A SYSTEMIZED APPLICATION METHOD OF RFID TECHNOLOGY FOR LOGISTICS IN BUILDING CONSTRUCTION PROJECTS

Koo, Do-Hyung[1], Yoon, Su-Won[1] , Chin, Sangyoon[2], Kwon, Soon-Wook[1], Kim, Yea-Sang[3]
[1] Dept. of Civil, Architectural, and Environmental System Engineering, Sungkyunkwan Univ., Suwon 400-746, S. Korea
[2] Dept. of Civil, Architectural, and Environmental System Engineering, Sungkyunkwan Univ., Suwon 400-746, S. Korea, schin@skku.edu
[3] Dept. of Architecture, Sungkyunkwan Univ., Suwon 400-746, S. Korea

Abstract

An effective logistics management is necessary for successful construction projects. So, prompt and precise logistics information collecting and management is needed, but there has been no systematic and effective method for this, Therefore, in this research, a standardized plan for RFID application in logistics management that could comprehend processes in building construction projects, was developed. With the 7 generalized process types that comprehend processes in construction projects, critical factors that should be considered for RFID applications were derived, and systematic and efficient application method for building projects were developed.

Keywords : Logistics, Progress management, RFID, Information Technology

1. Introduction

In construction projects, effective logistics management is a necessity for successful project management, but currently the field supervisor manages the construction project and manages logistics according to subjective methods by applying characteristics which vary from project to project. Therefore, these logistics managements possess problems in aspects of errors and reliability, causing schedule delay, low productivity and poor quality, so a systemized way for logistics management is necessary.

Currently, a ubiquitous era in which ever-developing computer technology is enabling information acquisition from anywhere, has opened. Already in the construction fields, the barcode techniques have been overtaken by RFID (Radio Frequency Identification) technology which is the core technology in the ubiquitous era, for project logistics management, with surging efforts into overcoming the limits of former logistics management, and the range of RFID-based management has been expanded to ready-mix concrete (Jaselskis 1995), steel frames (Chin 2005), curtain walls (Yoon 2005), and finishing materials (Kwon 2004).

However, the existing application of RFID in the construction industry focuses only on core materials, lacking consideration of applying it to the overall construction project. Especially, applying state-of-the-art technology like RFID to the logistics process is only presented in fragments according to each corresponding material, and research on process analysis and classification of materials related to the construction project has been lack.

Therefore, the objective of this research is to develop a systemized application method for RFID technology in logistics management to solve the current problems.

For this, a logistics process comprehending every project processes was derived from analyzing the present state of logistics management by interviewing construction practitioners and referring to classification systems for work items in buildings. Also, based on this research, a systemized method for applying RFID technology to logistics management processes, and its subordinate factors, and measurement plans was derived.

2. Features and applicative trends of RFID technology and problems

2.1 Definition of RFID and features

There are several domestic and overseas institutions defining RFID, but the Ministry of Information and Communication is perceiving it as an 'U-sensor network service' and defined it as 'providing services of information exchange between objects, location determination, teleprocessing system, and management by attaching electronic tags on products and collecting/processing information for each product'. Also, MIT Auto ID Center defined RFID as 'the internet of things', and described it as remote sensing tag-attached items in real time, through the internet or similar networks.

For RFID applications, we can examine by dividing into technological capacities, which includes methods of operating with batteries, methods of information storage in tags, frequency, recognition distance, recognition speed, environmental influence, tag size, and memory capacity, and system operating features, which include codes and industry standards related to encryption, verification, and identification of recognizing target.

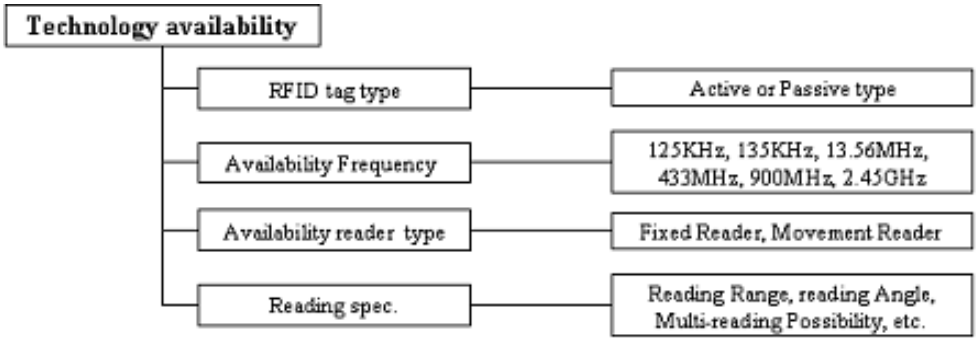


Figure 1 : Technology availability for RFID application (Chin, 2004)

