INTEGRATION MODEL OF COST AND SCHEDULE IN STEEL BOX GIRDER BRIDGE PRODUCTION PROCESS

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ABSTRACT : It is still difficult to share and utilize the information generated at each phase of a steel box girder production process due to the spatial gap and different level of management information. The physical distance results in the inefficiency of the information transmission, the accidental omission and typos of the relative information, and so on. Various levels of management information make it difficult to embody a new management system. Eventually, these factors incur the loss of cost and schedule and interrupt development of a new management system. This paper analyzes a current process and presents graphical process flow by using IDEF0. Based this analysis, the research for new production process and work breakdown structure (WBS) is conducted. At the end of this paper, the conceptual design of this system is suggested. Through new management system, it is expected that the model proposed in this study will improve the management process in the steel box production, and the improved process will reduce the redundant cost and schedule information, transmission and deposit generated by manual paper.

Key words : Integration, Steel Box, Cost, Schedule, IDEF0, ERD

1. INTRODUCTION

1.1 Research Objective

Steel box girder has some merits, such as constructability, reduction of a term of works and guarantee of a good quality, and makes it possible to be longer span and more beautiful bridges. Because of these factors, the production of a steel box girder has recently increased in the republic of Korea.

In case of a steel box girder, the production process consists of eight phases and cost and schedule management is conducted by using information which is generated at each phase. The generated information is essential thing in the cost and schedule management and should not have an error. At present, however, site managers have written down information on a document. And then, documents, which are called 'Daily Work Report by Crew Unit', are collected after works. In the process, the physical distance and different level of management information result in the inefficiency of the information transmission, the accidental omission and typos of the relative information, and so on. Eventually, these impedimental factors incur the loss of cost and schedule through a production process. This research is performed to improve these impediments.

1.2 Research Scope and Method

Before presenting a new management system, it needs to present the process of a steel box girder production. Because the process, which is not directly related to cost and schedule, can cause this research to be unclear, it should be conducted within a part of the whole process. Through analysis of current process, parts of the process are defined as a biding and contract particulars, operation particulars, management by crew unit, daily work management, monthly work management and application of monthly payment management. After analysis of the current process, this research suggests improved process. Based on suggested new process, a conceptual design of the system is presented at the end of this paper.

To conduct this research, the interview with managers, who have worked at practical business for a long time, is carried out. After some interviews, the results are analyzed at various aspects, and expressed as forms of IDEF0 and ERD. Using these method, this research presents the concept of a 'cost & schedule integrated management system'.

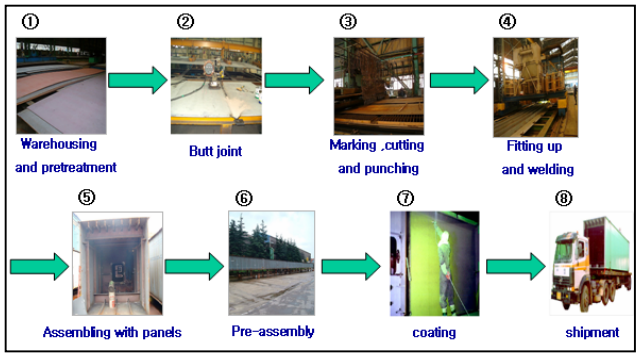

Figure 1. Production process

Table 1. Works of production process

Stages	Description
①Material warehousing & Pretreatment	• Purchase and deposit Steel plates, as a material, in a warehouse. • Cleaning surface of a steel plate.
②Butt joint	• Producing steel plates with various thickness.
③Marking, Cutting, Punching	• Producing members including flange, web, diaphragm, rib, stiff and beam.
④Panel Fitting up & Welding	• Welding rib, stiff and beam into flange and web.
⑤Assembling with panels	• Making a box by welding each panels pretreated.
⑥Pre-assembling with boxes	• Before site installation, preliminary combining boxes together.
⑦Coating	• Painting for preventing corrosion and securing the beauties.
⑧Shipment	• Sending completed boxes to the site.

