

EFFECTIVE COLLECTION AND SHARING OF REWORK INFORMATION IN CONSTRUCTION PROCESS USING SMART MOBILE

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Abstract

Rework during the building construction process has begun to affect both schedule and cost overruns. There is, however, a lack of research on collection and management about rework information and it still has not examined the fundamental causes and suggested solutions. Also, Safety management is similar with Quality management in construction site from inspecting nonconformity parts to ordering rework and making report repeatedly. In this way, safety and quality management in construction site has a possibility of improving efficiency. Meanwhile, smart mobile, up-to-date technology, is lightweight, portable and easy to input data, so it is used to various industries. This paper proposes a web-based rework information management system to collect, share, and manage efficiently the rework information by grafting functions of smart mobile. It is recommended that the proposed system would improve a collection process of rework information as well as a quality of project performance by sharing and using rework information.

Keywords: Rework, construction, quality, safety, smart mobile, web-based rework information management system

1. INTRODUCTION

Uncertainty is inherent in construction, and because construction failures occur due to complex reasons, feedback of construction failure information created in the construction management process is most important to prevent failures (Love, 2008). Although specialists in the construction industry recognize the importance of construction failure information, sharing of construction failures has not been accomplished due to negative perspective that disadvantages in personnel performance assessment and decreases of the company's image

may occur (Park, 2009). Rework, which is one of the major reasons of failure in the construction industry, has been recognized as one of important management items affecting unexpected costs and delays. In the case of construction rework generated in the construction stage, it is understood that the average of 15% of the construction schedule is delayed (Love, 2002a) and an average of 5% of total construction cost is increased (CII, 2001). Also, even though knowledge sharing is important to prevent the rework, because, due to characteristics of the construction industry, team unity is dismantled when one project is finished, their knowledge is hard to be converted to the competitive power of the company (Lee, 2005). Besides, there are many cases that the processing of rework was done administratively at the construction site, then the generated information was been reused, similar reworks tend to be generated repetitively. the construction industry has the one-time feature of an outside production method, cannot manage all the information generated during the project and have a standardized process. Also, most inspection works are executed at the site while all information required for the decision making is saved in the office, so it is hard to use the current information. Moreover, because the construction industry has longer project periods than other industries and the participants vary and change frequently, the necessity of information management is huge. In addition, it is most important to achieve high quality in a safe way in the construction industry (Loushin, 2006). It is clear that the condition to inspect and manage is similar with quality and safety and it can prevent accidents by performing the scheduled task exactly as planned (Hinze & Wilson, 2000; Ketola et al., 2002). In this way, TQM(Total Quality Management) considers that safety is one of the factor in construction management (Husin, 2008). Actually, safety and quality management in construction site are quite similar in the meaning of proceeding according to PDCA (Plan, Do, Check, Act). However, Safety management is weighted towards Do compared to quality management, so safety management needs to consider all of the procedure of PDCA (Kim, 2008). Also, the process from inspecting nonconformity parts to ordering rework and saving the rework information on paper document is similar, but inefficient. Meanwhile, with the rapid development of recent IT, distribution rate of smart mobile has been increased, and many companies derive the efficiency of work using the smart mobile. Construction industry also tries to apply the smart mobile in the work. Specially, construction site where various construction materials and processes are mixed uses the smart mobile as a tool for human resource, process management, quality and safety management. This can reduce the time required in the documentation and management for existing work processes and increase the work efficiency. Most of all, necessary information can be searched immediately at the site by using the smart mobile, and this means that efficiency of construction management can be increased with fast and accurate decision making. This study is to develop the rework information related to safety and quality management and sharing system using the smart mobile to solve the problems related to the rework information. To do this, existing rework process is understood, and by using the smart mobile technology, process the rework information can easily be saved. Based on this, knowledge-sharing system that inside and outside company sharing of rework information is available will be suggested. To verify the application of the suggested system in this study, a survey on the efficiency of rework management systems using the smart phone was conducted the survey targeted working-level persons, and was an investigation on the recognition of the possibility of a knowledge sharing system

2. LITERATURE REVIEW

Rework Research in Construction

Construction rework is defined variously in the researches related to the construction management. Ashford(1992) defines it that process satisfying the requirements with repetitions of completion and modification, and CIDA(1995), Love(1999) defines it that task executing nonconformity situations suitable for the requirement. CII(2001) defines the construction rework from the work, which executes the completed work again in the site and to the work, which removes the previously installed ones. Generally, construction rework means that work which should be repeated to accomplish the target quality.

