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The DEVELOPMENT OF WORK PERFORMANCE ANALYSIS SYSTEM

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ABSTRACT: The purpose of this study is to develop the web-based system for work performance analysis(WPAS). The need of work performance analysis system has already been suggested in many previous researches on the computerization of the performance measurement in the construction site by using the indicators such as time, cost and quality.

However, they had focused on measuring or analyzing the result when the project would be over. The WPAS suggests three indicators - work reliability, work effectiveness and work efficiency - to manage the performance of the construction site. It can help the manager more easily recognize the status of on-going work in the construction site by measuring and analyzing the work reliability rate, the work effectiveness and work efficiency every day.

This research includes the procedures for WPAS measurement process, database structure of WPAS which was analyzed by the IDEF0 and the data flow diagram. Finally, this research introduces the result of WAPS's case studies and validation in the Korean construction site.

Keywords: Work reliability, Work effectiveness, Work efficiency, Work performance analysis

1. INTRODUCTION

1.1. The Overview and Purpose

"Like the saying, the unmeasurable thing cannot be manageable," the capability to understand status of construction project and quantify and measure its performance improvement is required in order to execute effective construction project. Due to the importance of performance measurement, construction companies in Korea have made vigorous efforts to develop performance measurement system and indicator to measure the performance. However, until now the performance indicators utilized to measure success of a company's project are mainly focused on time and cost [1].

On the other hand, studies related to development of performance measurement system that utilize progress performance oriented indicator and progress indicator besides time and cost factors have been actively proceeded in overseas countries. The major advantage of performance measurement of a project with progress performance indicator is that providing feedback to solve problems that occur during a project is faster and easier in comparison with performance measurement via time and cost because the performance is measured up to the smallest work activity of a project. Although performance measurement via time and cost is done to measure performance regularly to manage particular type of project and a specific work activity better from the perspective of time or cost, this cannot be referred as proper measurement of progress performance [2].

The purpose of this study is to define the following three progress performance indicators - reliability of work, effectiveness of work, and productivity of work to measure progress performance of project and develop web based Work Performance Analysis System (WPAS) to measure and analyze progress performance of construction project utilizing such indicators. In addition, as measurements of work progress per project, contractor, and individual task are recorded in database through such system, the performance of on-going project can be analyzed, and solutions for problems can be planned. Also, the predicted progress of work in similar project can be projected.

1.2. Method & Area of Study

An emphasis of this study is placed on analysis and diagnosis of progress performance of a specific task in construction project, and WPAS of prototype presented in this study limits the range of primary data entry of the system to data entry of monthly schedule excluding stages for master schedule planning and standard task database establishment to measure and analyze progress measurement indicator of on-going project.

This study consists of five following main sections.

(1) Definition of indicator to measure progress indicator of a project
(2) Major task process for WPAS
(3) Database Structure and data flow analysis of WPAS
(4) Functional format of WPAS
(5) Review on system application through case study

2. PRELIMINARY STUDY

2.1. Definition of measurement indicators for WPAS

This study presents three measurement indicators - reliability, effectiveness, and efficiency to measure progress performance of construction project prior to development of WPAS (Fig. 1).

Progress performance indicator	Definition
Work Reliability	actual work done compared to planned work
Work Effectiveness	the effect of proceeding work on subsequent work
Work Efficiency	quantity of resource invested to execute a work activity

Figure 1. Progress performance indicator and its definition

Reliability of work refers to actual work done compared to planned work. The target of reliability measurement is the smallest work activity and is measured daily. Effectiveness of work is the effect of proceeding work on subsequent work. The target of effectiveness measurement is also the smallest work activity and is measured at the time of the completion of corresponding work activity. Efficiency of work is quantity of resource invested to execute a work activity, and in the prototype of WPAS the ratio between actual work done and quantity of resource consumed is calculated to find the optimal allocation of resource and consequently determine the possibility of completion of work [3].

2.2. Related research work

Production Manager developed by SPS, British company is the most frequently used program among project schedule management tools utilizing reliability indicator. The major advantage of Production Manager is that the master plan is corrected automatically as the status of the lowest level of sub-activity goes through the stage of completed, incomplete, or not-started, which makes the control and measurement of project plan possible. In addition, analysis of case study of a completed project per activity and cause of activity failure is used as data to establish plan for a similar project execution.

