Development of an Eco-Value Engineering Support System

Sun-Im Kang[1] , Jong-Hyeob Kim[2] , Mi-A Jung[1], Chang-Taek Hyun[3] and Sangwon Han[4]

[1] Master Student, Dept. of Architectural Engineering, University of Seoul, Seoul, Korea
[2] Ph. D. Candidate, Dept. of Architectural Engineering, University of Seoul, Seoul, Korea
[3] Professor, Dept. of Architectural Engineering, University of Seoul, Seoul, Korea
[4] Assistant Professor, Dept. of Architectural Engineering, University of Seoul, Seoul, Korea
Corresponding to jhkim80@uos.ac.kr

ABSTRACT: A number of urban renewal projects are currently being implemented around the world. Current project management tools are limited in effectively dealing with numerous issues regarding management of these projects (e.g., simultaneous execution of multiple projects). As an effort to address this deficiency, an Intelligent Program Management Information System (i-PgMIS) was developed for effective management of urban renewal projects. The i-PgMIS is a web-based system consisting of various modules including cost management, schedule management, risk management, change management, eco-value engineering (EVE) and so on. Based on the recognition of increasing awareness of creating sustainable built environment, this paper focuses on the EVE module that can support eco-value analysis at program-level management. The EVE module is expected to enhance value and sustainability of construction processes throughout the whole 'program' lifecycle and further to support program feasibility study based on life cycle costing.

Keywords: Value engineering, Urban renewal projects, Program management, Environment-friendly

1. INTRODUCTION

Urban renewal (UR) projects have been actively implemented worldwide in recent years to revive the quality of the residential environment of underdeveloped cities. UR projects are generally characterized for a great amount of capital expenditure, a long-term project duration and simultaneous execution of multiple projects [1]. Because of these characteristics, current project management tools and methodologies have limitations in effectively managing UR projects since these tools and methodologies mainly deal with a single project. Thus, an enhanced approach is required for program-level management (i.e., multi-projects management). The program management should be able to handle conflicts that may result from various stakeholders having different perspectives and interests. Thus, it is an important issue to set priorities among various management functions and processes throughout the whole 'program' lifecycle.

To this end, the authors developed a program-level management system, called Intelligent Program Management Information System (i-PgMIS) to effectively and efficiently manage UR projects. The i-PgMIS is a web-based system consisting of various modules necessary for the execution of UR projects including schedule management, risk management, performance management, change management, contract management, e-manual, conflict management, eco-value engineering and so on.

Meanwhile, with increasing awareness of global environmental problems, more and more people pay attention to sustainable built environments and green building. Particularly in Korea, project owners are increasingly asking their contractors to deliver high-quality projects in both cheaper and more environment-friendly manners. However, given that Korea has a limited number of environmental certificates/regulations and experts in this area, it is challenging to identify an environment-friendly alternative that can meet or exceed the owners' expectations.

Value engineering (VE) can be an effective tool to find a more valuable alternative (e.g., more environment-friendly or more economical construction process). However, existing VE tools lack applicability to program-level management because of its characteristics which are quite different from those of project-level management as previously discussed.

To address this deficiency, the authors developed a system called 'eco-value engineering (EVE)' support system that can facilitate the environmental value analysis at program-level management.

2. LITERATURE REVIEW

2.1 Status of Urban Renewal Projects in Korea

Currently, in Korea UR projects are being performed in up to 1,162 districts. Among them, 392 districts – 38.1% of the entire number – already completed their UR projects. The number of districts where UR projects are still processing is just 248 – 9.7% of the entire number of the districts. 522 districts – approximately 52.2% of the entire number – even do not initiate UR projects yet.

`

Those states of UR projects described above can be represented as Table 1.

Table 1. Status of UR Projects in Seoul, Korea

	Number of districts	Area (1000 m2)	New construction (units)
Completed			
- Korea	392	16,387	315,917
- Seoul	361	15,580	301,402
In progress			
- Korea	248	15,925	228,460
- Seoul	93	5,600	91,583
Planned			
- Korea	522	40,221	483,139
- Seoul	155	11,454	177,849
Total			
- Korea	1,162	72,533	1,027,516
- Seoul	609	32,634	570,834

Source:LHC(2011)

As shown in Table 1, UR projects in progress or planned account for a significant proportion. There are a variety of reasons for this status of the UR Projects. Most likely reasons for it are: conflicts due to complex concerns of participants, inefficient working process, mixture of private and public development sectors, and lack of efficient management techniques.