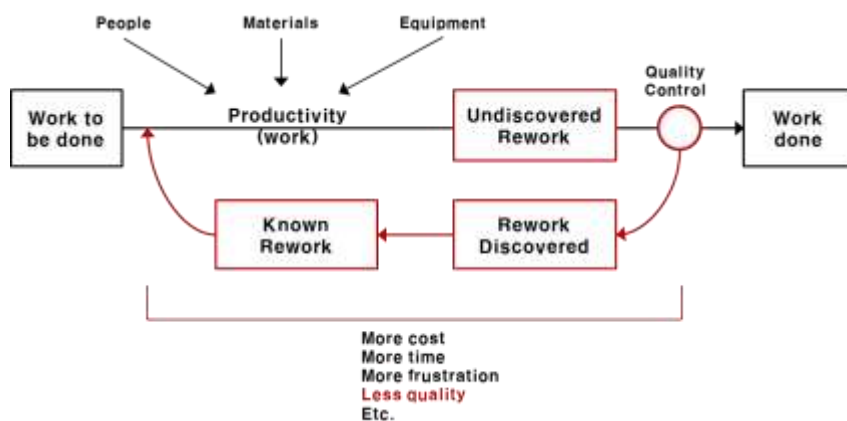


Figure 1: The Quality Control Rework Cycle (AEW Services, 2001)

Figure1 means the rework should be executed by discovering the necessary parts for the rework underlying during already completed work through the quality management in the construction process. Because work previously executed is repeated while rework is discovered and executed, additional cost and item is also required. Also, in the construction site, numbers of workers execute the construction work by using various materials and equipment, management is getting complex, and due to lack of the communication between participants, it is easy to generate the rework.

To solve this problem, various researches on the rework have been performed.

Love (199) tried to prevent the rework by investigating the reasons of rework in the actual construction project. Hwang, Bon Gang (2009a, b) argues the necessity of rework to maximize the construction cost performance by analyzing the construction rework from the construction project. Love (2004) argues that from the result of rework reason analysis, there is lack of communication in the design team including ordering body and suggested the new ordering system focused on communications. In addition, Zhang(2009) figured out the rework information in the construction industry to suggest the task modification and integrated management system to prevent the rework.

If previous researches were compared, they finds out the reason for construction rework and emphasizes the necessity of rework management by calculating the additional cost generated

due to the rework, and suggests the management system for this. However, suggested communication-focused ordering system, task modification and integrated management system only expresses the theoretical suggestion, and researches on investigation and improvement about rework process and saving of rework information are not sufficient. Also, by looking for the reasons through analysis of saved rework information, it emphasizes the importance of rework information, but researches on suggesting the basic solution through rework information sharing is insufficient.

Thus, this study suggests the sharing system using the web and improving the rework process in the construction site by using the smart mobile. For using this system to search the defect of safety and quality then save it all, it can improve the efficiency of construction site management.

Smart Mobile in Construction Industry

Smart mobile can do long-distance work process and is portable, and opinion sharing among relating people is easy. In addition, when saving data, real-time data saving is possible, and since work can be done even in offline situation, it can solve the problems caused by differences between site and office works, and it can promote the productivity increases. These advantages are also used in the construction industry.

Irizarry(2009) suggests the adjacent construction equipment rental place searching application and application, which can be used in the safety education, and relating education data can be searched in real times if education data related to the safety management is required in the site.

Domestic A construction company interlocks the Project Management Information System(PMIS) established and used in the company to the smart mobile, so basic which can use the smart mobile not only in the task, such as mail, board and approval, but also in construction, labor and material management in the site has been operated. Specially, work order for the work, which can be the problem during site inspection, is registered with the smart mobile to use them in the management task under offline (Lee, 2011). However, in real tasks, if smart mobile and PMIS is used in a same time, it can be recognized as the overload of overlapped work of information input.

I-phone based “Site Clean Up” is the site environment management application, and construction manager can take a picture of place where environment management is required, even he/she does not meet the subcontractor, to order the countermeasure. Also, subcontractor can take a picture of modified environment right after executing the order and send it to the construction manager for the confirmation. Like this, if smart mobile is used in the construction site, information exchange can be done faster so that efficient of management work can be increased.

Smart mobile can search the information in the outside of site, and advantage which decision for the work is that moves to the office after site inspection in the rework process. And, process finding relating information can be done in a same time with the site inspection, and picture took with the smart mobile is sent to web automatically, so transmission process of

picture information took by camera to the computer can be omitted.