2. STEEL BOX GIRDER BRIDGE PRODUCTION PROCESS

A current process of steel box girder production can be divided into eight stages, such as 'Material warehousing & Pretreatment', 'Butt joint', 'Marking, Cutting, Punching', 'Panel Fitting up & Welding', 'Assembling with panels', 'Pre-assembling with boxes', 'Coating' and 'Shipment'. Each stage is as follows (table 1, figure 1).

To present the process of these works, this research utilizes process modeling, using graphical process modeling tools such as integrated definition for function modeling (IDEF0) [6]. IDEF0 presents some activities and the relationship between them by using arrows of input, output, control and mechanism.

Work information, which is generated at each stage, is recorded on the 'Daily work report by crew unit' and collected after a work of the day. Collected information is recorded on the 'Daily work report' for checking the amount of daily input resources. Daily work reports are collected for one month and become the 'Monthly work report'. Through a monthly document, work managers can identify a status of work process. By using the amount of work resources recorded on the monthly work report, 'Application of monthly payment' is made out (figure 2).

As illustrated above, existing process consists of a chain of controls. Therefore, it spends a lot of time managing the cost and schedule. It is also impossible to exchange management information between work sites at a same time. At the end of month, A 'Monthly work report' and 'Application of monthly payment' are made out. These works are required much time.

