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DEVELOPMENT OF A WEB-BASED COST AND DURATION MANAGEMENT SYSTEM FOR MEGA-PROJECTS

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ABSTRACT: Urban renewal projects, in the form of mega-projects, are being actively implemented both nationally and internationally to revitalize inactive cities. These programs, however, are difficult to manage efficiently due to their need for a large budget over a long period of time and due to conflicts with stockholders. Moreover, existing cost and duration management systems are structured with emphasis on the design and construction stage of unit projects, thus limiting their application to long-term mega-projects that are integrated with various facilities. To solve these problems, this study developed a web-based system that can collectively manage the cost and duration of mega-projects at a program level. The unit modules included in the system--CBS organization, construction cost and duration prediction, and total cost and duration prediction--can support decision-making at the early stage of the program. Furthermore, the modules, which include contract management, execution management, change management, and program progress management, support the program operations for its successful accomplishment. The web-based cost and duration management system developed in this study is expected to be used as a valuable tool that supports the successful accomplishment of mega-projects through their efficient management throughout their life cycle.

Keywords: Cost and duration management, Mega-projects, Urban renewal, Web-based

1. INTRODUCTION

Urban renewal projects, in the form of mega-projects, are being actively implemented both nationally and internationally to revitalize inactive cities. Their application is in fact being expanded to government and private development projects, thereby increasing their significance [1]. Mega-projects, however, cause problems such as conflicting interests between stockholders, fusion of the private and public development sectors, operation and maintenance difficulties, and asset management difficulty. These problems greatly affect not only the program duration and cost, but also its operation and maintenance [2].

The existing cost and duration management systems, however, are structured with emphasis on the design and construction stage of unit projects, thus limiting their application to long-term mega-projects that are integrated with various facilities over a long period of time [3]. Especially at the program level, numerous problems, including cost increases and project delays, occur due to the inadequacy of the cost and duration prediction and management technique. Accordingly, to solve these problems, a cost and duration management technique at the program level that considers the entire project life cycle is required.

Hereupon, this paper will discuss the development of a web-based cost and duration management system for urban renewal projects, in the form of mega-projects that considers the projects' entire life cycle.

2. LITERATURE REVIEW

2.1 Mega Projects and Urban Renewal Projects

Table 1. Initiation of Mega-projects

Period	System	Main Project	Organization
1970s	Urban Redevelopment	Gwibin Road; Mapo	National
1980s	Civil Capital Project	Lotte, Jamsil; Coex	National
1990s	Liberalization of Distribution Prices	Sigma 2; Tower Palace	Local Government
2000s	Financial Market Development	Jukjeon Yongin; Pangyo	Private

The mega-project is a large-scale project that combines various facilities including residential, commercial, office, cultural, public, and recreational facilities, which is executed in program units. Since the 1970s, national mega-projects have been in continual progress. The main projects for given periods are summarized in Table 1 [4].

Various problems, however, including conflicts between stockholders, increases in project costs, and project delays have arisen during the implementation of these projects. The problems encountered in urban renewal projects in the form of mega-projects, which Ha [4] pinpointed, are shown in Table 2.

Table 2. Problems with Urban Renewal Projects

□ Conflicts between stakeholders
□ Increases in project cost and delays in project implementation
□ Mixed use of public and private development sections
□ Lack of regulations and proper business processes
□ Importance of performance management
□ Insufficient experience and specialists
□ Lack of a management system at the program level

Accordingly, a management technology at the program level is required to solve the identified problems.

2.2 Cost and Duration Management Technique

Cost and duration can be seen as the most significant management factors in the entire process of implementation of mega-projects. Accordingly, accurate predictions at the early stages of the project and efficient management of the process have a great effect on the project's success.

2.2.1 Construction cost and duration prediction

Decision-making at the early stage of a project has a significant impact on the project. Limited and uncertain information on the project and complex correlations among various factors that affect the project's construction duration and cost make it difficult, however, to predict and manage pertinent tasks [5]. Many researchers have studied cost prediction at the early stage of projects using various techniques, such as Multiple Regression Analysis (MRA), Monte Carlo Simulation (MCS), Artificial Neural Networks (ANN), and Genetic Algorithms (GA). An increasing number of studies are using the Case-Based Reasoning (CBR) technique.