3. DEVELOPMENT OF REWORK MANAGEMENT SYSTEM

Overview of Rework Management System

Document used when quality and safety management in the construction site consists of various items, such as work procedure, drawing, check list, manual, etc., and these document are saved in computerized document format. However, because a manager uses printed paper when inspecting the site, it is hard to find the required information in a short time so they should move to the office to find out the required document (Cho, 2007). In addition, to record the inspected content, they should move to the office again, and if there is much data to be recorded after the inspection, and it is hard to memorize the all contents without looking at the site when he moves to the office. Specifically, in case of rework, there is a lot of information to be obtained depending on required quality and safety standard. The field situation should be recorded accurately, as there are many inefficient parts of work if a computer is only used.

Thus, this study applies the smart mobile to the rework process to search the quality information in real times at the site, so fast decision making is possible. Information can then be saved without any overlap between the site and the office.

Also, by analyzing the rework information saved through the web and comparing it to the daily quality and safety management plan of other current projects. This comparison to the quality and safety management plan of other projects is done so that rework can be prevented. Through a web-based system, the availability of rework information which is insufficient can be improved and sharing utilization can be increased. Beside, saved rework information can be linked with PMIS using site management in each company, thus site information can be managed more efficiently.

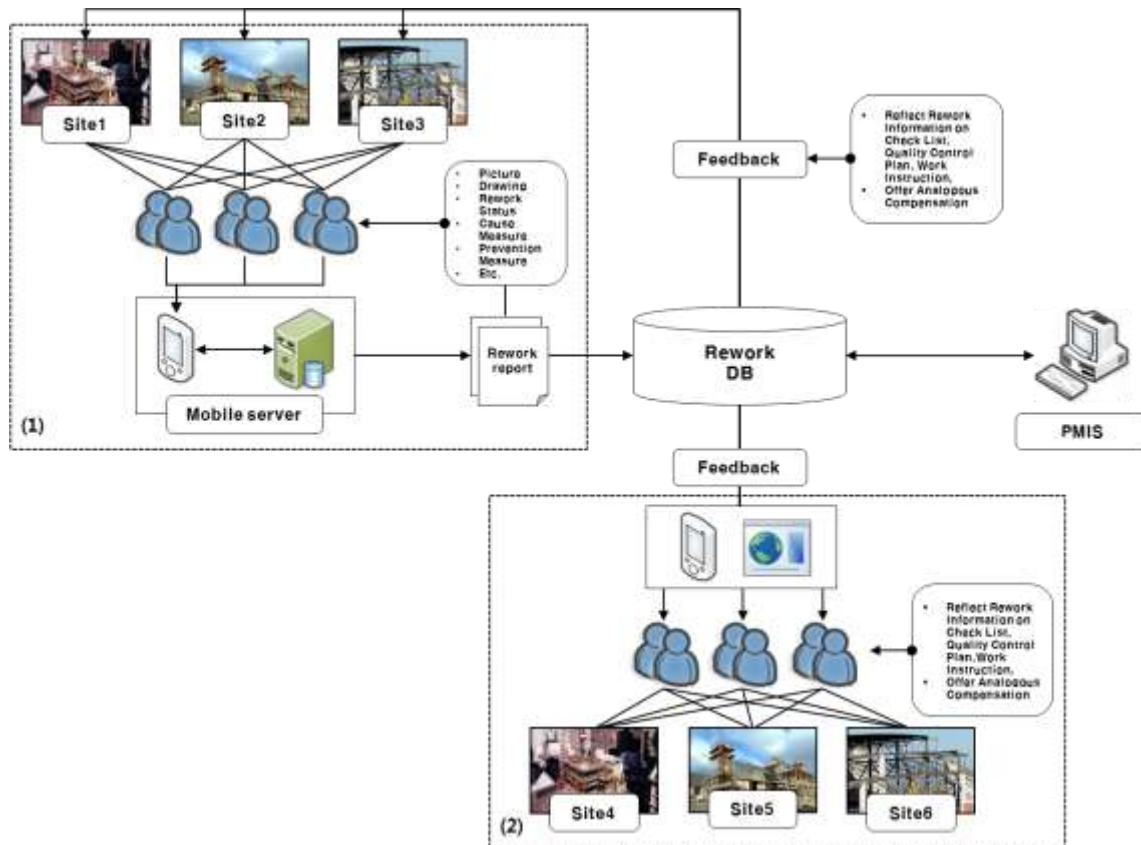


Figure 2: Conceptual model of Construction Rework Information System

Rework information management system suggested in this study consists of two parts as shown in figure 2.

(1) Support internal task process: saves the rework information generated in various projects executed by one company by using the smart mobile and write them to rework report, and by saving them in web server, Rework Database will be created.

(2) Sharing internal information: saved rework database searches similar data depending on parts, processes, and materials and can be used as field and quality management data on other projects.