Technological capacity can be classified into RFID tag types, available frequency, available reader types, and reading specifications as shown in Figure 1. Tag types can be divided into passive and active types according to the power provision methods for data transmission. There are 6 types of frequencies, but usually 125KHz, 13.56MHz and 900MHz are utilized in Korea according to the situation of the application field. Reader types can be divided into fixed readers that are installed in fixed locations such as the field entrance, and mobile readers which can be carried by the field supervisor. Reading specs must be used accordingly to the appropriate situation, after considering tag and reader's reading range, angle, and multi-reading capability. These matters, of field characteristics, must be considered to derive the most effective application plan for each project.

2.2 Cast study for RFID applications in the construction Industry

There are various fields applying RFID including transportation, manufacturing, admission restrains, food, logistics, sports and medical fields. Recently, various research has been performed, and they include Jaselskis's(2003) application flow diagram and Chin's (2004) strategic consideration matters.

Jaselsikis (2003) presented that the consideration on the performance that RFID application requires is necessary, and Chin (2004) insisted that not only technical availability is needed, but also that domain applicability and information management strategy is necessary.

Furthermore, RFID application has been developed for logistics in a plant project (CII 2003), and for highway construction projects by the Federal Highway Administration of USA (Cawley 2003).

Bechtel (CII 2003) used the passive type tag and handheld reader to produce a 30% reduction in required time for the procurement management of pipes and pipe hangers. The Federal Highway Administration (Cawley 2003) used RFID to analyze the health of concrete by measuring temperature during the construction of a highway, and suggested the possibility of applying RFID in the stage of conditional modification and maintenance by using temperature-measuring sensors.

In Korea, RFID application examples can be sighted in personnel management, ready-mixer concrete operation (Choi 2004), structural steel management (Chin 2006), and curtain wall material management (Chin 2005) in construction projects. However, the existing research and examples only present flow charts based on technical consideration and strategies to overcome its limits, or mentioning fragmented trial examples and RFID applications based on only a few materials without sufficient consideration on applying RFID to logistics management for overall processes in construction. Also, RFID application plans may alter depending on the characteristics of a project, so a systemized logistics management process is needed to comprehend the whole construction projects. Therefore, to derive a systemized method for effective RFID application, it is necessary to derive generalized types of construction logistics in construction projects and to analyze critical factors that should be considered in various phases of a project life cycle.

3. Analysis on logistics management process depending on construction work types

3.1 Classification stage for analyzing process

The analysis of logistics management processes has been undertaken to analyze the process of each construction work type and its sub-work types to derive process types and critical factors to be considered in each process of logistics management. The construction work items were classified into the 17 items at the highest level and 80 items at the medium level according to the standard of 'integrated construction information classification system' announced by the Ministry of Construction and Transportation of Korea government. And then 5 office projects are analyzed to classify the main work items of a building construction project and to derive 176 related items at the medium level. The process analysis was performed according to the material acquisition methods and site construction methods, material types, material units, labor and key equipments of each construction line as shown in Figure 2.