CBR is a data-mining technique that remembers similar situations applied to the solution of previous problems, and uses the information and knowledge gained from such situations to solve a new problem. Generally, the CBR technique has four phases: Retrieve, Reuse, Revise, and Retain [6]. This study used the CBR technique to predict the construction cost and duration of mega-projects.

2.2.2 Total cost and duration prediction

A nationally standardized methodology for economic analysis of public architectural projects has not yet been established. Economic analyses based on relevant fields, according to the nature of the project, are being conducted, though [7]. With standard construction companies, basic information concerning construction costs from their previous projects are inputted in a database and used to calculate new project costs [8]. Numerous problems, however, such as cost increases and delays in work schedules, are arising, as urban renewal projects and other mega-project-scale businesses have insufficient performance data. Accordingly, prediction and management technologies at the program level are required to resolve these problems.

2.2.3 Cost and duration management

Existing Project Management Information Systems (PMISs) are suitable for single and multiple project management, and focus on the management of the construction phase. Their functions do not perfectly satisfy the demand, however, so they are unstable from the viewpoint of users [9]. The limitations of PMISs as proposed by Kim [10] are shown in Table 3.

Table 3. The limitation of PMIS

Category	Contents
Localization of the Unit Project Site	□ DB construction for unit projects (not mega-projects) □ The "user" refers only to the staff at the headquarters unit project site.
Difficulty in Maintaining Security	□ Difficulty in maintaining security due to the exposure of detailed categories on-site. □ Apprehension with the exposure of details on the general management of the headquarters.
Unnecessary Exposure of Information	□ Apprehension with the exposure of large amounts of information □ Apprehension with the confusion on the gathering of inappropriate information
Insufficient Exceptional Labor Force in Information Management	□ Difficulty in finding exceptional laborers who can smoothly manage information □ Increase in training costs for professional laborers

Accordingly, unlike in the existing method, a management system at the program level is required for efficient management of mega-projects.

3. MAIN TECHNIQUES FOR SYSYTEM DEVELOPMENT

To successfully execute and efficiently manage mega-projects, this study primarily defined the main functions that need to be included in the cost and duration management system.

3.1 Cost Management Technique

The breakdown of the required work into smaller manageable pieces is a very important process in program management. A component at the lowest level of a Program Work Breakdown Structure (PWBS) is called a program package, which is a management interface between program management and project management [11].

As mentioned, accurate prediction of the total cost is very important in the success or failure of the entire program. A prediction system at the program level is insufficient, though [1]. To accurately predict the total cost, a Cost Breakdown Structure (CBS) that details all the levels of the total program cost must first be constructed. This is an important procedure in predicting the total cost. After the prediction of the total cost, followed by the establishment of a plan, the method of and strategy for managing the process of the program becomes the key factor in the success or failure of the program. The total cost must be applied according to plan, and countermeasures to unavoidable changes and circumstances must be prepared.

This study conclusively defined CBS organization, construction cost prediction, total cost prediction, contract management, execution management, and change management as the main technologies for efficient cost management. These technologies are shown in Fig. 1.

Fig. 1. Main Technologies of Cost Management System

3.2 Duration Management Technique

Mega-projects related to urban renewal projects follow a complex procedure in accordance with large- scale projects. Concerning the institutional aspect, urban renewal projects that follow the Urban and Residential Environment Maintenance Law of South Korea are largely categorized into 9-12 level-one executive processes and approximately 60 level-two processes. Each level-two process can be further divided into 1-2 levels according to its status [9]. Accordingly, standardized operation of the business process is required for efficient management of the entire program duration.

As much as the prediction of the construction cost and the total cost is significant at the early stages of the program, the management of the schedule is also very important. Accordingly, this study defined PWBS organization, standard Business Process Structure (BPS) organization, construction duration prediction, total duration prediction, scheduling arrangement, and program progress management as the main technologies for schedule management. These are shown in Fig. 2.

Fig. 2. Main Technologies of Duration Management System

4. UNIT MODULES FOR COST AND DURATION MANAGEMENT SYSTEM

4.1 CBS Organization Module

The study of Hyun [1] identified 59 priority-managed cost items through domestic and foreign CBS, literature studies, case analyses, and professional consultations for the establishment of cost items that are appropriate for mega-projects. This study organized a standard CBS based on the results of the aforementioned study, and reflected it in the system. The system user is able to efficiently execute the CBS organization task through the standard CBS. Furthermore, the organized CBS can be modified according to the nature of the program. The organization of the CBS through the standard CBS is shown in Fig. 3.