Under the guidance of LCI (Lean Construction Institute), the United States has developed schedule management tool employing work completion rate. DePlan is the most famous so far among commercialized tool using work completion rate indicator. Deplan introduced by IGLC emphasizes on management and measurement of work completion rate of design work, and the advantage of Deplan is that the correlation of cooperative activity can be analyzed through DSM (Dependency Structure Matrix); activity without completed preparation for the activity is not assigned to activity list as various conditions of activities that will be executed within 4 weeks are analyzed through Constraint Analysis function. Moreover, in the reporting function the automatic notice related to weekly or daily activity can be forwarded to project participants, and summing and measuring reliability of work is also made possible [4].

Recently, companies in Korea has developed management tool using reliability indicator, and for instance, GS construction company announced TPMS, daily activity management system. The advantage of TPMS is that activity is monitored daily through daily activity management, and that cost analysis is possible as materials and costs are calculated in the system whenever task is completed through correlating materials and costs of activity per activity. Also, summing and measuring reliability is made possible for a project along with automatic creation of schedule and performance analysis [5].

2.3. Difference of other existing system

This study differentiates WPAS from other existing system that utilizes only reliability indicator. (Table. 1)

In the application of Production Manager, DePlan, and TPMS the objective is to measure overall performance of entire project of a large construction company; however, WPAS can be used for consulting purpose to measure performance of projects in small and medium enterprises where the construction management is not monitored by a system, and as a diagnosis tool for execution of specific activity that may delay the schedule. The input and output of information from Production Manager and TPMS is broad. On the other hand, WPAS consisted of simple functional module to measure reliability, effectiveness, productivity enhances practical application of users at site. The input and output of information from Production Manager and TPMS is broad.

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Table 5. Approach method of service quality

Section	Production Manager	DePlan	TPMS	WPAS
Nationality of Software	UK	USA	KOREA	KOREA
Measurement Scope	The whole of project	The whole of project	The whole of project	The selected trades
Measurement Subject	All trade contractors	All trade contractors	All trade contractors	Limited trade contractors
Measurement Indicator	PPC	PPC	PPC	Work Reliability Work Effectiveness Work Efficiency
Measurement Cycle	Daily	Daily	Daily	Daily
Supporting Function	WBS DB/ Failure reason analysis	DSM/ Constraints analysis/ Failure reason analysis	PDA tool related TPMS/ Resource monitoring system related JIT	Process Mapping Tool/ Constraints analysis/ Detail Failure reason analysis related WFAS
System Complexity	High	Medium	Very High	Medium

In WPAS the analysis of productivity per task as well as influence on other activities through effectiveness of work is possible as productivity and effectiveness indicator are added to the existing indicator such as rate of work completion

If the cause of incomplete or not-started activity is not identified when the status of activity is checked in correlation with FRAS(Failure Reason Analysis System), WPAS can check the possibility of delay in a task beforehand through detail cause analysis within FRAS.

3. THE DEVELOPMENT OF WORK PERFORMANCE ANALYSIS SYSTEM

This study focused on developing the system to measure the work performance by using progress performance indicators such as work reliability, work effectiveness, work efficiency.

3.1. Major task process for WPAS

A major task process for WPAS is divided into 5 steps such as (1) step 1: task setting, (2) step 2: Work Plan, (3) step 3: constraints analysis, (4) step 4: measurement & analysis, (5) detail failure reason analysis. In addition to the major task process, sub-task process includes inputting basic information such as documents or drawings related to construction site.