Meanwhile, task process of construction rework information, which is complex when a rework information management system is used, can save time, which in and out of the field and office by using the smart mobile. Also, by using the web, saving and sharing of information is possible. Thus wider knowledge management is possible.

The web system in this study can use the internal task process supporting and internal information sharing which saves the rework information. However, outer sharing of rework information may be hard because of negative awareness about publication of failure information and because rework is recognized as a failure. It is assumed that an efficient connection plan with a quality and safety management system, is being used in the existing construction, overall management system.

Development of Rework Process Using Smart Mobile

(1) Overview of Rework Process in construction

This section compares the procedure of the rework information management system using smart mobile to existing task procedures. The existing task procedure was researched and generalized through a literature review related to the rework task procedure and Site Personnel interviews as shown in figure 3.

The nonconformity report is the report prepared to find the nonconformity parts of quality or safety shown at the construction site and correct it. The rework action plan is recorded together with it, and both should receive the final approval of site manager.

The rework result report indicates the rework to improve the nonconformity situation, decide and record the action taken, and contains the entire company's information from the discovery of rework to the result confirmation

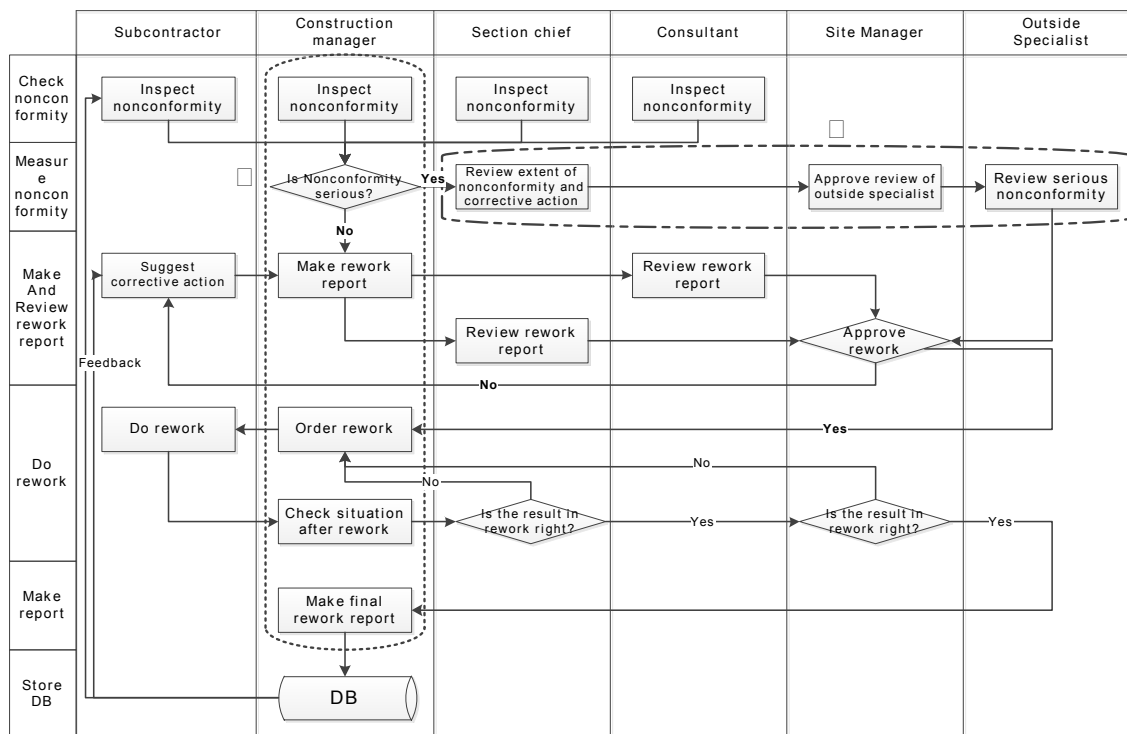


Figure 3: Flow Diagram of Rework Process in construction field

At the site, construction manager executes quality and safety management continuously and finds out the nonconformity situation, where rework is required. The construction manager, subcontractor, chief and consultant discover the nonconformity situation and inform it to the construction manager. The construction manager decides the level of nonconformity, and if he decides that it is serious, he requests the review of the outside specialist through an internal meeting to find the solution. After the review of outside specialist is finished, rework is ordered and executed through the rework approval of the site manager. If then nonconformity is minor, a rework report can be prepared with the construction manager's judgment. The subcontractor who executes the nonconformity parts should suggest the rework plan to solve the nonconformity when preparing the rework report. The rework report prepared by the construction manager is submitted to the chief and consultant for the review

process. After the reviewing, the site manager approves the rework, if the rework is not approved, efficient measures should be suggested again. The suggested measure is indicated in the rework report again and the review and approval process will be repeated. When the rework approval of site manager is completed, the construction manager requests the subcontractor who constructed the nonconformity part the rework to confirm that the rework is completed. The chief informs the site manager of the rework result if the action taken is not satisfactory. If correction does not satisfy quality and safety standards or additional work is required, he requests the construction manager to do the rework again. Rework content taken and verified by the site manager is included in the rework result report by the construction manager and saved as rework DB.