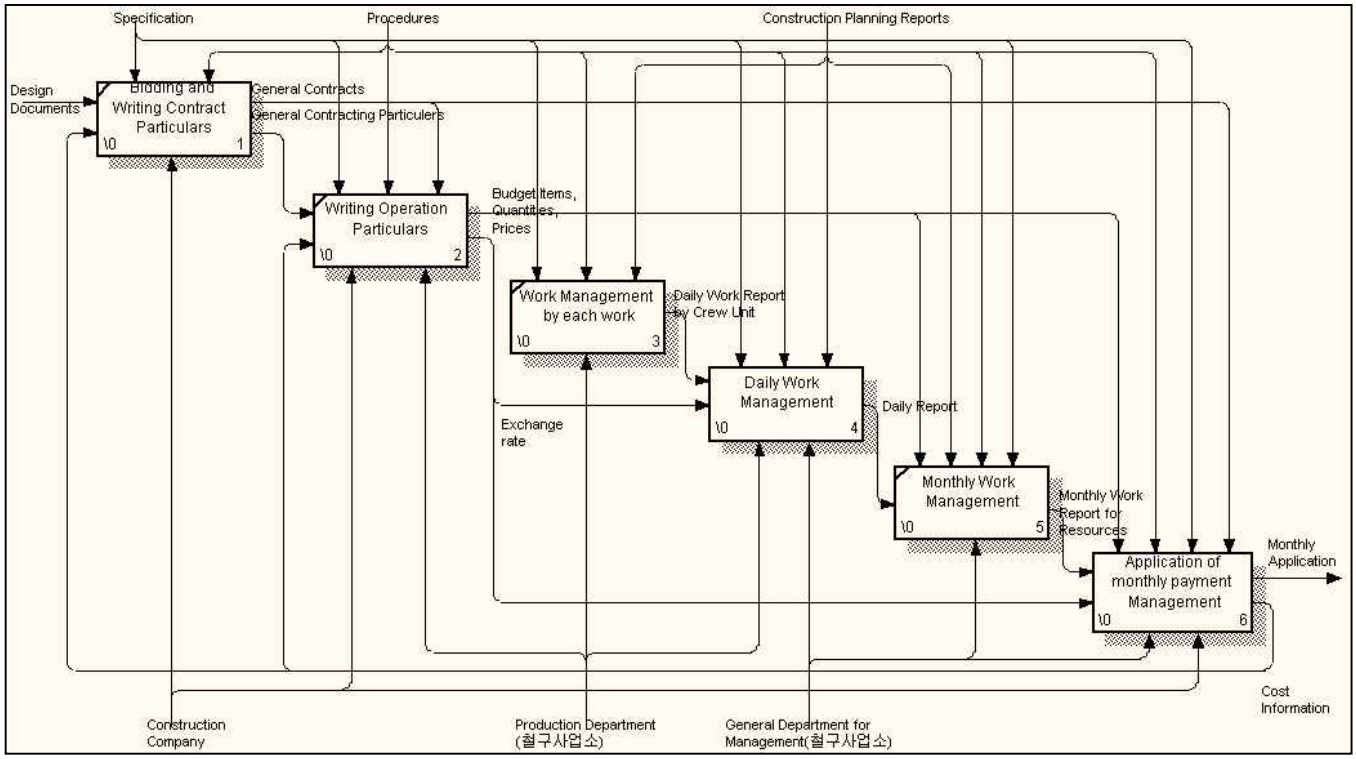

Figure 2. IDEF0 of the current process

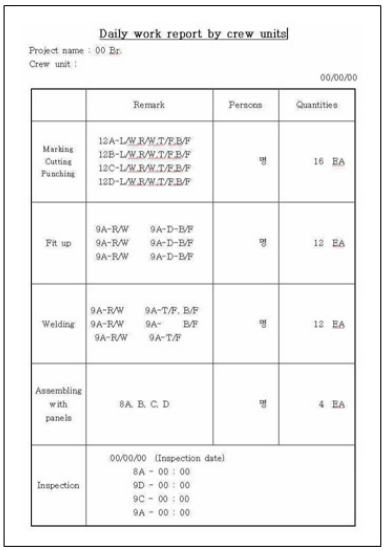

Figure 3. Daily work report by crew unit

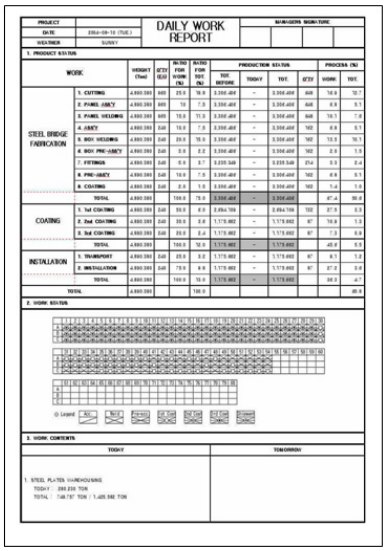

Figure 4. Daily work report

Figure 5. Application of monthly payment

3. THE LEVEL OF MANAGEMENT

3.1 Various Levels of Management

The documents, which are used in a production process, are as follows (figure 3, figure 4, figure 5). 'Figure 3' is a 'Daily work report by crew unit' and includes some contents on it. It is written about detailed information about resources. For example, '12A-L/W,R/W,T/F,B/F', which is located in a row of 'Marking, Cutting, Punching', means to complete to make left web, right web, top flange, bottom flange of twelfth box of a 'A' row. Similarly, 'Panel fitting up & welding' is expressed like '9A-R/W'. In other words, work management on 'Marking, Cutting, Punching' and 'Panel fitting up & welding' is dealt at the level of members unit. Unlike this, 'Assembling with panels', 'Pre-assembling with boxes', 'Coating' and 'Shipment' is recorded by using a form of '8A, 9A'. Work management of four stages is accomplished at the level of box unit. Comparing with former and later stages, each stage has various management levels. Next, 'figure 4' is a 'Daily work report'. Looking into this document, management level is changed at each stage because the document is based on 'Daily work report by crew unit'. Therefore, differences of management levels should be reflected in making Work Breakdown Structure (WBS) of a steel box girder production.

'Figure 5' is an 'Application of monthly payment'. Application of monthly payment is a written application which shows the production cost based on actual input resources. Its cost items are largely divided into 'Production of steel bridge' and 'Coating'. In case of 'Production of steel bridge', management unit is defined as Ton. Differently from this, management unit of 'Coating' is defined as square 'Meter'. In a point of time when information is collected, information is written as forms of box number and members' name. In an application of monthly payment, however, there are not box numbers and members' names but only two units (ton, square meter). This fact makes necessity of conversion of information is necessary for making a 'cost & schedule integrated management system'.