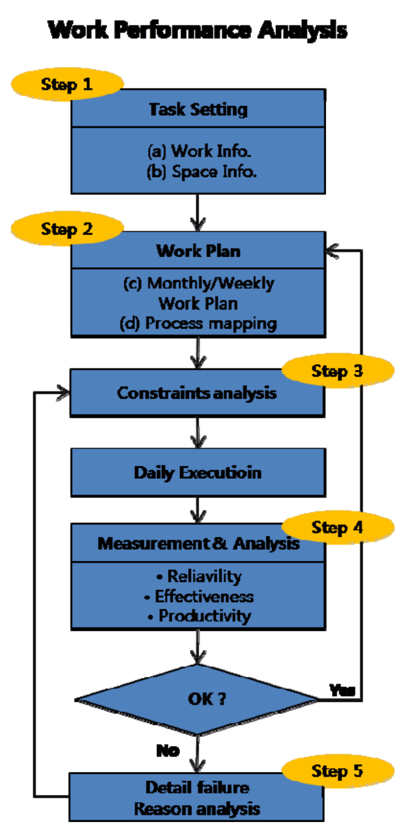

Figure 2. Progress performance indicator and its definition

(1) **Step 1**: In task setting stage, activity and location information of corresponding project is defined, and this provides primary data to establish work plan. Activity information is divided into three levels - Activity, Sub Activity, and Task. Location information is divided into four levels - building sector, building activity, stories in building, and household activity per floor(Fig. 3).

(2) **Step 2**: Work plan stage is divided into planning planning includes sub activity of activity. The monthly planning is established with entry of monthly, weekly planning, monthly activity duration and start date after inputting and process mapping. Planning stage consists of activity and location information. Weekly information defined at task setting stage and building activity of location information. Planning includes task of activity information and household activity per floor of location information, and the process of planning is the same as monthly planning.

Process mapping is created after weekly planning, and defines the relationship between proceeding and subsequent tasks (FIg. 4).