Case of No. ① is the minor nonconformity case generated frequently at the site, and is work which can be solved without any special meeting. Thus, if smart mobile is applied to the No. 1 process, it is possible to increase the improvement of the rework task.

Case of No. ② is the serious nonconformity case, so it does not occur frequently, but because the nonconformity information is delivered to the outside, security of the information is important. Because a meeting should be held the time required for the work process is long, and the work procedure is complex. Thus there are many people who participate in the decision-making process. Due to this reason, it was decided that the rework task was hard to improve by applying the smart mobile.

(2) Existing Rework Information Management Process using Computer

If the No. ① task is considered the task that can be improved by using the smart mobile, it can be divided into discover of rework task, decision, record, execution, and preparation of report; and tasks executed at the site and office, it can be shown Figure 4.

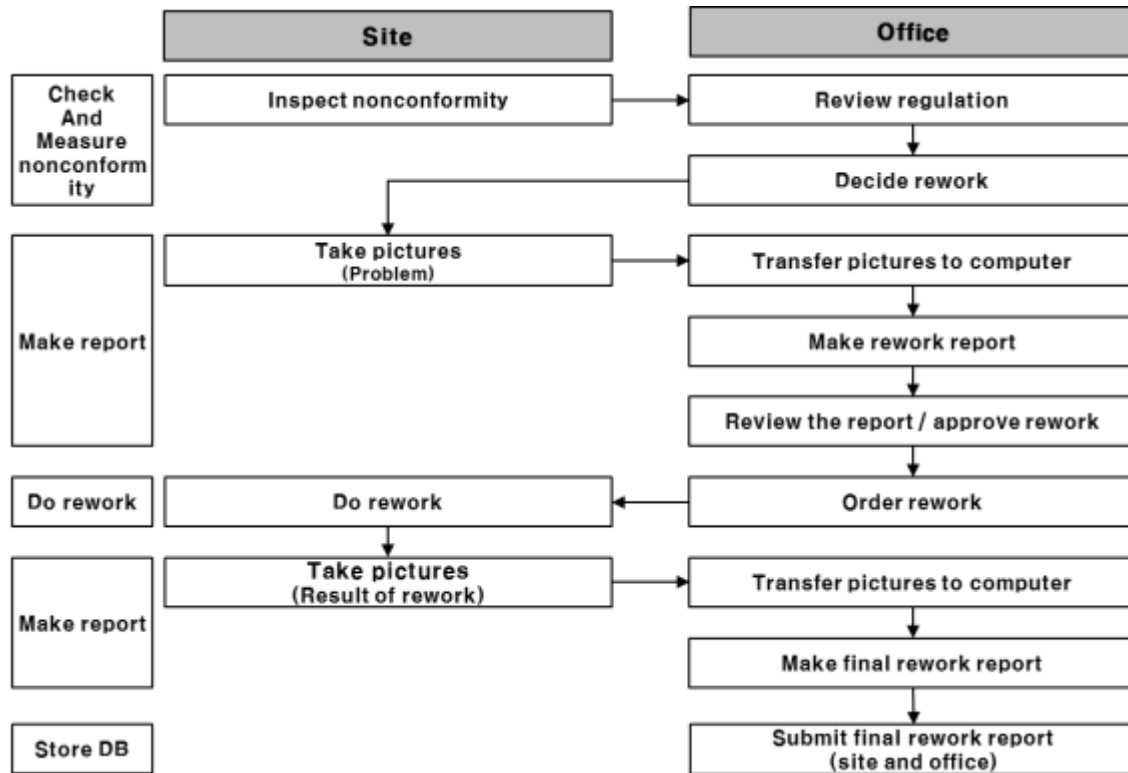


Figure 4: Flow Diagram of As-Is Rework Process in construction field

If defect items are discovered during inspection that do not meet the quality and safety standards and relevant regulations such as drawings, specifications and regulations, the field manager decides whether rework is necessary. If he decides that rework is required, he moves to the field, takes pictures of site with a digital camera and records the circumstances. After he defines the site conditions, he returns to the field office and transfers the picture data in the digital camera and searches the drawings, specifications, work procedures and quality and safety standards related to the part where rework is required. He then writes the 1st nonconformity report. When the 1st nonconformity report is finished, rework is ordered by approval of the construction site manager. If rework is ordered for subcontractor, the quality standard related to the rework report should be provided so that subcontractor can accurately understand the work contents. After the subcontractor's rework is completed, the field manager checks whether it achieves the target quality and meets the safety standard through site investigation and review and whether or not it should be reworked. The field manager should return to the office after checking the rework results, and inputs the rework information into the 1st nonconformity report.