In order to perform a successful UR Projects by 2020, the Seoul Metropolitan Government announced standards of the expansion and examination of the areas where are scheduled to be renovated. Especially, with the proposal of promoting the completion of the projects in non-performed districts, the Seoul Metropolitan Government plans to expand UR Projects while focusing on strengthening the publicity [2].

2. Green Value Engineering and Value Engineering System

With use of an improved AHP method, Qian and Shoufeng studied examination of green construction alternatives [3]. Abdulaziz investigated a way of getting synergistic effect between value engineering and sustainable construction [4]. Song conducted a study about green VE to examine eco-friendly elements such as land use, transportation, energy, materials and resources, water resources, air pollution, maintenance, ecological environment and indoor environment [5]. Jang conducted a research on creation of CO_2 emission basic unit database as well as development of calculation procedures from green VE development stage, while performing calculation of CO_2 emission basic unit based on both frame construction's standard of estimate and the detailed statement [6].

Vickers studied about the system engineering which can systemically reflect value engineering change proposals [7]. Park explored web-based VE supporting system which can be efficiently used for various participants in workshops [8].

Table 2. Literature Review

Category	Author	Content
Eco-friendly Value Engineering	Qian and Shoufeng (2008)	Evaluation of green construction alternatives based on value engineering
	Abdulaziz (2009)	The synergy between value engineering and sustainable construction
	Song (2011)	Development of the first prize model and suggestion of the checklist in certification systems for project architecture and green building
	Jang (2012)	Calculation of CO_2 emission basic unit of frame construction, and creation of CO_2 emission basic unit database as well as development of calculation procedures from green VE development stage
Value Engineering Support System	Vickers (2008)	A system engineering approach to value engineering change proposals (VECP)
	Park (2009)	A web-based VE supporting system for VE facilitators and members in VE workshops

2.3 Existing development of the function PMIS and PgMIS

In this study, for the efficient management of large projects such as UR Projects, major technologies which are used for program management are analyzed. At the same time, PMIS and PgMIS which is mainly utilized for project or program management in the United States is examined first. As for such systems, there are software A, software B, software C and software D developed by company K. Table 3 arranges the analysis result of the previously mentioned systems as well as the main features of i-PgMIS

As shown in Table 3, the main features of the existing developed system can be identified. Moreover, these features can be compared to the main functions included in the i-PgMIS. On the one hand, asset management, facility management, energy management and etc. are not included in the functions of i-PgMIS. On the other hand, performance management, conflict management, EVE and etc. are the included modules of i-PgMIS.

Table 3. Comparison of Software & i-PgMIS

Category		Software A	Software B	Software C	Software D	i-PgMIS
Scope of Application	Project	●		●	●	●
	Program	●	●	●		●
Module	Planning	●	●	●		●
	Contract Mgmt.	●	●			●
	Cost Mgmt.		●	●	●	●
	Schedule Mgmt.	●	●	●	●	●
	Document Mgmt.	●	●	●	●	●
	Change Mgmt.	●				●
	Business Process Breakdown Structure		●			●
	Electronic Approval	●		●		●
	Dashboard		●	●		●
	Etc.	BIM Interconnection Export to MS Office		Asset Mgmt.	Facility Mgmt. Energy Mgmt.	EVE Performance Mgmt. Conflict Mgmt.

3. i-PgMIS

3.1 Components of i-PgMIS

For managing program efficiently, i-PgMIS consists of the program portal creation & control system, the program portal system, the stakeholder's system, the UR web center. Fig 1 shows the components of i-PgMIS.
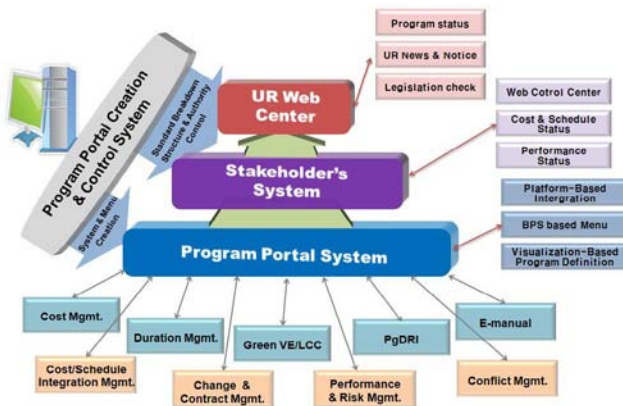

Fig 1. Components of i-PgMIS (Source [10])

The program portal creation & control system is a system customized to convenient management of each project whose characteristics are different with each other. With this system, management modules can be freely selected, depending on the characteristics of individual projects. The module can manage standard classification system, menu creation, interface with unit systems, authorization control, document form and so on. It enables the selection of project type and procedure module within plug & play method. At this point, plug & play method can be used according to the system user's requirements, after creating program portals.