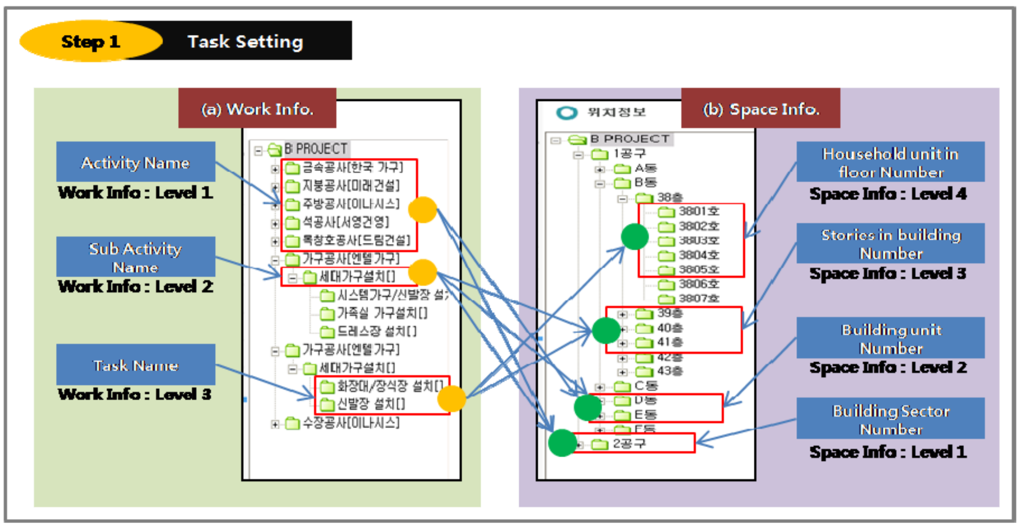

Figure 3. Step 1: Task setting

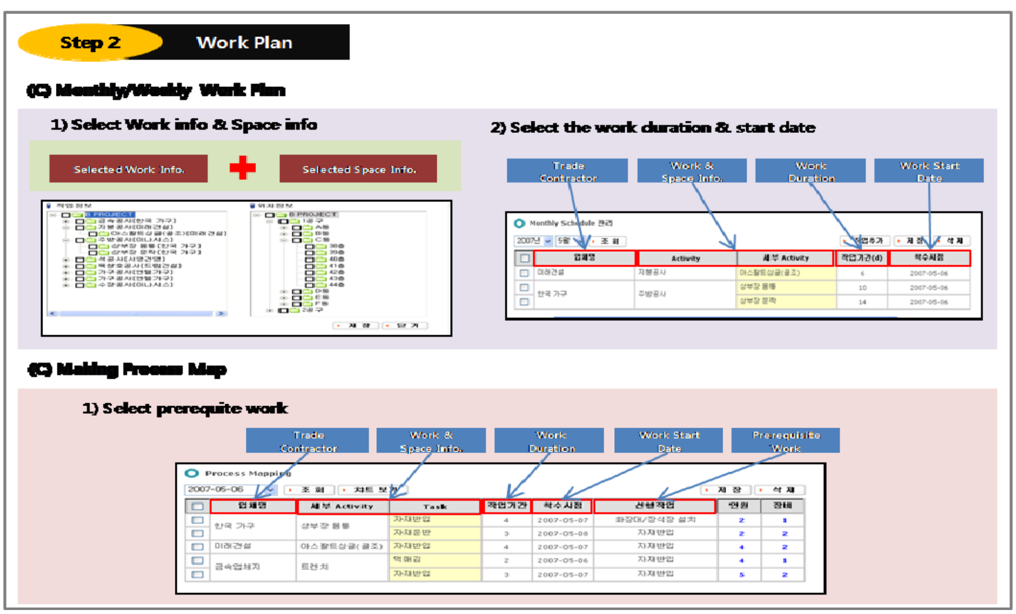

Figure 4. Step 2: Work Plan

(1) **Step 3**: In constraint analysis stage the items required to start individual task through weekly planning are checked in advance. Various condition analysis includes conflict between activity space, verification of labor and equipment used, safety review, and approval/review of design(Fig. 5).

(3) **Step 4**: Measurement & Analysis stage refers to verification of progress of activity after completion of daily work, and also investigate the completion of individual task as well as the delayed days caused by not-started or uncompleted activity and inputs whether the activity is delayed by itself or incomplete proceeding activity. Through this process, reliability, effectiveness, and efficiency of contractors for a project is calculated (Fig. 6).