As described in above, there are too many waste of times while he comes and goes between the field and office, making the process of rework information inefficient. Also, there are many cases that the nonconformity report may be completed after writing the paper.

(3) Improved Rework Management Process using Smart Mobile

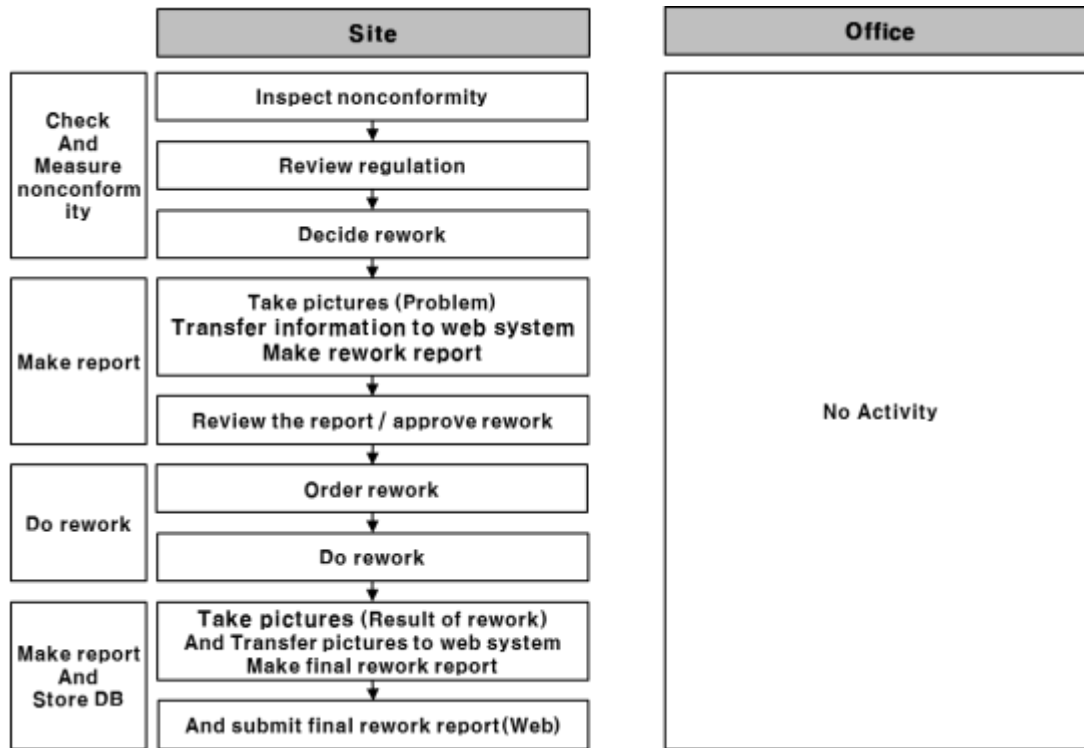
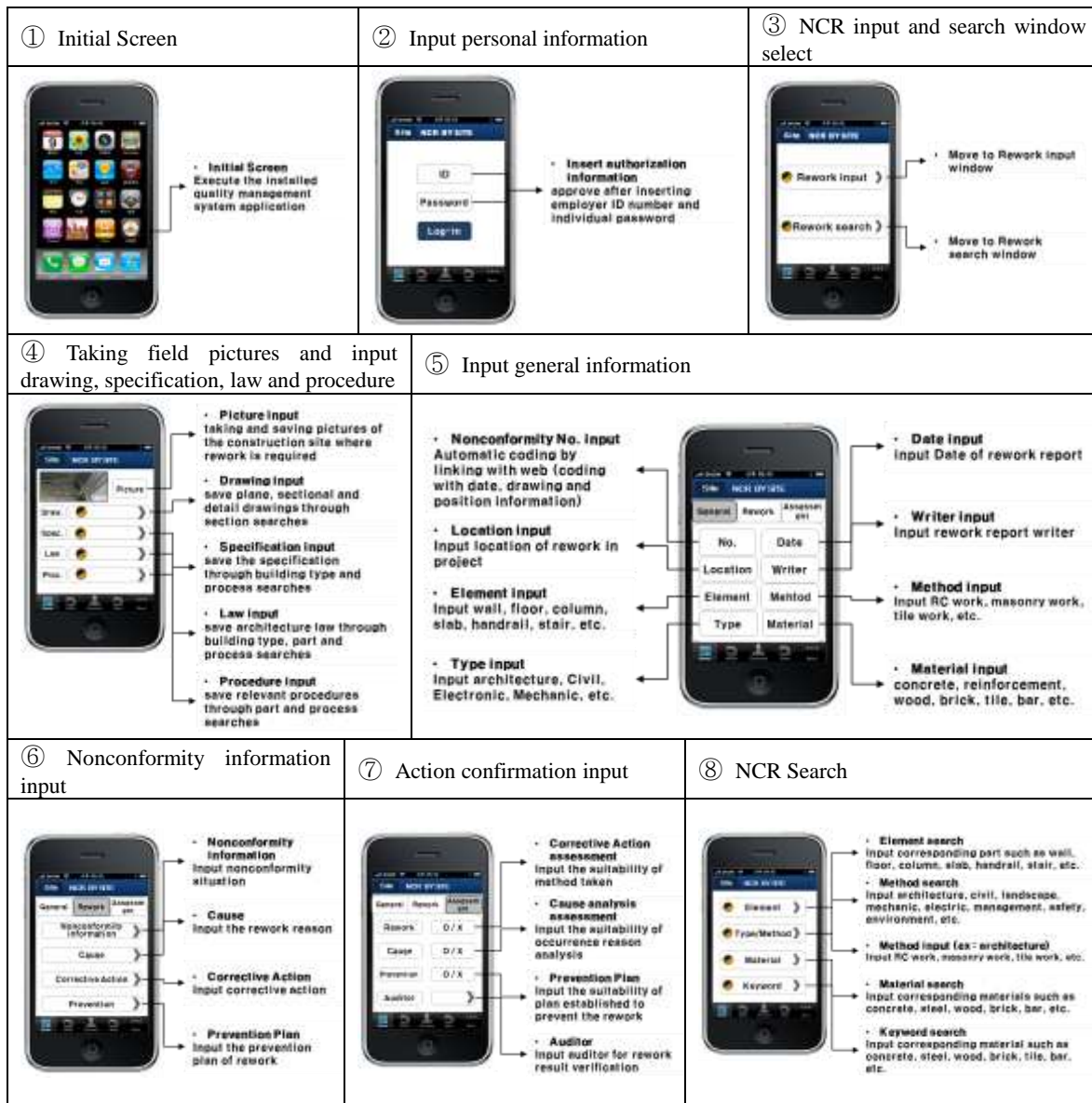


