MANAGEMENT SYSTEM FOR STRUCTRURAL STEEL PRODUCTS USING BARCODES BETWEEN CONSTRUCTION JOB SITE AND STEEL FABRICATION SHOP

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ABSTRACT

A large number of structural steel products are imported from other Asian counties into Japan, making it difficult to control and monitor fabrication status and quality assurance effectively. This has been recognized as a serious problem by project managers, especially so in Japan, because high-rise buildings require highly complex systems of joints and cross-sections, in order to provide earthquake-proof engineering design. Therefore, General contractors (GC) must perform strict inspections of imported structural steel products, and it is necessary to develop a collaborative management system between construction job sites and steel fabrication shops. This facilitates information exchange and communication.

This paper introduces a case for the development of a production management system based on barcodes, to monitor and control the whole production progress for a large scale steel fabrication shop. In order to develop a practical system to monitor and control the steel fabrication progress and status, the detailed processes of steel production tasks are analysed prior to considering system development, and the findings will be also applied to existing small information systems.

We will then discuss the upgrading process of those systems, towards making a complete production management system, by extending the application area of barcodes into all production tasks in the fabrication shop. This will include monitoring production progress and steel fabrication status as well as supporting production information with the general contractor at the construction job site.

Keywords: Barcode, Production progress, Production management system, Structural steel product, Steel fabrication shop

1. Introduction

Research background

Structural steel products are essential materials to the construction industry, and are usually produced and supplied within the same country. However, recently there has been an increase in the international movement of steel products, as a result of cost-competitiveness, and an increase in international construction projects.

It is the responsibility of on site project managers to oversee production the progress of structural steel products imported into Japan from overseas fabrication shops, and this is an important factor affecting the cost and schedule of high-rise building projects. Japanese engineers must take in to account earthquake-proofing regulations and, by mandate they must complete not only the certification of steel fabrication shops, but also act as third party agents of quality inspection as responsible stakeholders.

Certification programs for steel fabricators have been put in to operation to designate government or nongovernment agencies, such as the AISC (American Institute of Steel Construction, Inc.), and the KICT (Korea Institute of Construction Technology), and their specifications are regulated in line with other countries. Japan also has developed a unique steel fabricator certification program (Japan Steel Structure Appraisal Center), and in 2011, there were over 2,600 steel fabricators registered, and about 20 overseas.

However there are various difficulties in managing structural steel production at a distance from the construction site. For example, steel fabrication progress and quality management cannot be systemically monitored and controlled by the manager or supervisor remotely. Also, changes in production schedule cannot be taken in to account, as the duration of delivery has to be added in accordance with the distances from steel fabrication shops to construction job site. During a building construction project, structural steel production, including fabrication, inspection, shipment, and erection, must be managed strictly and accurately. Thus, it is necessary to developing a new systematic method to monitor and manage the whole of the production process for structural steel progress.

As the first step of this study, in this paper we introduce the detailed analytic results for a structural steel products production process, as well as the results for the development of production progress monitoring and collaboration methods with the construction job site. Fig. 1 is a conceptual diagram for the research scope of this paper, illustrating the production information flow and material flow in a building construction project. The solid box shows the area dealt with in this paper, and the dashed box shows the final research goal.

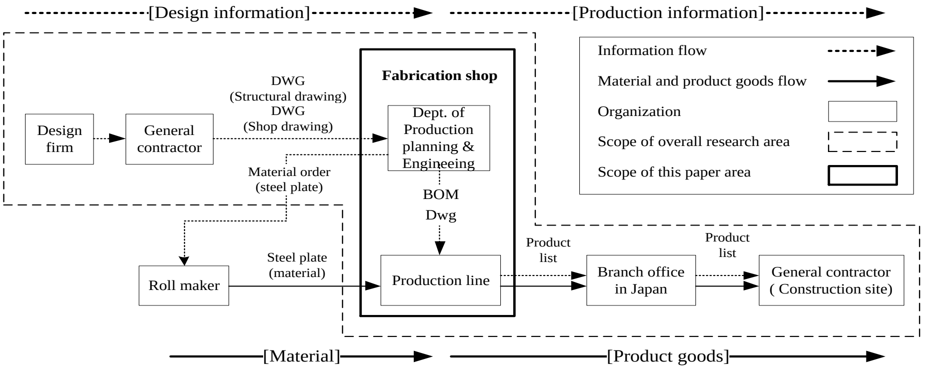


Fig. 1 Research scope

Research purpose

Our aim is to develop an integrated system to support production management for structural steel product between construction job site and steel fabrication shop. In this paper we introduce our research for developing a production management system (PMS) and a systemic integration process for a steel fabricator.