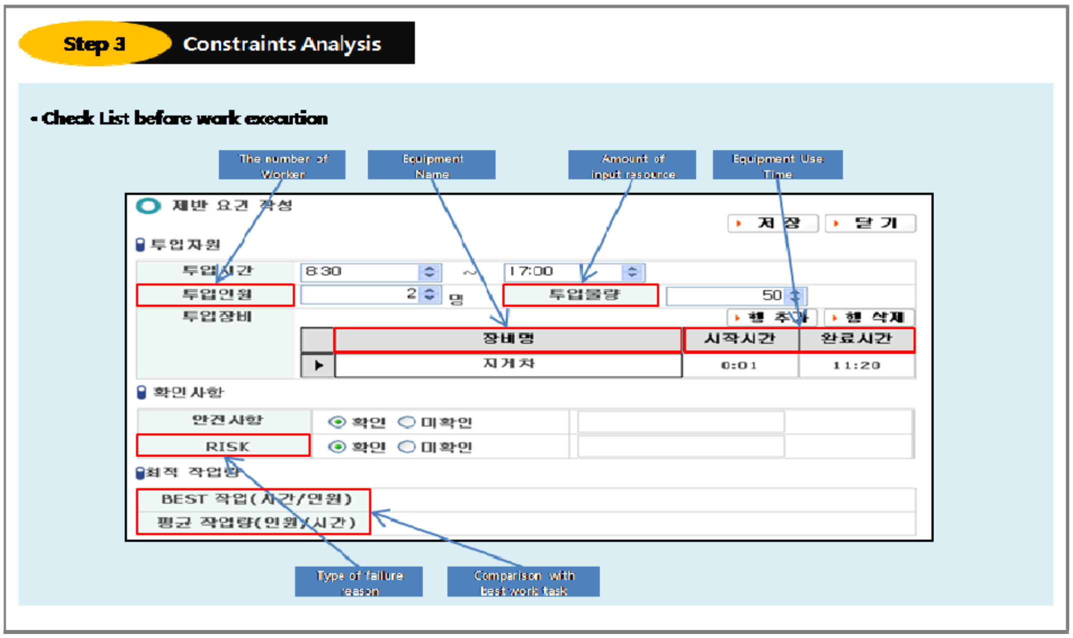

Figure 5. Step 1: Task setting

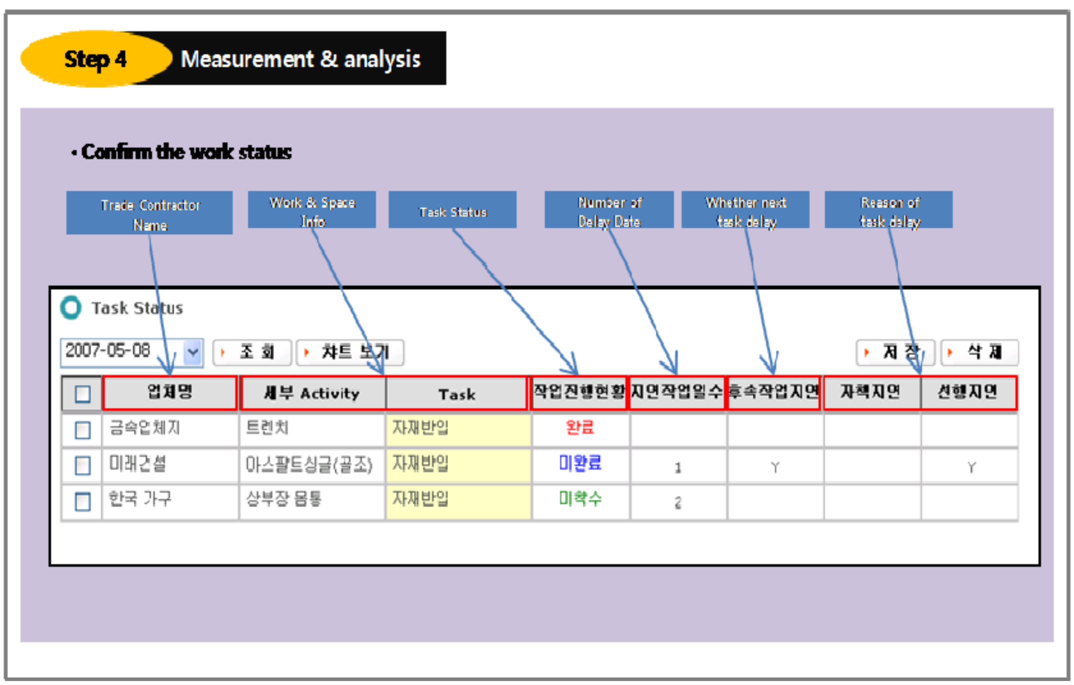

Figure 6. Step 1: Task setting

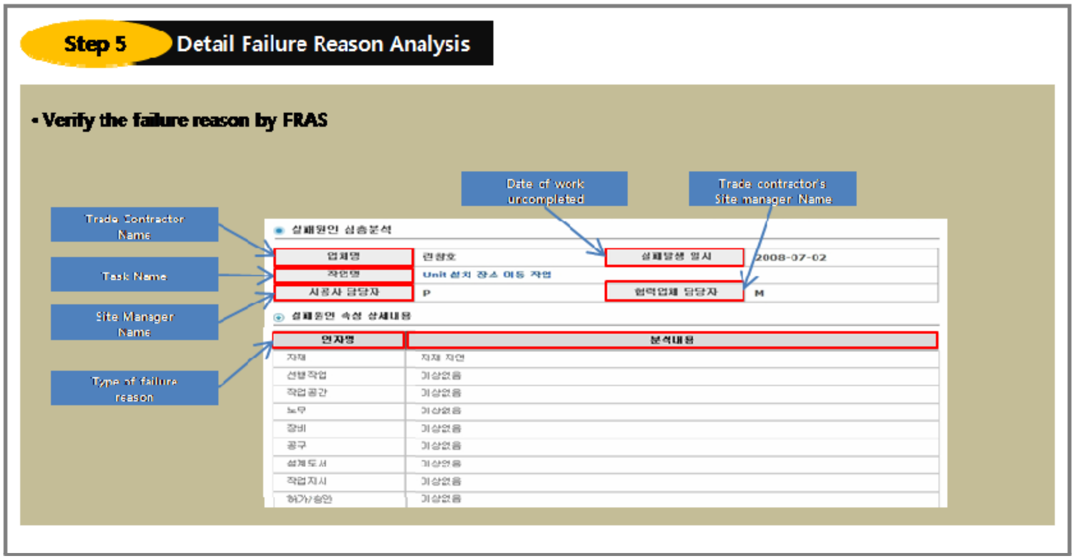

Figure 7. Step 1: Task setting

(2) **Step 5**: Detail failure reason analysis stage reduces occurrence of delay through identifying cause of delay in individual tasks of contractors with low progress rate or failure cause of not-started or incomplete activity that is not identified in Step 4(Fig. 7).