`

The program portal system, which is based on platform, is mounted with the modules in sub-category systems such as cost and duration management.

For UR projects with the various participants, the system for participants is developed for obtaining information about program status and management of the program that are processed by subject.

In the UR web center, overall search is available in the matter of the status of implementation of program, including cost of the entire ongoing project and program schedule. Also, the status of implementation of projects is managed in the UR web center. Although UR projects are increasingly implemented, the information related to UR is separately provided. As the need for stakeholders' participation in program increases, program -briefing capability which enables an easy access to information is required. The UR web center was developed in order to meet such needs, and offers a whole list of projects that are currently in progress (Fig 2).

Fig 2. The UR web center of i-PgMIS

3.2 Function of i-PgMIS

As confirmed in table 1, i-PgMIS consists of the detailed systems which function in various ways. These detailed systems are: technicians who are needed for programs management, cost management system, duration management system, risk/performance management system, electronic manual and conflict management, EVE and change/ contract management system.

Table 4. Function of i-PgMIS

Category	Major System
UR Project Management System	UR Web Situation Room
	System of Generating/Managing Program Portals
	System for Participants
Program Portal System	Schedule/Organization/Community Management System
	Electronic Manual/Conflict Management
	Visualization-Based Program Definition System
	Standard Categorization System and System
	Cost and Duration Estimation/Management System
	Risk and Performance Estimation/Management System
	Contract Management System
	Change Management System
	Document/Information Management and Electronic Payment System
	EVE Support System
	PMIS Connection System

First of all, as a major functional system, cost & duration management system provides the predictive ability in the early stage of project, so that it functions to manage efficiently cost/duration information at every single stage of project. In particular, through the step-by-step management of project implementation as well as the project progress management, the system plays a role in management of the status related to cost and duration.

In i-PgMIS, estimation and management of project cost and duration are carried out with the following steps – estimation of construction cost and duration with use of CBR (Case Based Reasoning) method, prediction of cost on the initial stage of project s by entering a small handful of information, and enforcement/progress management based on urban renewal working process. Within these steps, the estimated result on cost is provided through cash flow. Thus, it can support the user's decision making. It also functions as a system of managing progress of each working process and of managing cost implementation according to establishment of plan for cost implementation.

Next, change & contract management system systematizes a working process to manage efficiently

`

various changes in costs, duration and so on.

Risk/performance management system is linked to working process, while PgDRI(Program Definition Rating Index) is associated as a risk factor. PgDRI is generally used as a standard for project value and prediction, within the performance measurement module of the performance management system that supports step-by-step performance estimation and management.

4. ECO VALUE ENGINEERING SUPPORT SYSTEM

4.1 Eco Value Engineering and Its Characteristics

Reflecting the size of a project, step-by-step characteristics and so on, EVE system possesses different modes so as to make the work more efficiently. In doing so, this system enables i-PgMIS to manage and provide various information about cost DB information linkage, existing practices DB, related materials, document management, communications and so on. Additionally, for making VE experts work in comfort, the system undertook feedbacks of practitioners, which would be reflected on the research implementation. Based on the feedbacks, the initial model of the system was improved again and again, so that it finally constitutes UI. Furthermore, as analyses of AHP, LCC and so on were facilitated, approach to VE became convenient and easy.

4.2 Eco Value Engineering and Its Constitution

EVE largely consists of an UI that shows the purpose for environmental certification, the progress and the overview and status of menu and project. The relevant detailed screen is shown in Fig. 3 In the menu, the user can choose one among the buttons for project management, preparation phase, analysis phase, execution phase, document management and community (see ① of Fig 3). Through each category on the menu, the user can conduct overall VE. Next, the user can determine overview of project, status of project and the goals (see ② of Fig 3). The overview of project can be edited on the project management menu. Also, the user can see the progress and the status. If the user clicks the relevant icon, he or she will be also able to go to the appropriate step and perform VE.