3.2 Work Breakdown Structure

As stated prior chapter, making a work breakdown structure has to be considered about different management levels at each stage. Looking into work reports, 'Material warehousing & Pretreatment' and 'Butt joint' can be efficiently managed at the level of project unit. On the other hand, 'Marking, Cutting, Punching' and 'Panel fitting up & Welding' need to control at the more detailed level (Panel unit). The others (Assembling with panels, Pre-assembling with boxes, Coating, Shipment) should be managed at the level of box unit (figure 6).

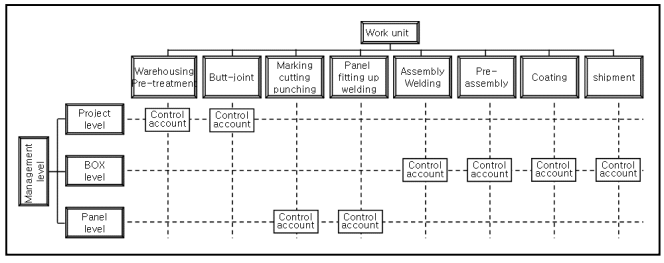

Figure 6. Level of the works management

Like this, each stage has its own unit. Accordingly, new work breakdown structure, which would be applied to a 'cost & schedule integrated management system', should be made under considering these different levels. In figure 7, left and middle WBS, which are managed by the level of panel unit, are concerned with 'Marking, Cutting, Punching' and 'Panel fitting up & welding'. Right WBS is concerned with 'Assembling with panels', 'Pre-assembling with boxes', 'Coating' and 'Shipment' and controls these works at the level of box unit.

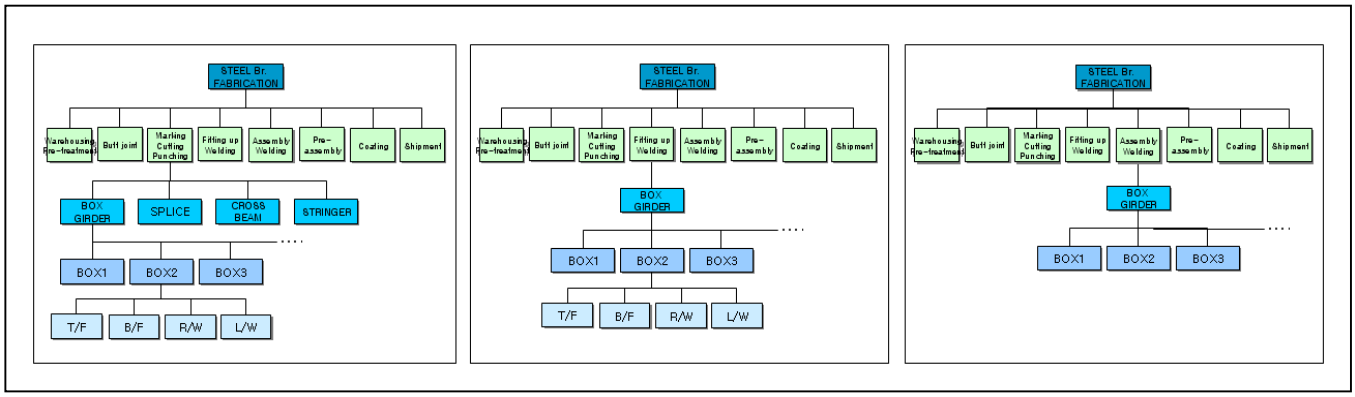

Figure 7. WBS of the steel bridge production

4. IMPROVED PRODUCTION PROCESS

For applying to a 'cost & schedule integrated management system', it is unreasonable to use current production process. Information of the current production process is rewritten by a man, and so accurate delivery of information is impossible. For embodying real time exchanging of information, work information should be delivered not as a form of a document, but as a form of the electronic. Therefore, a new management system, using computers and PDAs, is required for development of the improved production process.

New process was developed in considering of utilizing computers, PDAs and concepts of database. As using these technologies, improved production process can be simpler and more powerful. While current process has two phases, 'Daily work management' and 'Monthly work management' in IDEF0 diagram (figure 2), new process combines two phases into one that is called as 'integrated management system for site information' (figure 8). Looking into new IDEF0 diagram, the integrated management system receives site information, which is generated from the work site, and yields various 'cost & schedule information' and 'Application of monthly payment' based on basic information (budget items, quantities, prices, exchange rate).