3.1. Database structure & data flow analysis of WPAS

Through IDEFO method for each detailed process managing procedure of the estimable process, we analyzed 4 kinds of characteristics such as 'Input', 'Output'. 'Control' and 'Mechanism' and define the process of the detailed processing management(Fig. 8).

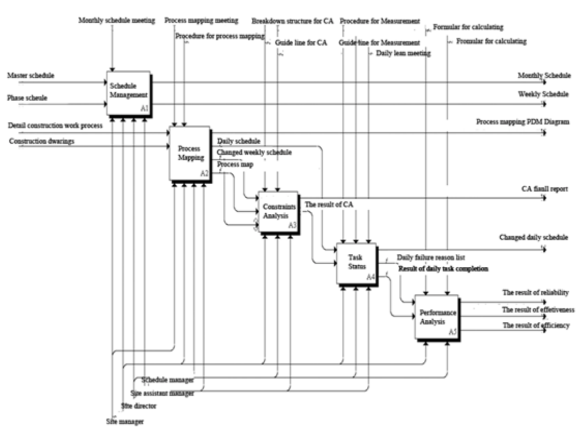

Figure 8. Data flow analysis of WPAS

Table 2. WPAS's input & output data

Classification	Input data	Output data
Initial Data of System	•General data of project · ID/PW by Each Partner ·Charger's data	·Outline of project ·Emergent contact network
Task Setting	·Task code setting data ·Task classified code setting data ·Partners' code setting data	·Task code ·Task classified code ·Partners' code
Management of Processing Map	·Process by each partner ·Period by unit task ·Several drafts ·Hierarchical relationship of partners ·Whether the same equipment is used or not ·Weather the spaces for task are impact each other or not ·Other task blocking cause	·Process by each partner ·Weather the spaces for task are impact each other or not ·Necessary equipment and man power ·Analysis of various conditions by partners and task
Management of Tasking Inventory	·Name of partners/task ·Task started date/Task Finished date ·Amount of individual task ·Necessary equipment and man power	·Monthly processing table ·Weekly processing table ·Daily tasking plan
Present Condition of Proceeding Task	·Name of task ·Condition of proceeding task ·Cause of tasking failure/Condition of including the tomorrow task ·Condition of delay remorse/priority of delay	·Name of the delayed task ·Contents of the cause for the task failure ·Name of the tomorrow task
Analysis of Performing Task	·Partners Code ·Name of charger ·Date and period of inspection	·Analysis table of the task reliability by partners/chargers ·Analysis table of task utility by the partners/chargers ·Analysis table of the task productivity by partners/chargers

		·Analysis table of task by the cause for task failure

In this study, we wrote data flowing diagram to analyze the data flow between the high positional modules and the low positional modules of the system of task performing analysis. (Fig. 9) shows DFD analytic screen of the stage of processing map.

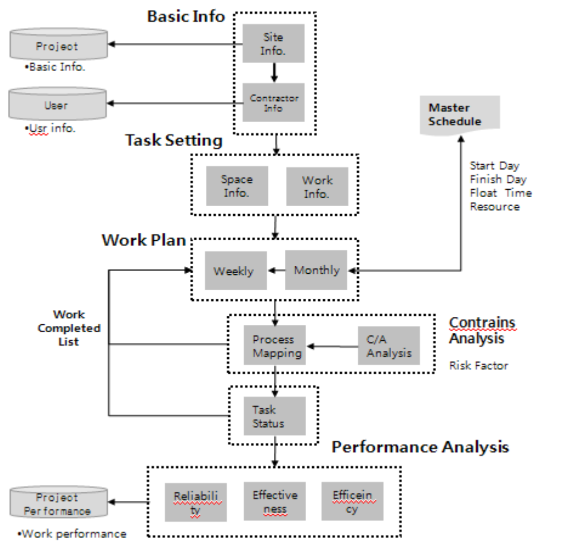

Figure 9. The example of WPAS's data flow diagram

We wrote object relation diagram according to the composition by the function of the system of task performing analysis at the stage of developing the stage and compose the relativity between individual objects analytic data model. (Fig. 10) shows entity relationship diagram(ERD) of task performing analysis.