Figure 5: Flow Diagram of To-Be Rework Process in construction field

If smart mobile application is used, field manager can search the drawing, specification, law, construction plan and work order in real times, so he can find out nonconformity items and decide the necessity of rework. In addition, while field inspection is executed, by using the camera equipped in the smart mobile, field picture can be taken and saved while sending them to the rework information management system established previously. Input all the information related to the rework, prepare the measurement report and by using the mail sending function of smart mobile, send it automatically. Then after approval of the site manager is received, rework is ordered and executed. After the rework is completed, take pictures of the action taken and send them to the system to prepare the results report. The system in this study saves the final nonconformity report in the web-based system. Stored rework information can provide feedback to the similar rework information through parts, process, material, and keyword searches. The improved rework process, when smart mobile is applied to the rework information management, task done in the office will be reduced and handled immediately at the site. This means that field management can be done efficiently by overcoming the gaps of task due to distances between field and office. Meanwhile, to use the smart mobile in the field tasks requires interface configuration and execution processes.

4. DEVELOPMENT DETAILED SYSTEM

Smart Mobile Interface for Data Input and Process



This application is developed using ios. It creates the screen that can save report and search the rework information generated during the construction stage. When looking at the interface flow of rework information for a management application; first, execute the application, and insert the employer ID and password to login, then select screen which can insert the Rework information from the site and search for similar Rework information. When the rework, which you want to search, is inserted, the picture, drawing, specification, law, and procedure can be inputted with a simple touch of screen. Then other information input is completed, general information such as nonconformity Number., date, writer, location that happen construction rework and the type, method, and material are inputted,

then nonconformity information of contents, reason, action taken and prevention plan can be inserted. Finally, after the rework information is inputted, evaluation on rework executed can be inserted. When rework information is searched, element, method, material and keywords are inserted, choose to derive the similar cases. In case of architecture work, construction methods can be divided into temporary work, earth work, bracing work, foundation work, reinforce concrete construction, steel construction, water-proof construction, masonry work, tile work, carpenter's work, curtain wall construction, stone construction, roof work, fitting, glass work, plastering work, metal work, painting work and other work, by using the touch method, then inserting and searching the construction-type.