This new system has some functions, including real time exchanging of information, automatic generating of work reports and application of monthly payments and storing information as a form of database. Real time exchanging of information prevents information from being omitted or regenerated and causes the work efficiency to be increased. Database can efficiently store a lot of information and also define a relationship with all information, and so new information, which is not existing information, can be generated in a short time. Concisely, these functions can make total process to be efficient and accurate.

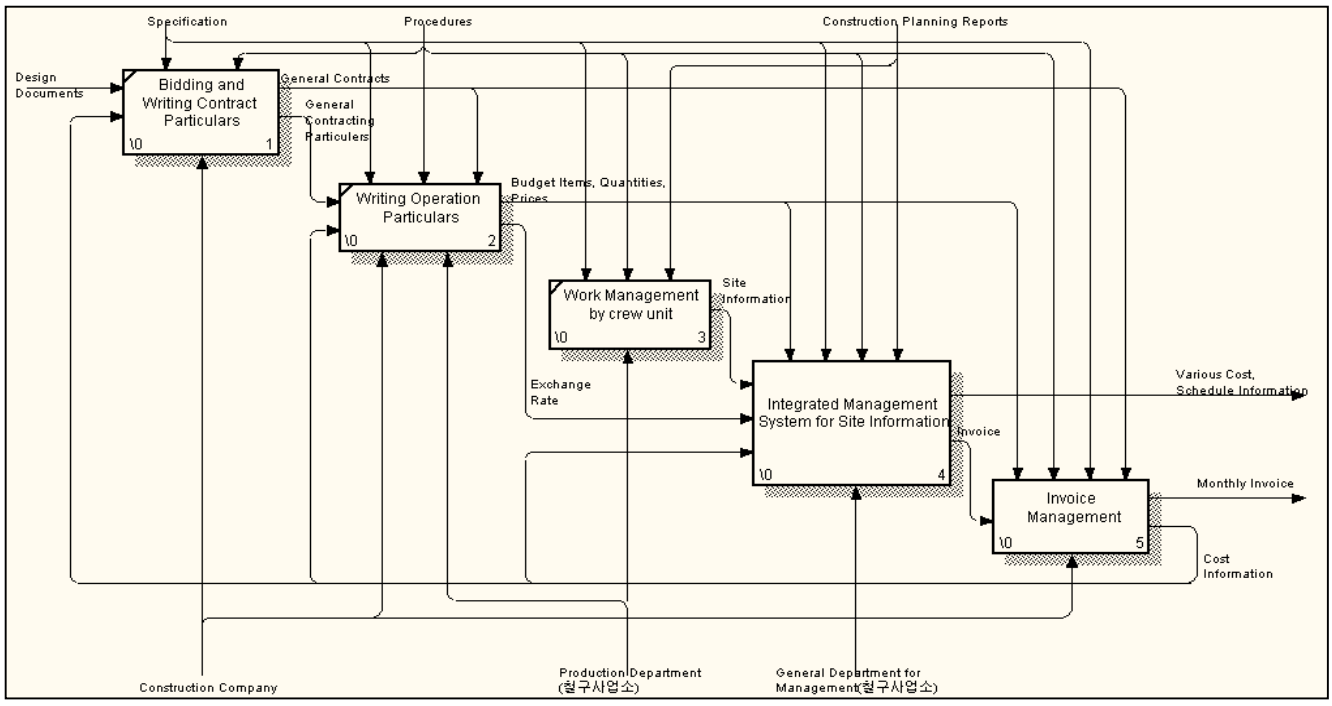

Figure 8. IDEF0 of the improved process

5. COST&SCHEDULE INTEGRATED MANAGEMENT SYSTEM

5.1 The flow of information

As illustrated above, a new management system must have some functions, such as real time exchanging of information, automatic conversion of work reports into application of monthly payments and storing information as a form of database. For real time exchanging of information, PDA and database system are applied to this system.