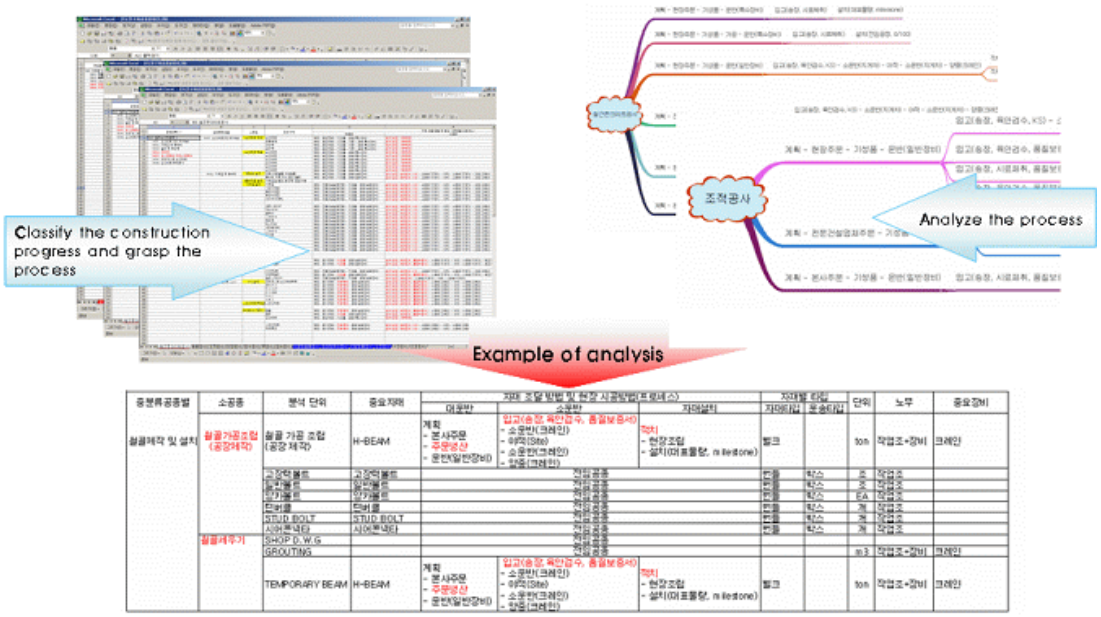


Figure 2 : Example of the analyze the process about the logistics and the progress management

3.2 Deduction of process types for logistics management in construction

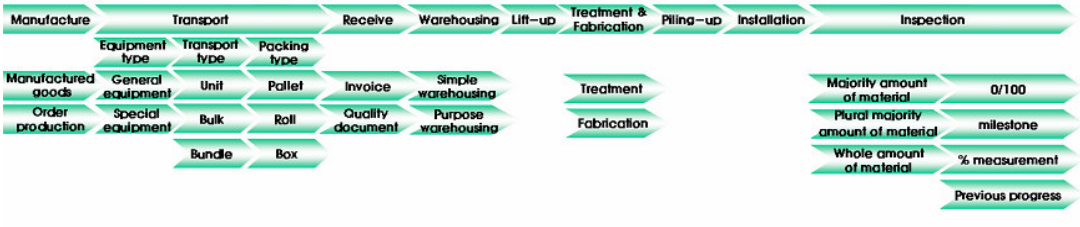


Figure 3: Classification of the work process

Based on the analysis of logistics and progress management process by each construction work items, it was identified that the process could be different by the situation according to the project characteristics and supervising methods. Each process can go through stages of production, shipping, warehousing, storage, treatment and assembling, piling, installing, verifying, and there are subordinate aspects for each stage as shown in Figure 3. Considering all possible combination of those processes, it was identified that total 1,008 different processes could be derived based on 176 construction work items. However, most of these numerous processes could be summarized into just a few standardized processes due to their redundancies.

Categorizing a RFID-based logistics management process into 7 types enables to reduce the initial required time, cost, trial and error in the application of RFID technology. And it is more helpful to supervise and manage the project in the big picture. Therefore, in this research, the characteristics of the seven standardized process types were analyzed as shown in Figure 4.

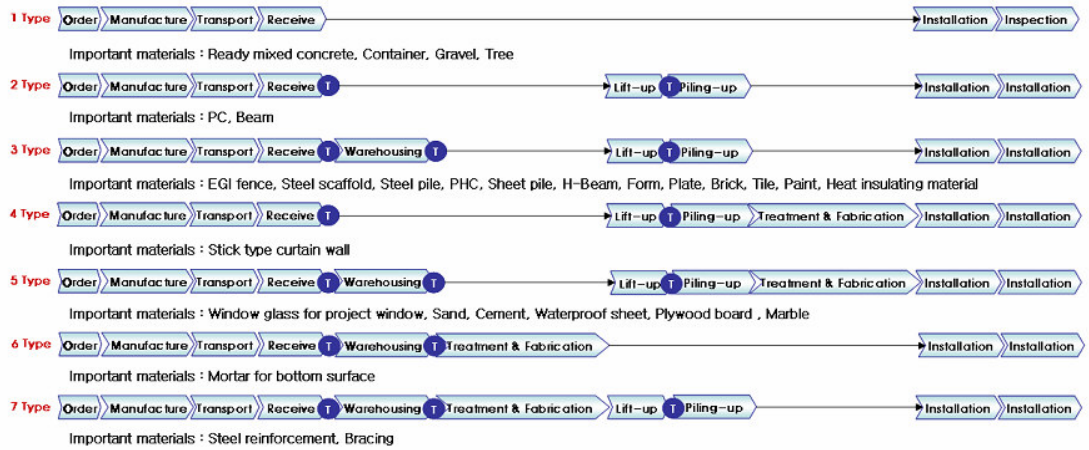


Figure 4 : 7 kinds of process type

Type 1: This process runs directly from receipt to installation at construction site. Mostly bulk materials, such as ready-mixer concrete, aggregates for concrete, and components that can be directly installed as soon as they are received at the site belong to this process.