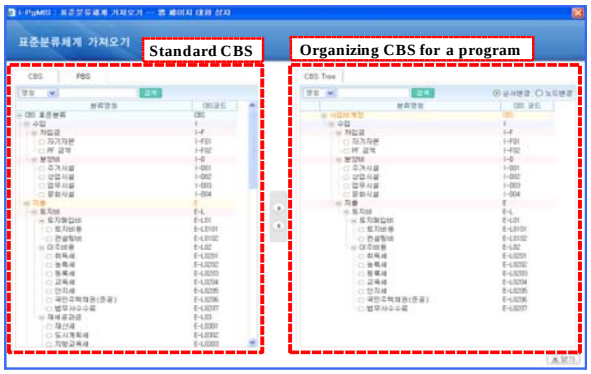

Fig. 3. CBS Organization UI

The organized CBS can be used to predict the total cost at the early stages of the program, and is connected to the tasks of execution management and contract management during the process of the program.

4.2 Construction Cost and Duration Prediction Module

The physicals that compose the program are delivered as a single project with one or a collection of multiple physicals. Accurate judgment of these physicals cannot be made at the early stages of the program, however, and thus, this study predicted the construction cost and duration by speculating on a single project with a single physical, as shown in Fig. 4.

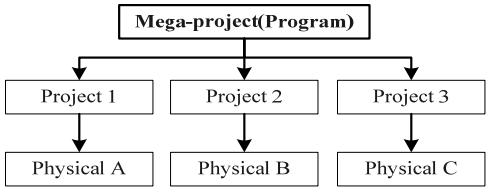

Fig. 4. PWBS at the early stages of Mega-projects

This study applied the widely used CBR method to the system. The retrieval of similar cases and the prediction of the construction cost and duration are shown in Fig. 5.

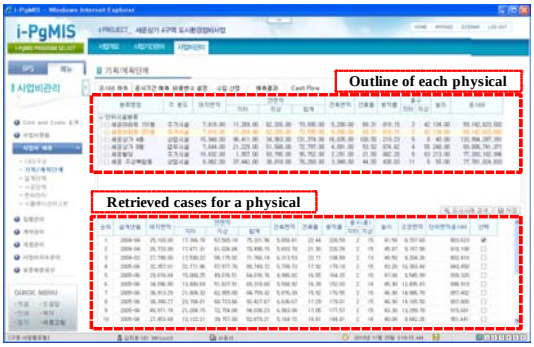

Fig. 5. Construction Cost and Duration Prediction UI

4.3 Schedule Arrangement Module for Optimum Total Costs

In section 3.2, the construction duration based on each physical was predicted. The profit and cash flow of programs depend largely, however, on the sequence of construction of each physical in the execution of mega-projects. Accordingly, this study developed a scheduling arrangement module for the optimization of total costs, centered on the construction stage that incurs the most expenses during the entire program.

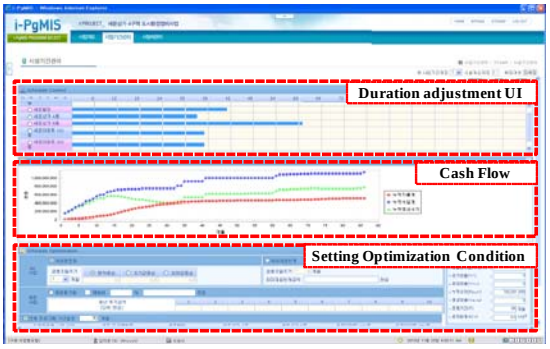

Fig. 6. Scheduling Arrangement Module UI

The scheduling arrangement module is managed according to a simulated annealing (SA) algorithm, based on the profit and expense data generated during construction stage (i.e., profit such as sales profit, and expense such as construction cost). Fig. 6 shows the UI of the scheduling arrangement module.

4.4 Total Cost and Duration Prediction Module

4.4.1 Total cost prediction

There are serious difficulties in accurately predicting the total cost and duration at the early stages of a program. This study organized the relationships of these factors into a formula, based on the aforementioned CBS cost items, to predict the total cost of a mega-project at the early stages of the program. For example, one of the CBS cost items, land cost, is calculated by multiplying the site area and the land cost per m^2 (land cost = site area * land cost per m^2), and the consultation cost is calculated by multiplying the land cost and the consulting ratio (consultation cost = land cost * consulting ratio).