Fig 3. Eco Value Engineering Support System and Its Constitution

4.3 Eco Value Engineering and Its Major Functions by Step

EVE is a web-based standard system which can be utilized as a tool for information sharing, maximizing information application and facilitated communication. It establishes a collaborative system at work and a real-time processing system for cross-functional workers participating in one working stage.

Table 5 organizes the step-by-step key features included in EVE.

Table 5. Eco Value Engineering Support System and Its Major Functions by Step

Step	Major Feature
Input of project information	Input of project information on a new project; Creation of a list of ongoing project(s); and, selection of project phase and mode.
Preparation phase	This step consists of goal setting, team organization, schedule establishment, model analysis, object selection and information collection.
Analysis of functions	This step provides functional DB according to the kind of facility, project space and part. The user can organize listed functions in the drag & drop manner. Project's major functions are determined based on evaluation and analysis result.
Materialization and evaluation of created ideas	It contains a search function for ideas. If the user selects the Green VE mode, the ideas related to eco-friendly themes will separately appear.
Development	This step shows the number of selected idea(s) by sector and it suggests analysis status and progress rate. If the user inputs renewal or exchange duration, he or she can analyze LCC.
Suggestion and announcement	This step contains the report function.
Execution and follow-up measures	According to status of being selected, this step provides a list of ideas.

4.3.1 Project Overview

When a project is created, EVE system can reflect the characteristics of the project. Depending on the size of the project, a program mode or a project can be selected (see ① of Fig 4). In the case of selecting the program mode, the user can use the combination/operation function to manage a number of programs by grouping them. Also, the user can select the Green VE mode that considers eco-friendly elements (see ② of Fig 4). The Green VE mode suggests guidance for Green buildings. At this point, the kind of project can be selected according to the facility (see ③ of Fig 4). And, a specific phase of the project can be chosen (see ④ of Fig 4). Suggesting proper

solutions that should be considered along with characteristics of a particular project, this system can help VE experts.

Fig 4. Project Overview UI

4.3.2 Goal Setting and Feedback

Setting a goal of the project is important to the success of the VE performance. For setting the goal, you can input cost, function and value so as to evaluate improvement degree (see ① of Fig 5). Moreover, when you select a desired scheme to obtain an eco-friendly certification, it is possible to set a target score according to certification systems (see ② of Fig 5). In doing so, the user can be supported for personal ideas that meet the specific goal.
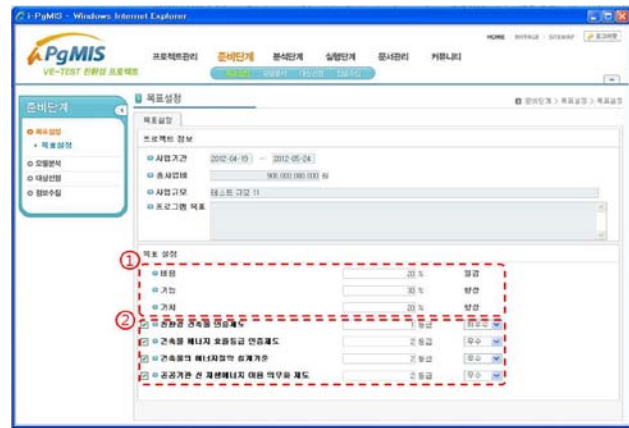
Fig 5. Goal Setting for Preparatory Step UI

The user can check the level of performance compared to the original goal in the meantime of VE performance. The user can determine the degree of the user's completion of the original goal in advance, as comparing it to target score. Then, the user can analyze it (see ① of Fig 6).At this stage, both target score and completed score are provided according to eco-friendly certification schemes. Thus, even participants who lack of knowledge about eco-friendly affairs or products can acknowledge the result easily (see Fig 6).

Fig 6. Degrees of Completion of Goals in Comparison with Original Target UI

4.3.3 Information Offer upon Eco-friendly Laws and Regulations

With EVE, it is possible to search ideas of practices that are similar to selected project. Letting the user to enable to search ideas related to a specific keyword, EVE supports a creation of a new idea (see ① of Fig 7). When Green VE mode is selected, it is also possible to use the search function for ideas about relevant practices. Here, eco-friendly ideas are separately displayed at the same time. Thus, the user can receive proper guidance. Moreover, official schemes dealing with eco-friendly ideas, which are associated with personal idea and other detailed information about laws, are provided too (see ① of Fig 7).