Type 2: Materials or components that are installed and verified without warehousing or piling, such as precast and steel components belong to in this type.

Type 3: The most components and materials belong to this process. This process goes through receipt, warehousing, lift-up, piling-up, installation,, and installation confirmation.

Type 4: After receipt, they are piled-up at the installation location. And assembling is conducted right before installation Construction materials that require treatment and assembling at the construction site before installation like stick-type curtain walls.

Type 5: After receipt, shipping, storage, piling, treatment and assembling, installation, verification stages are processed, and materials such as sand, cement, and ready-mixer mortar are included in this process.

Type 6: Materials like floor mortar that goes through receipt, warehousing, assembly, and installation belong to this process.

Type 7: After warehousing, treatment, and assembling, assembled components are lifted up and piled before installation and verification stages. Rebars and bracing materials that are assembled at work sites belong to this process.

3.3 Considerations for each stage of RFID-based logistics management

For appropriate RFID application plans to achieve RFID-based logistics management, we need to analyze the considerable matters of each stages of the 7 process types. The process stages can be largely classified into production stage, shipping stage, and field supervising stage.

3.3.1 Production stage

The production stage is generally divided into a stage where the field supervisor verifies and orders material consumption and shipping schedules for the project, and another stage in which he manages the production of materials. In the ordering stage, the field supervisor considers material consumption and shipping schedules of the project, which does not affect the application of RFID technology. This stage stands for manufacturing the ordered products. The major management targets for the field supervisor vary depending on the

characteristics of the materials. There are materials that require management from the time of acquisition, and there are materials that require long-lead time management. To apply RFID to these materials, various information including the tag attachment date, precise quantity and items of materials when forwarding, field location and delivery location, gate number can code coded or associated with RFID tag, enabling smooth logistics management by the field supervisor and project participant.

3.3.2 Shipping stage

The shipping stage is from the production of goods to shipping to the construction site, requiring consideration on shipping equipment, material packing units. An application method of RFID technology is decided according to these forms and units. The shipping equipment is divided into general equipment and special equipment, where general equipment refers to ordinary shipping resources used in construction projects like dump trucks, and special equipment refers to resources that need specific shipping faculties like mixer trucks for ready-mixer concrete. In the case of special equipment, RFID tags are attached to the equipment itself with enabling it to be utilized through logistics management.

Material shipping types can be classified into unit, bundle, and bulk types. Unit type materials are those which the specific ordering quantity is displayed as EA, and the single material is valuable for its own role in achieving the goal. Examples include iron bars and curtain walls. For unit type materials, RFID tags are attached to each unit, enabling convenient logistics management, and steel-frame logistics management is already being utilized at a real-world construction site in Korea.

Bundle type materials are those ordered by EA in specifications, and materials acquired in bundles when ordered. Examples are steel frames, cement and bricks. RFID tags are attached to the package in bundle type materials.

Bulk type materials are those ordered in volume units in the specification, and examples are ready-mixer concrete, gravel, sand, etc. In the case of bulk type materials, the shipping resource is used as the logistics management unit.

The material packaging unit can be divided into the 3 types of box, roll, and pallet, and RFID tags are attached to the packaging units for logistics management. Box types are those materials shipped in cased packages like boxes or containers, and ceiling texture and tiles are relevant. Roll type materials are shipped in rolls, and vinyl and waterproof sheets are relevant. Pallet type materials are shipped in pallets, and cement bricks and cement are relevant.

3.3.3 Field supervising stage

The field supervising stage is the field process of storage, piling, installation, and verification stages after warehousing and shipping.

Storage is divided into 2 forms. They are simple storing, in which materials are just piled up in the site and only the usage and quantity of stocks are managed, and the other is objective storing, in which materials are stored in specific locations that are related to the next actions that will take place. An example of simple storing would be bricks that are stored just to figure out the usage and quantity of stocks, and rebars are an example of objective storing, because they are stored in pre-allocated areas that relate to the succeeding process. In simple storing, RFID technology is used to count the amount of materials, and

in storing for a specific purpose, more precise locating process is required so a detailed location-tracking scenario is demanded.