This research is carried out within a case study for a large scale steel fabricator, which has already developed several small information systems based on barcodes. Therefore, we try to extend the barcode application area to the overall production process, as well as dealing with the systemic integration of the existing small and new system. In other words, the objective of this research is not only “how to apply barcodes in a steel fabrication shop to monitor production status and progress” but also “how to integrate those systems efficiently to developed a collaboration model” at the same time.

Research method

This study is based on a large-scale steel fabricator in order to perform analysis and tests practically. Their main production factories are located in Thailand and China, and the company has established a branch office in Japan. They produce over 50-60,000 tons of structural steel annually, exporting to Japan, China, and other Southeast Asian counties.

Previously, we investigated various component identification methods, such as barcode, RFID (Radio Frequency Identification), and other sensor technologies. For example, RFID tags are widely used in special industrial areas to handle product goods and material, whereas barcodes are more commonly found in daily life. As the factory has already implemented several small barcode systems, this is the option we have chosen, in order to maintain consistency, and with the knowledge that these can easily be upgraded to RFID in the near future (Kim et al, 2011).

In order to understand the structural the steel production process precisely, we first investigate the production process of structural steel at a large size steel fabricator, and then, analyzed the implementation and architecture of it is existing small systems. Secondly, we will discuss the development of PMS applicable in the fabrication shop. Finally, a method for systemic integration with existing small systems will be explained using class diagram.

2. Literature review

Structural steel fabrication and production research

A significant number of researchers have studied the fabrication and production problems of construction components, and recently the application researches of RFID and/or BIM have increased tremendously for tracking materials and construction components (Song et al, 2006, Torrent et al, 2009), welding and erecting quality management (Ikeda et al, 2006, Nakajima et al, 2009), as well as measuring project performance (Chin et al, 2007) on the construction site.

Also, Azimi (2011) has proposed an integration method to manage steel fabrication projects, however the focus was upon on the visualization of performance measuring in steel fabrication projects.

Barcode application and information exchange standards

Barcodes are widely used to implement auto identification systems in many industrial products (Chang et al, 1997). This research uses barcode technology to identify structural steel products for managing production progress and quality assurance. A barcode is a series of thick and thin parallel lines stamped on packages but a number of variations now exist, including scatterings of dots and embedded codes hidden within images (Youssef et al, 2007), which can be read by optical scanner or laser reader.

Due to the standardization of barcode technology, several international standards have already been defined, allowing countries and industries to developed barcodes based up on the international standards.

AISC barcode standard: "Standard specification for bar-coded shipment label and Electronic Advance Shipment Notice (ASN)"

A barcode standard for structural steel products, known as the "Standard specification for bar-coded shipment label and electronic advance shipment notice", was developed by the AISC (American institute of steel construction) in 2004. This was based on the ASN-Barcode to support control of the physical shipment of structural steel products and the tracking of mill test information. The developmental purpose of the new barcode standard is to introduce a system in order to assure the reliability of steel products, and it is composed of a three-part standard: the rule of barcode placement, an electronic data file format (based is based on Extensible Markable Language (XML)), and electronic mill test report data.

The exchange of information between producer and end user facilitated by this system is written as an electronic data file, defined by an ASN class diagram (Fig 2). This consists of two parts: the header contains basic shipping information and the body, which contains more detailed information for the properties of steel products as well as mill test information under the title "heat". AISC's barcode standard is just focused on the logistics of rolled structural steel products, whereas XML allows the exchange of a wide variety of data on the Web and elsewhere.