This study defined in advance all the variables (i.e., land cost, consulting ratio, etc.) that are included in the formula for the CBS cost items, and reflected them on the system. The variables include outline variables (information on the program outline, such as the site area), setting variables (setting of variable values based on legal standards or actual cases, such as with the consulting rate), and input variables (variables entered directly by the user, such as the land price per m^2). Fig. 7 shows the process of cost/duration prediction and management.

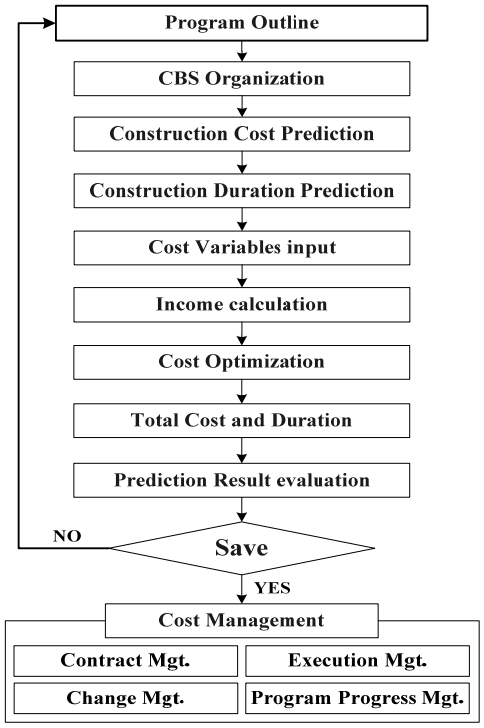

Fig. 7. The process of Cost/Duration Prediction and Management

4.4.2 Total duration prediction

As explained previously, urban renewal projects involve approximately 60 management processes. This study revised the management processes of urban renewal projects based on the aforementioned details, through numerous consultations with professionals who are currently executing actual urban renewal projects. Ultimately, level one was defined as involving the three phases of Basic Plan Establishment, Program Execution, and Execution Completion and Operation and Maintenance; and level two was defined as involving seven phases from the Basic Plan Establishment to the Completion and Liquidation. In level three, the lowest stage, the executive process, was standardized into 84 phases, from the Establishment of the Execution Policy and Program Delivery to the Liquidation and Disbandment of the Association. With the exclusion of the construction phase, which consumes the most time among the aforementioned phases, the starting and ending points of the remaining 83 phases were defined. The total duration is estimated based on the construction duration that was predicted by the cost prediction module and the 83 durations that were defined. Fig. 8 shows the standard business process for, and information on, the duration.

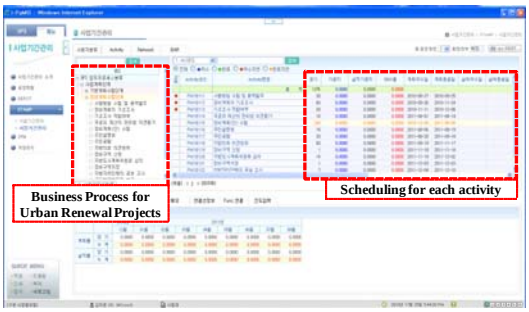

Fig. 8. Standard Business Process and Duration Information UI

4.5 Other Modules for Cost and Duration Management

As shown in Fig. 7, once the total cost and duration have been determined and the program plan has been established, the management of the program is executed according to the planned cost and duration. This study developed contract management module, execution management module, program progress management module, and change management module for efficient management of mega-projects.