Short-distance moving and lifting-up refers to the transferring of materials in the work field, divided into concepts of vertical and horizontal. Short-distance moving is horizontal material transferring with forklift trucks, and lifting-up refers to vertical transferring through machines like cranes, hoists, and highlanders, Materials that require location-tracking is installed with RFID readers that enable this function.

Piling refers to the process where materials are transferred to the location in which they will be used according to each schedule, and consideration is needed to determine whether the demanded information is simple locations as in storage, or scheduled piling information, or simple piling conditions for determining material quantity.

The installation stage refers to the process of being constructed by laborers, and the field supervisor inspects whether the operation is being correctly executed by mobile RFID readers.

4. Development of standardized application plan for RFID technology in logistics management

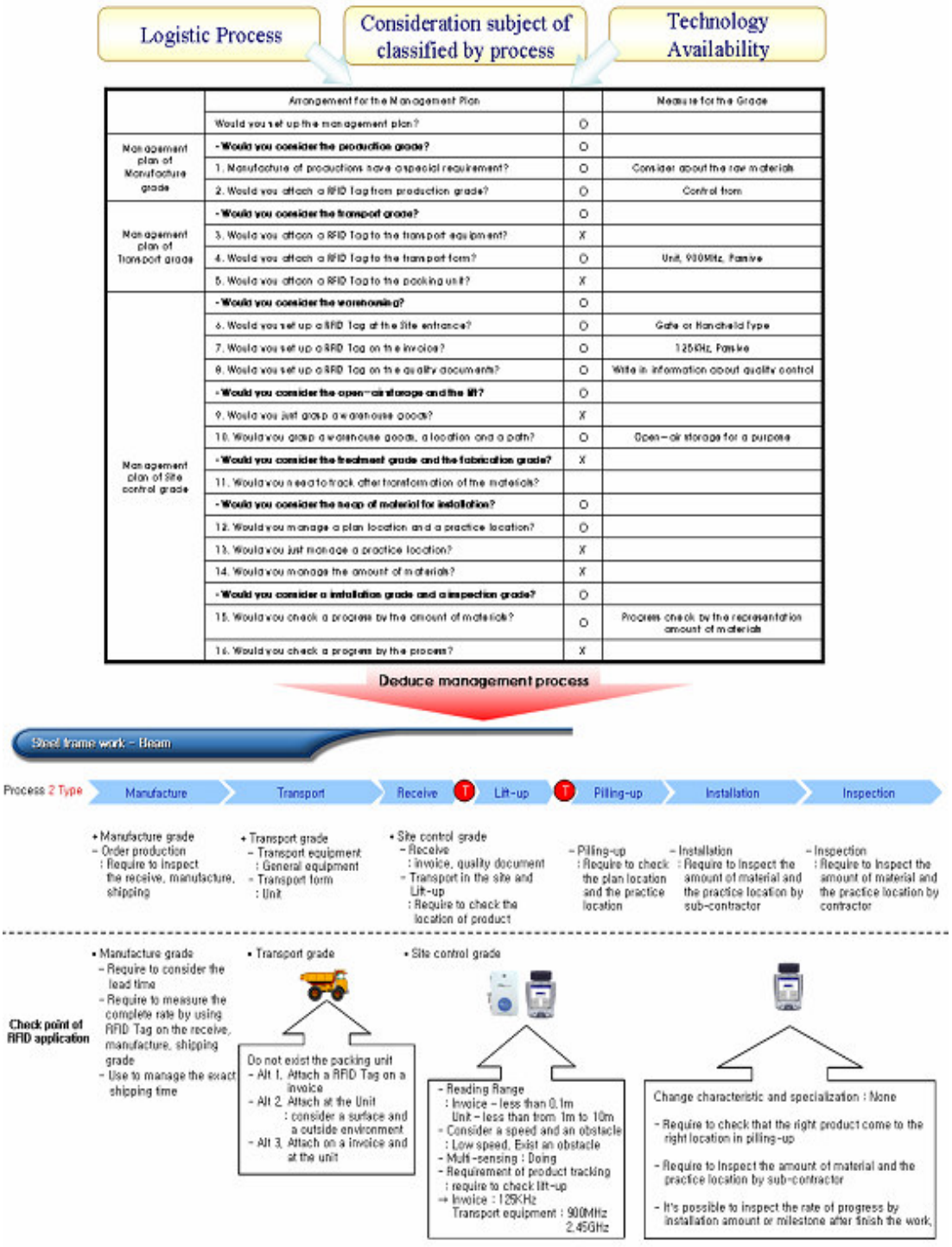
Through this research, with integrating logistics processes with consideration factors of each process, a systemized method for the application of RFID technology was developed as shown in Figure 5.