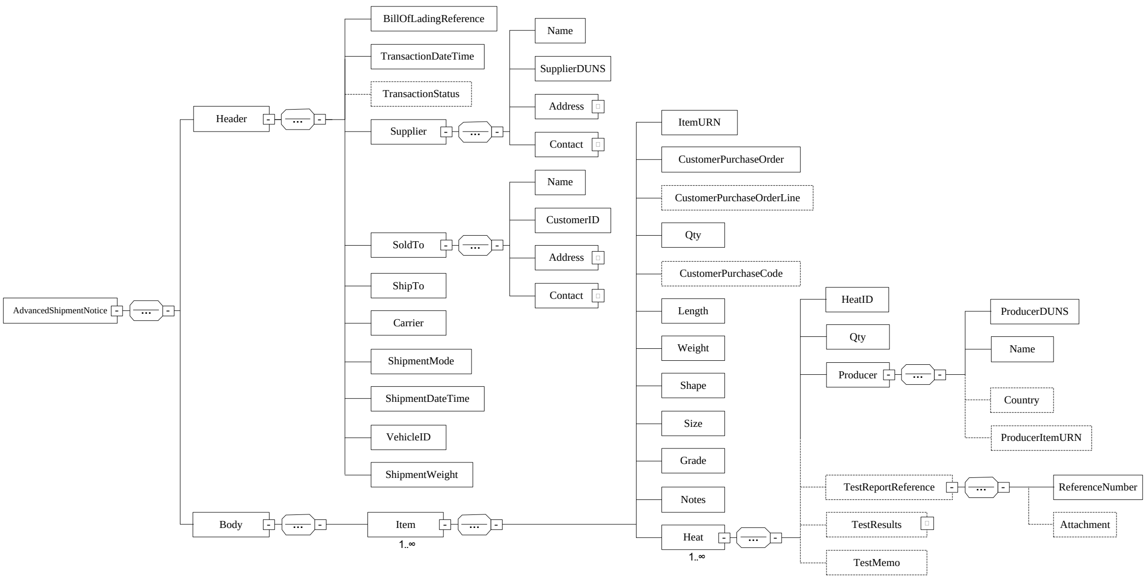


Fig. 2 Class diagram of electronic ASN (AISC, 2004)