Fig 7. Information Offer upon Eco-friendly Laws and Regulations Target UI

4.3.4 Checklist Offer

At the designing/planning stage, VE project selects a particular object. At this point, a checklist is provided for the object selection. This checklist includes RFP basic configuration items that are needed for VE performance. Also, there are the items that have been frequently changed for basic and practical design VE due to some RFP errors (see Fig 8).

Fig 8. Analysis Phase of Searching Ideas UI

In addition, with this system it is possible to analyze the analyses on AHP, LCC, LCA and so on. The progress status is displayed step-by-step, so the VE performance and management can be systemically conducted.

4.4 Eco Value Engineering Support System and Its Expected Effect

Compared to other processes for existing VE/LCC analysis, EVE will reflect eco-friendly elements at the program level. It will also provide VE/LCC supporting tools. It is assumed that EVE will systemically organize the domestic eco-friendly certification affairs and their working process according to existing laws and regulations. In doing so, it helps understanding of step-by-step working process for the participants who join large-scale and complex programs including UR projects. Consequently, EVE will support actual administrative affair management. Furthermore, it is expected that EVE will contribute to environment problem, that is, one of the significant global issues. In addition, while various projects are going through the design and construction stages, EVE will be able to support stable management of cost which is based on VE. As a result, reduction of the expenses will be possible.

5. CONCLUSIONS

Recently, sustainable UR projects have been actively conducted around the world. Unlike management of a single project, UR projects are characterized for a great amount of cost expenditure, long business duration and the simultaneous execution of a number of projects. In consideration of these characteristics of UR projects, it is certain that there are limitations to management of UR projects with existing project management methods mostly focusing on management of a single project. To address this necessity, the authors developed i-PgMIS that integrates various management modules necessary for program-level management including project cost/duration management, risk management, performance management, change management, contract management, electronic manual, conflict management, eco-value engineering (EVE) and so on. Among these,

this paper focused on the EVE module based on the recognition of the absence of a systematic approach for identifying environment-friendly construction processes, despite owners' increasing awareness on sustainable built environment

The EVE aimed to support eco-value analysis at project-level management. For this, the authors first defined a checklist based eco-value analysis procedure to incorporate sustainability into a formal value engineering process. Also, for an applicability and accessibility purposes, the authors developed web-based user interfaces that can facilitate the value analysis procedure.

It is expected that the EVE module would enhance value and sustainability of construction processes throughout the whole 'program' lifecycle. Further, it is expected to support program feasibility study based on life cycle costing.

REFERENCES

[1] Kim, G. R. and Yu, J. H., "Suggest a Work process of Change Management in a Urban Regeneration Project", Korea Institute of Construction Engineering and Management 2010 Annual Conference, Vol. 10(1), pp.245-246, 2010.
[2] Urban Rearrangement Project Statistics Data, Mnistry of Land, Transport and Maritime Affairs, Approval No. 11663, 2011.
[3] Qian, S. and Shoufeng, C., "Evaluation of green construction alternatives based on value engineering" Wireless Communications, Networking and Mobile Computing, 2008.
[4] Abdulaziz S. A. The Synergy between Value Engineering and Sustainable Construction, CTBUH 8th World Congress, 2008.
[5] Song, C, "Performing Method of Green VE for Sustainable Office Building" Master's Thesis, University of Seoul, 2011.
[6] Jang, D., "Unit Data and Estimating Process of CO2 Emissions with Structural Work BoQ for Green VE" " Master's Thesis, University of Seoul, 2012.
[7] Vickers, J.R., "A System Engineering Approach to Value Engineering Change" , SAVE, 2008.
[8] Park, H. M., "A Web-Based VE Supporting System for VE Facilitators and Members in VE Workshops" , SAVE, 2009.
[9] Cha, Y., Jin, R., Son, M., and Hyun, C., "Change and Contract Management Modules of intelligent-Program Management Information Systems (i-PgMIS) for Urban Renewal Projects", ISARC, 2012.
[10] University of Seoul Academic-Industry Cooperative Research Team, The Five-Year Urban Regeneration Project Management System Development Report, KICTEP, 2011.

`