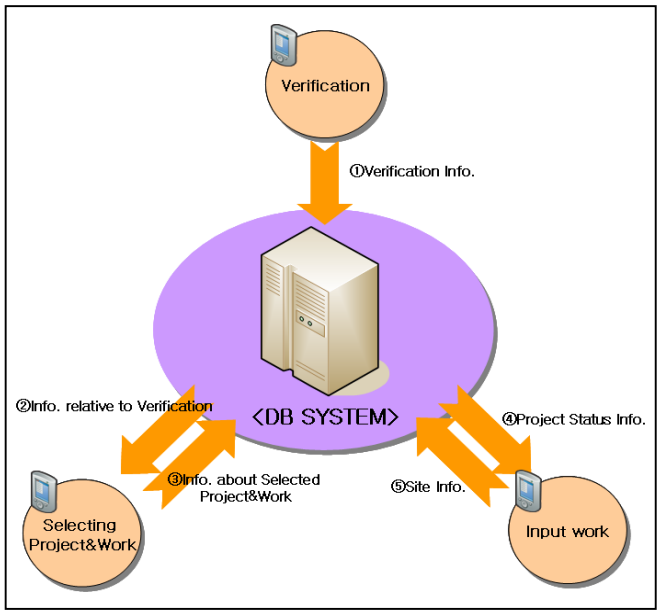

Figure 9. Abstract of information flow

'Figure 9' is described the relation between PDAs and database system and the rough procedures of a management system. PDAs collect work information in the site and send it to a database system as a form of the electronic. This information is exchanged in a real time, and the steps of exchanging information are as follows. Largely it consists of three steps, which are 'verification', 'selecting project & work' and 'input work'. The 'verification' is used for identifying users and 'selecting project & work' for defining detailed work. In a step of 'input work', essential work information is sent into a database system.

The detailed information, which is generated for a

Table 2. Components of information

Information			Components
① Verification information			employee number + password
② Info. relative to verification			access Info. + work Info. by individual
③ Info. for selecting Project · work			project ID + work ID
④ Project status Info.			project name + site location Info. + starting date + forecasted completion date + boxes Info. status + work Info.
⑤Site Info.	manpower		crew units name + number of crews
	equipments Info.		name of using equipments + number of equipments
	materials Info.	warehousing	steels type + standard dimension + quantities
		pre-treatment	steels type + standard dimension + quantities
		butt joint	steels type + standard dimension
		marking, cutting, punching	selected steels + Box number + members name
		fitting up, welding	Box number + members name
		assembly with panels	Box number
		pre-assembly with boxes	Box number
		coating	Box number
		shipment	Box number