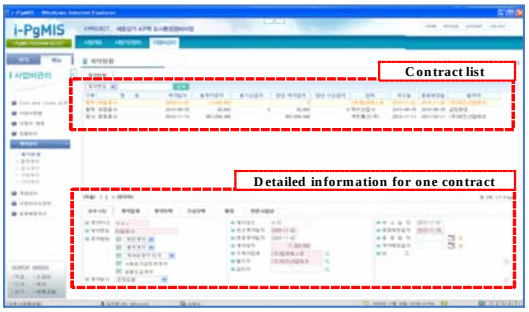

Fig. 9. Contract Management Module UI

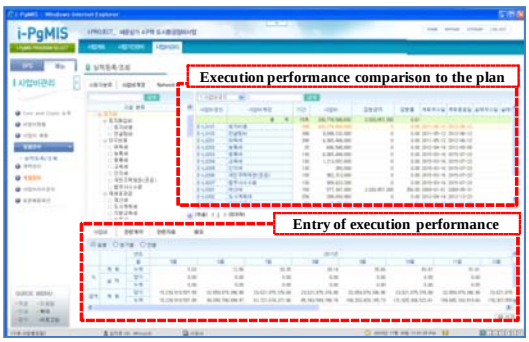

Fig. 10. Execution Management Module UI

The contract management module manages all contracts during the program process. Detailed functions within this module include contracted corporation management, contract history management, and earned value management. This module also includes functions related to cost items, as described previously. The execution management module manages all executed costs during the program process. This module is connected with the CBS cost items, and was constructed to compare the execution performance with the plan for each cost item. Fig. 9 and 10 show the UI of contract management module and execution management module.

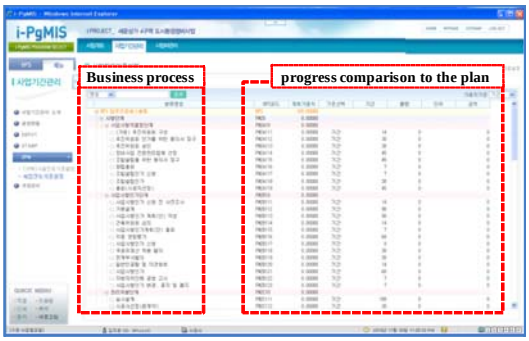

Fig. 11. Program Progress Management Module UI

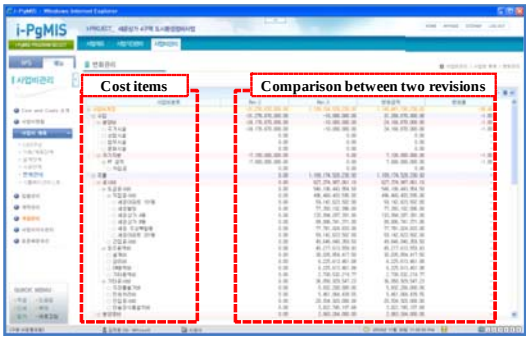

Fig. 12. Change Management Module UI

The change management module records the quantity of changes and the causes of the changes in the cost and schedule during the program process, to enable the program director to prepare countermeasures for such changes. The director uses the program progress

management module to manage the schedule. The stage of completion of the schedule can be verified in relation to the schedule plan. If the term of work is delayed, the module proposes a suitable countermeasure. Fig. 11 and 12 show the UI of program progress management module and change management module.

4.6 System Test

This study developed a system with corresponding tests for the unit modules. Accordingly, the verification of each unit module was completed during the process of the system development. The ultimate purpose of this study is the integration of all the unit modules included in the web-based cost and duration management system. Accordingly, to verify the efficiency of the integrated system, a preliminary test bed was conducted that was based on the data from the validity analyses of two actual mega-project cases. The results of the test showed that the interlocking of all the modules, excluding the scheduling arrangement module that was established to optimize the total costs, is smooth, and that each prediction module was also normally managed.

Although one module did not smoothly interlock with the others, it is considered a remarkable achievement within the primary integrating dimension. Its completion will be heightened through continual supplementations in the future, and a main test bed is scheduled to verify the system

5. CONCLUSION

This study developed a web-based cost and duration management system for the efficient management of mega-projects for urban renewal. The unit modules that are included in the system are the cost-management-related modules on CBS organization, construction cost prediction, total cost prediction, contract management, execution management, and change management, and the duration-management-related modules on PWBS organization, construction duration prediction, total duration prediction, standard PBS organization, scheduling arrangement, and program progress management.

This study completed the verification of each unit module in the system development process. The test results for the final integrated system, however, showed slight errors in the scheduling arrangement module. Accordingly, the completion of the system must be enhanced through continual tests and supplementation.

The ultimately developed system does not only support decision-making by the owner at the early stages of the program, but it is also expected to support the efficient execution of mega-projects during their entire life cycle.

ACKNOWLEDGEMENT

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