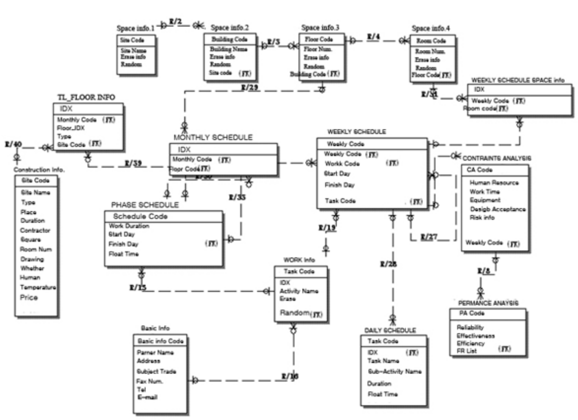

Figure 10. WPAS's entity relationship diagram

The chargers who join the system of task performing analysis consist of field foreman, process managing charger, field engineer and foreman of partner company. Filed foreman joins the management of processing map, taking a charge of whole the task. Process managing charger sets monthly plan, analyzes several conditions for each task on the weekly process table, confirms the content of tomorrow task and estimates task reliability. Field engineer performs revealing the process mapping and the cause of task failure and analyzing detailed cause of failure. Foreman of partner company writes weekly process table with a base of the monthly plan set by the process charger. Also, he takes the charge of confirming the task developed condition.

3.2. Functional formation of WPAS

In this study, like (Fig. 11), we composed total 6 high positional functioning modules such as inputting of basic data, task setting, management of tasking items, management of processing map, task status (present condition of task performing) and performance analysis. Also, under the this high positional modules, we composed total 12 low positional modules such as basic data of field, partners' data, positional data, professional data, monthly professional items, weekly professional items and processing map writing and confirming, present condition of task planning, tasking result managing, analysis of tasking reliability, analysis of tasking utility and analysis of productivity

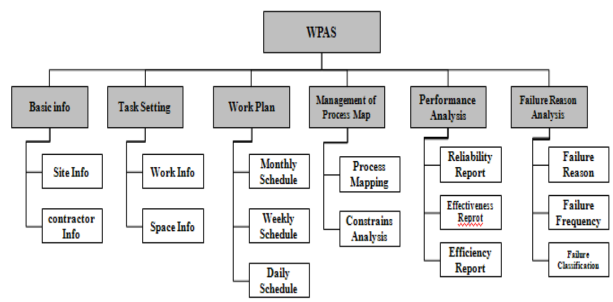

Figure 11. Functional formation of WPAS

3.3. Case Studies and validation of Work Performance Analysis System

In this study, we applied to WPAS in the apartment construction site during 1 month for validating the effectiveness of WPAS. (Table.3) shows the summary of the site.

Table 3. Summary of case study

Section	content
Project Name	OO Apartment Construction Site
Research Duration	Jan. 12 , 2009 ~ Feb. 8 , 2009
Subject Trade	Finishing work (Interior work, Electrical work, Fife fighting work, Equipment work)
Subject Building Num	Building Num 101, 103, 105

At first, we collected the basic data such as phase schedule, Monthly schedule, Weekly Schedule and documents related to the construction work. Second, we defined tasks for daily based measurement throughout the discussion with the site director. Third, we measured the work reliability and work failure reason in that site for 2 weeks without WPAS(As-Is case study) and 2 weeks by using WPAS(To-Be case study).

According to the measurement result during As-Is case study, the average of daily work reliability shows 71%(Fig. 12) and the total frequency of work failure is sixty seven(Fig 13).