Web Process

Rework information inserted by using the smart mobile is saved in the server as an electric document through the web-based system. The construction manager can search the rework information and compare it to the quality management plan by using the computer and smart mobile at the construction site. Thus, activation of feedback of rework information saved through this is possible. To do this, content configuration of the web interface is important as follows. In the case of searching for rework information that is already saved for other construction site, the generalization process, which removes the unnecessary information such as nonconformity report number, date, and writer, will be executed. It will be divided into general information, rework information and other references. The general information includes element, method, and material and the nonconformity information. It shows about all of conditions related to the rework and prevention plan as text. In addition the front and the rear situation pictures of rework corrective action taken will be displayed on the screen with text. In the other reference, an additional window will pop up when clicking, then specification, construction plan, work order, and building law can be downloaded. Web interface should be easy for all inserters and users. This emphasizes the importance of rework information to minimize the negative awareness that the release of rework information damages company reputation. To do this, generalization of information should be required and before establishing the system, various opinions should be accepted through expert consultation.

5. QUESTIONNAIRE SURVEY

(1) Summary of Survey

A survey of the Site Personnel was conducted to determine the quality and safety management and rework information management system that is established and used in the construction company. A total of 50 surveys were distributed and 50 copies were collected. Survey items consists of personal data, rework information management system in the company, real condition, field task application status of smart mobile in the field task, web-based sharing system status, and capability of suggested system.

(2) Efficient of Rework Task using Smart Mobile

From the survey results, some large construction companies have already established an information and management system, so the rework task has been also processed and inputted electronically. This is a formal task, and in the case of small and medium-sized

enterprises, most do not have an information management system due to economic issues. There are many reasons why feedback of rework information is not done, for example, the rework report is stored in paper and disposed when project is completed. In addition, they feel it is inconvenient to save the rework information and writing the report.

From the results of this study, diagramming the rework task smart mobile process was done. Smart mobile is used it can reduce the differences between field and office tasks. Also, there is the opinion that even if the system is not established, the application of smart mobile is useful because drawings can be checked in the field using CAD applications or PDF and Hangul documents can be saved so that they can be checked at the site.

As above, if smart mobile is used, not only management efficiency improves but also applications in various tasks can improve.

(3) Analysis of Awareness on Rework Sharing System

Everybody agrees the necessity of sharing and the importance of rework information. Negative awareness results were found because it was thought that rework is a site failure and company information leakage is a failure of the company negatively effecting personal performance evaluation. However, it shows that if rework information is generalized within the scope which does not influence the negative effect on the company's image, 70% of the respondents may share the rework information with others. There are many opinions when sharing rework information internally. Evasion of the responsibility for rework should be avoided, and modification of restrictions on the occurrence rework is required.

Based on the survey results, establishing the system requires consideration of social awareness. To do this, regulations for rework information should be submitted for public orders. Also, for internal and external sharing of rework information, generalization of information should be performed first, and the cost of establishing the system should be minimized. In addition, the difficulty of smart mobile application and web-based information management system should be lower to increase their efficiency.

6. CONCLUSION

Because rework in the construction industry increases the cost and delays the schedule, and the re-occurrence rate is high, management of rework is required. Although people working in the construction industry are aware of the importance of rework information, there is no effort to share rework information because of the negative connotations of rework. Because information which task processes of rework information cannot be verified through surveys, the task of coming and going between field and office has been done inefficiently. The places where rework information management systems are established are limited to certain major companies.

By using the smart mobile suggested in this study, necessary information can be searched rapidly, and rework information can be saved, so efficient tasks can be achieved by improving the construction rework process. Also, through web-based rework information system, sharing of rework information is possible. Thus, negative awareness of rework in the

construction industry can be changed and information difference between major company and small and medium-sized company can be reduced. Regardless of the size of a company, rework rate in the field can be reduced by sharing rework information.

Rework information saved and shared through a rework information management system can be used as construction class material in the university, and it can be reused as the educational data for new employees and subcontractor's employees. In addition, reflecting on the quality and safety management procedure at the site is the place where rework occurs can be easily managed in advance.

However, a rework information management system as suggested in this study is only a prototype, and to implement this concept, technical items for establishing the system should be considered. Also, a rework information system prototype which is the final output of this study was not applied at an actual sites, but only in the research survey. Finally, since it uses the existing integrated construction information classification system, if this classification system is used for the core information by analyzing various rework cases, it is expected that the search for and use of rework information can be easy.

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