years by applying analyzed energy performance data.

Hanok factors were simulated by GBS and performance evaluation for elements were operated to estimate energy consumption into cost. GBS used for this study is made by Autodesk and it is a flexible cloud-based service that allows user to run building performance simulations to optimize energy efficiency and to work toward carbon neutrality earlier in the design process.

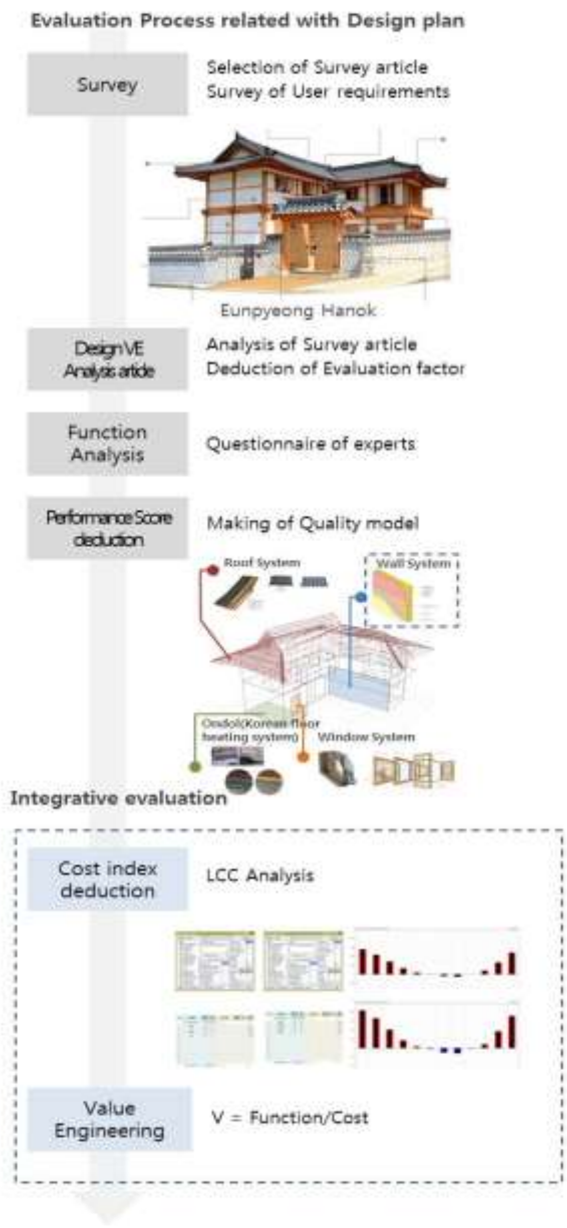


Figure 4. Value Engineering Process for Hanok

C. *Value Assessment for Wall Systems of Hanok Residence*

A traditional wall system and a newly developed wall system were used as basic forms for the comparative study. Eunpyeong Hanok was chosen to simulate VE factors. Because buildings can be measured by taking only one factor for the assessment, it is needed to select any indoor element or system which is composed of roof, floor, and wall. The original wall has advantages in eco-friendliness, while new wall system has high energy performance.

TABLE III. SIMULATION INFORMAITON

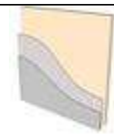
No.	VE-1
Area	Eunpyeong Hanok
Plan No.	-
Type	Cost Reduction
Function	Energy Performance Improvement
Suggestion Type	F : Maintenance of Function C : Cost Reduction
Factor	Traditional wall system
	New wall system

VE Evaluation shows that new wall applied with cost-reduced type is better than traditional wall in aspects of energy performance and cost. Table IV shows how monthly or annual energy demands are presented in the value of cost, and it can be useful data for designers who often try to change their design alternatives.

TABLE IV. TRADITIONAL WALL SYSTEM

Factor		*New wall applied with new system*			
		 High-heat transmission coefficient			
Performance Score		-			
Cost	Monthly Energy Demand (Wh)	Jan	4477982	Jul	487080
		Feb	3539899	Aug	606670
		Mar	2195968	Sep	44710
		Apr	924289	Oct	483257
		May	213029	Nov	2041833
		Jun	72560	Dec	3809618
	Annual Energy Demand	18,897,092 Wh (139,483 Wh/m^2)			
	Annual Energy Cost/m^2	12,790 (KRW)			
	LCC/m^2 (40 Years)	-			

TABLE V. NEW WALL SYSTEM

Factor		*Traditional wall*			
		 Environment friendly			
Performance Score		-			
Cost	Monthly Energy Demand (Wh)	Jan	11330803	Jul	710557
		Feb	8865204	Aug	960061
		Mar	5829052	Sep	11750
		Apr	2817692	Oct	1712723
		May	861570	Nov	5402821
		Jun	46499	Dec	9777249
	Annual Energy Demand	48,325,980 Wh (356,702 Wh/m^2)			
	Annual Energy Cost/m^2	56,570 (KRW)			
	LCC/m^2 (40 Years)	-			

On the other hand, it is turned out that traditional wall systems need 2.5 times more energies every month than new wall system, and maintenance expenses per year was getting increased by almost 5 times. It means that better building components can lead to achieve much more benefits in aspects of the lifecycle cost (LCC). Finally, it is proved that appropriate VE can reduce building construction period and cost with designers' decisions in timely manner as shown on Figure 5.

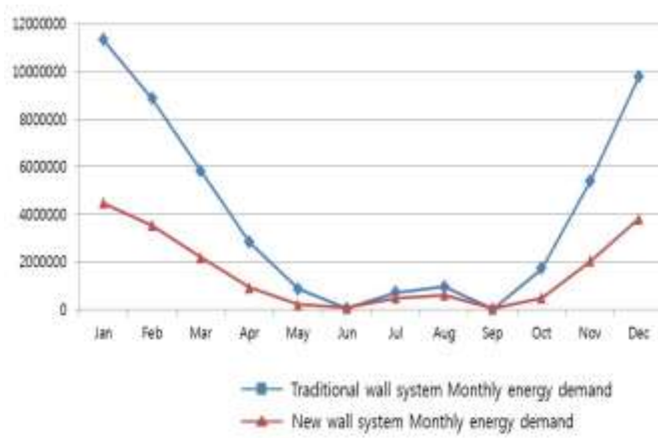


Figure 5. Monthly Energy Demand

IV. Conclusion

The purpose of this study is to suggest a prototype standard of Hanok evaluation by VE process to help designer or constructor to make decision quickly base on its results. Software programs such as GBS was used to come out objective data, and modeling data is able to offer building information when experts try to change or maintain building elements by comparing cost data reports.

A traditional wall system and a newly developed wall system were used for comparative VE analyses. The original wall has environmental advantages, while new wall system has high energy performance with economic strengths. In addition, it is proved that appropriate VE can lead to reduce building construction period and cost effectively.

Future study will include other residence elements of Hanok, and more building types such as office, residence and convenient facilities. More supporting VE processes will make Hanok to have best qualities in design and construction, and guidelines for environmental and/or spatial planning would be more systematical.

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