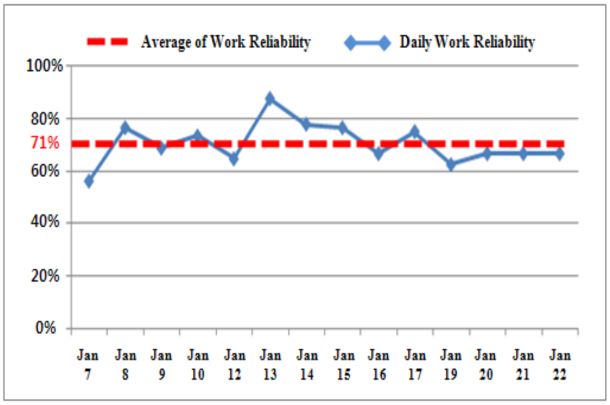

Figure 12. The change of daily work reliability during As-Is case study

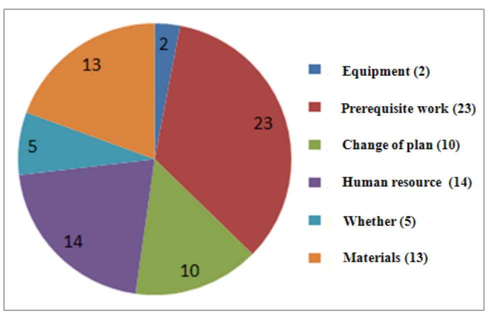

Figure 13. The frequency of work failure during As-Is case study

However, in the measurement result after applying to WPAS, the average of daily work reliability shows 84%(Fig. 14) and the total frequency of work failure is twenty one(Fig. 15).

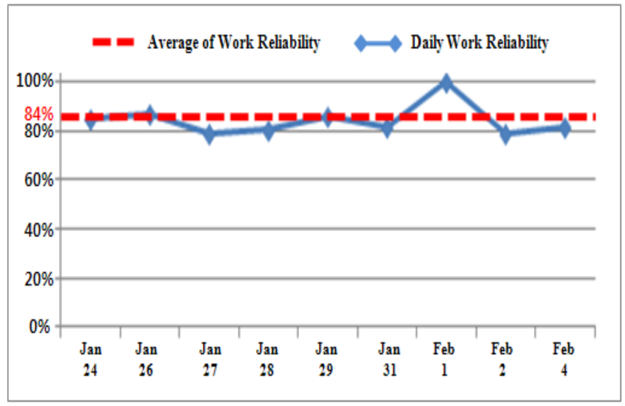

Figure 14. The change of daily work reliability during To-Be case study

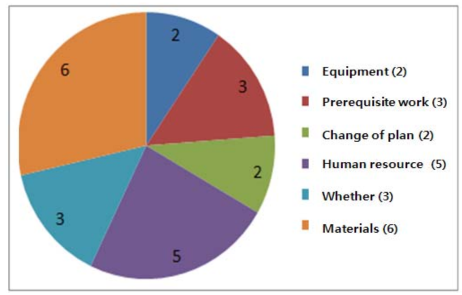

Figure 15. The frequency of work failure during To-Be case study

In this case study, we knew the possibility of WPAS's success in the finishing work. Specially, WPAS's constraints analysis before daily task execution was a major reason that reduced the frequency of work failure by eliminating the risk task. And WPAS's management of process map reinforced the comprehension to the other subcontractor's work process and showed that how they could have a big influence to all participants in the site by making uncompleted task themselves.

4. CONCLUSION

It is very important for measuring and analyzing the work performance to know "where am I" or "where will I go". Therefore, many researchers studied the methodology for measuring the performance at the level of task or project and suggested the many measurement indicators so far.

This study focused on developing the system to measure the work performance by using progress performance indicators such as work reliability, work effectiveness, work efficiency. We suggested (1) the definition of indicator to measure progress indicator of a project, (2) a major task process for WPAS, (3) database Structure and data flow analysis of WPAS, (4) functional format of WPAS, (5) review on system application through case study.

According to the interview and questionnaire in the site, WPAS had a big influence on improving the average of work reliability by using the constraints analysis and management of process map to eliminate the work failure risk factor during the system application.

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