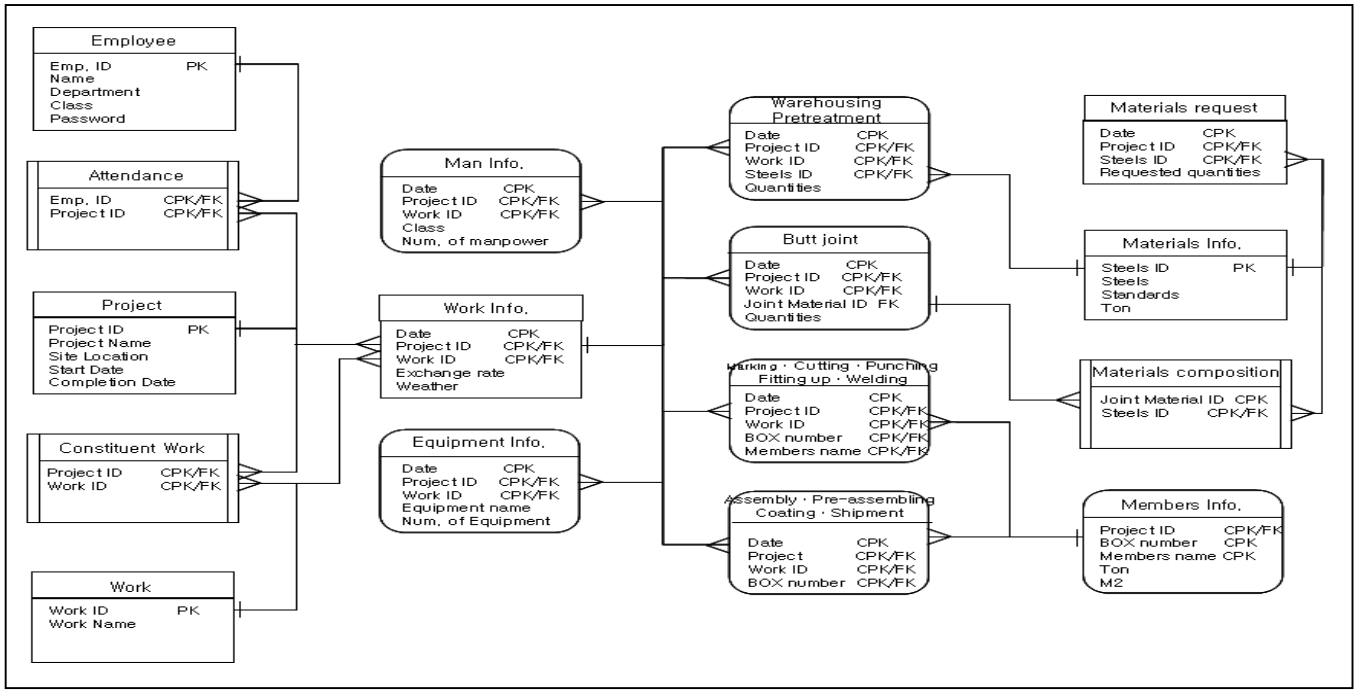

Figure 10. ERD of new management system

procedure, is presented in table 2. Odd number in circle means information that transfers from PDAs to a database system. In other hands, even number means information that transfers from a database system to PDAs.

Of this information, '⑤site information', which is related to resources, is divided into three groups (manpower, equipment, materials info.). 'Manpower' and 'equipments' have a fixed form at each phase, while 'materials' has various forms at each phase. Various forms of the 'materials' result from differences of a management level. Detailed components for each other, which are presented in table 2, are sent to a database system through PDAs.

5.2 The structure of information

To store and utilize unit information delivered from PDAs, a database system should have a proper frame of the relationship between pieces of information. As Entity Relationship Diagram (ERD), which can visually express the relationship between pieces of information, is a typical model, it is utilized for this database system. 'Figure 10' is ERD that is applied to this system. Roughly speaking, it can is said that a table of 'work info' is center of the relationship. At left of the center, tables of general information are located. They consist of three table, including 'Project', 'Employee' and 'Work', and are connected by a composite table for preventing from being the many to many relationships. At right of the center, there are tables of site information. They are subset tables of the table of 'work info.' and connected with the tables of 'materials' and 'members'. The tables of 'materials' and 'members' is used for changing from 'box number' or 'members name' to 'Ton' or 'M2'. In other words, they include essential information that is needed to yield cost of the production.

6. CONCLUSION

As illustrated at figure 2, existing process consists of a chain of controls, and so it spends a lot of time managing the cost and schedule. Besides, it is impossible to exchange management information between work sites at a same time. To remove these impediments, we need a new production process and management system. Firstly, this paper analyzes current work reports and finds two items that are applied to a new management system. One is differences of management levels and the other is the conversion of information that is required for yielding costs. Differences of management levels should be reflected in making Work Breakdown Structure (WBS) of a steel box girder production. The conversion of information is embodied by defining the relationship between pieces of information.

New process was developed by utilizing computers, PDAs and concepts of database. These technologies will improve a production process and a management system. A new management system must have some functions, such as real time exchanging of information, automatic generating of work reports and application of monthly payments and storing information as a form of database.

It is expected that the model proposed in this study will improve the management process in the steel box production, and the improved process will reduce the redundant cost and schedule information, transmissions and deposits generated by manual paper. Accordingly, 'Cost & schedule integrated management system' provides more effective and accurate management through the real time control.

This paper suggests basic details of a new management system. In consequence, application in the actual production process should be realized in the future. Analysis, which is about the productivity and feasibility about the new management system, should be completed by using results derived from this application.

ACKNOWLEDGMENT

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