First, the most appropriate process type for the material is selected from the 7 standard logistics types. Even the same material may need different process type according to the features of a project, so field supervisors need to select the most suitable process for their project. After giving consideration to observable factors, the selected logistics process needs to be decided with management stage and unit, and measurement methods. The field supervisor decides in what stage will the RFID reader will be used to measure, what management unit will be measured, and what methods will be adopted for measurement. For example, in the case of structural steel members, a unit type material, the logistics management is performed by the field supervisor by attaching tags to each unit and in the stages of production, shipping, warehousing, short-distance shipping, craning, piling, installing, and verifying. For the measurement method, a fixed reader is installed in the field entrance, automatically measuring when received at the site, and the field supervisor can measure through mobile readers, like PDA readers.

However, the management stages and unit, and measurement methods can be modified by the field supervisor. Due to the specialty of the field, if the supervisor requires measurement to be taken place only in the warehousing and verification stages, the RFID application and measurement methods can be altered. The most appropriate feasible RFID technology is selected through the check list with the configured management stage and unit, and measurement methods as shown in Figure 5, and the management process is derived through this. The check list is arranged with factors that need to be considered in each stage for applying RFID technology. Therefore, the field supervisor can develop the most suitable standardized plan for logistics management after a review of the management stage and unit, and measurement methods that he has selected.

Accumulating the outcomes from applying RFID standardized plans in every process of the construction project and complementing the faults will lead to a deduction of a standardized RFID logistics management plan that can comprehend the whole construction project.

The RFID application plan that for the deducted logistics management can be used by the field supervisor as a precise and standardized data for measuring logistics, and enables the application of RFID to various construction lines, leading to a more effective and economic application.



	Arrangement for the Management Plan		Measure for the Grade
	Would you set up the management plan?	O	
Management plan of Manufacture grade	**- Would you consider the production grade?**	O	
	1. Manufacture of productions have a special requirement?	O	Consider about the raw materials
	2. Would you attach a RFID Tag from production grade?	O	Control from
Management plan of Transport grade	**- Would you consider the transport grade?**	O	
	3. Would you attach a RFID Tag to the transport equipment?	X	
	4. Would you attach a RFID Tag to the transport form?	O	Unit, 900MHz, Passive
	5. Would you attach a RFID Tag to the packing unit?	X	
Management plan of Site control grade	**- Would you consider the warehousing?**	O	
	6. Would you set up a RFID Tag at the Site entrance?	O	Gate or Handheld type
	7. Would you set up a RFID Tag on the invoice?	O	125KHz, Passive
	8. Would you set up a RFID Tag on the quality documents?	O	Write in information about quality control
	- Would you consider the open-air storage and the lift?	O	
	9. Would you just grasp a warehouse goods?	X	
	10. Would you grasp a warehouse goods, a location and a path?	O	Open-air storage for a purpose
	- Would you consider the treatment grade and the fabrication grade?	X	
	11. Would you a need to track after transformation of the materials?		
	- Would you consider the scop of material for installation?	O	
	12. Would you manage a plan location and a practice location?	O	
	13. Would you just manage a practice location?	X	
	14. Would you manage the amount of materials?	X	
	- Would you consider a installation grade and a inspection grade?	O	
	15. Would you check a progress by the amount of materials?	O	Progress check by the representation amount of materials
	16. Would you check a progress by the process?	X	

Figure 5 : Example of standardization process by using RFID at the steel-frame work

5. Conclusion

For successful construction projects, effective logistics management is essential, but the existing studies are focusing on separate construction materials, and the consideration of applying the method effectively to the overall project is lacking. Therefore, in this research, we have developed a systemized method for logistics management for field managers using RFID technology.

With this effort, the limits and problems that existed due to the subjective logistics management by field managers is expected to be resolved, and a foundation for a more precise and prompt project management could be provided.

Further research is needed for applying RFID technology to projects with integrating with ubiquitous sensor network technology like Zigbee to overcome the limits of RFID reading performance and environment.

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