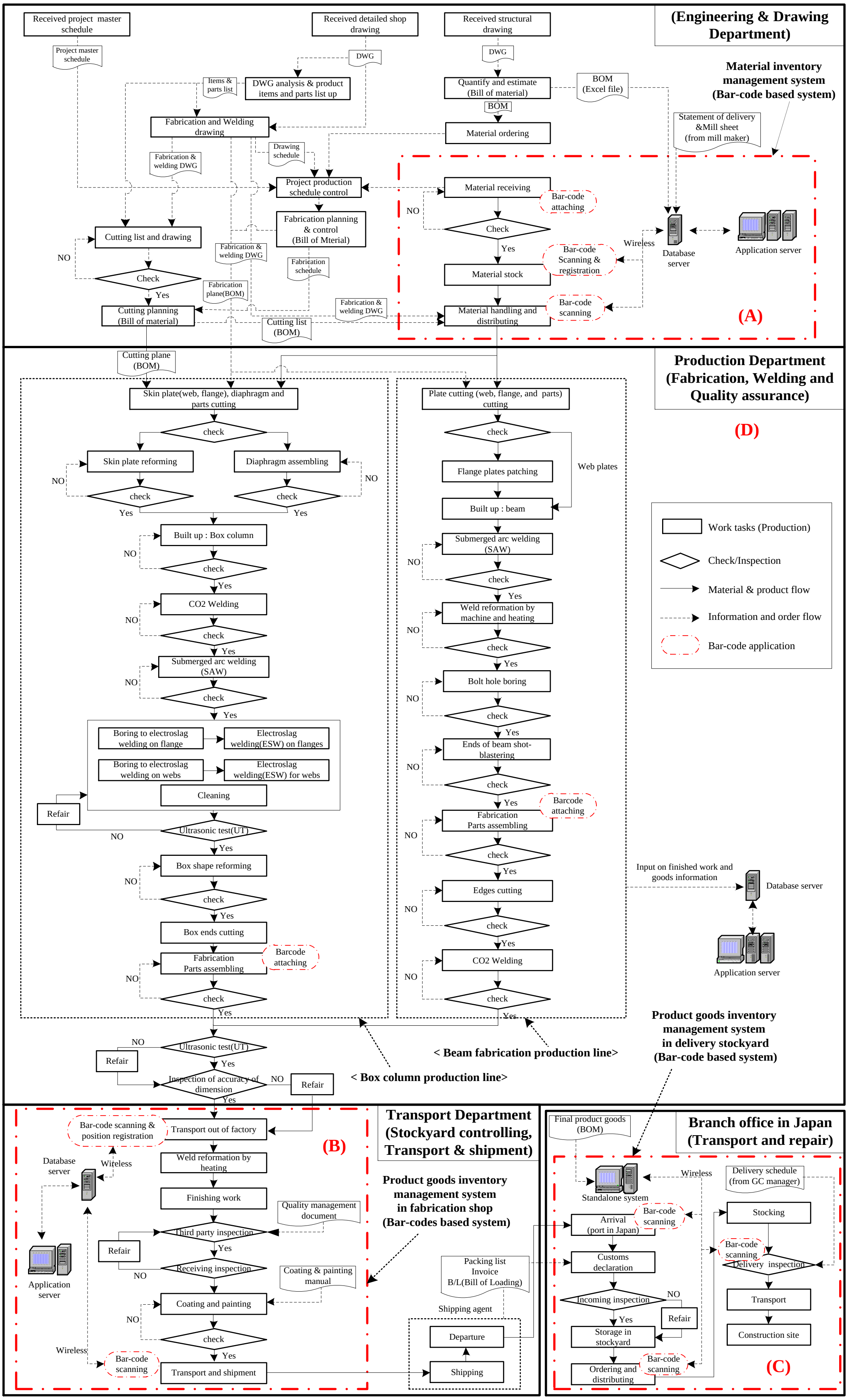


Fig.3 Production progress of structural steel products in a steel fabrication shop

3. Steel fabrication progress in a large scale steel fabrication shop

In order to develop a production management system for steel fabrication, the whole production process must be taken in to account. Therefore, a detailed diagram of steel fabrication progress must be designed, including the preparation of fabrication and welding drawings, material supply, product planning, quality inspection, transport and shipment.

Large-beam and box columns are the most representative product produced by the steel fabricator, and we pay particular attention to the product progress of these two components. Both structural steel products are basically built up by web and flange, and progressively assembled by parts such as the bracket, diaphragm, stiffener, angle, channel, pipe, hock and so forth. Thus, they are usually produced on different production lines, in accordance with the difference of their production process. Fig 3 shows the detailed production process of structural steel. Additionally shown are implementation of the company's pre-existing small systems based on barcodes, where areas (A), (B), and (D) cover the existing small systems, and area (C) will deal with the production management system developed during our research (PMS).

4. Introduction of existing small systems

In order to develop a management system, the most important thing is to integrate production processes of structural steel, as well as to connect to existing systems. Therefore, here we introduce the detailed implementation and roles of those existing systems.

Material inventory system (MIS) for steel plates

This information system plays a role in controlling material circumstances and relays their positions. Initially, each steel plate is ascribed a barcode, encoded using a mill sheet number, used to handle steel plates. In order to do so, separated steel plates are kept in a stockyard (approx. 7,590 m^2), and their positions are registered on MIS using the grid address of the stockyard.

In the case of the fabrication shop, 14 types of steel plates are classified by type and thickness, before being stored in the stockyard. When steel plates are moved from the stockyard in to the factory, the manager has to confirm this by matching a BOM (Bill of material) and a barcode reading.

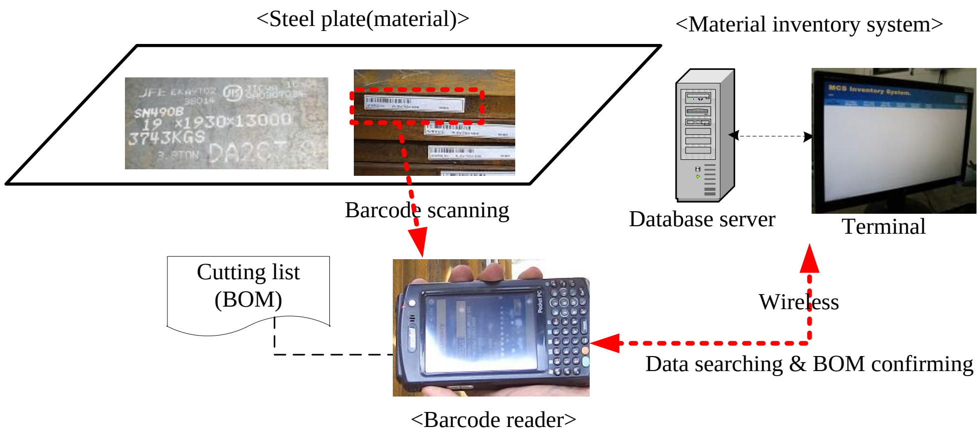


Fig. 4 Barcode implementation of MIS for material control

Delivery management system (DMS) for structural steel products

In addition to the arrival and departure of structural steel products, painting, straightening and other trivial work is usually performed in the stockyard. This work cycle is very complicated and repeated often. Thus, it is very important to find out the positions and to control transportation of the appropriate steel products efficiently.

To decide storage positions, some constraint conditions need to be considered, such as the ability of the gantry crane and the dimensions of the stockyard (approx. 94,289m^2). When a structural steel product moves in the stockyard, a barcode system is used to register, search, and modify positioning information. Registering is a simple way to read and store each barcode sequentially. Before product barcodes are read, they must be assigned position information from a positioning barcode, which is attached on a stationary supporter. When a transport manager needs to find a product, he can search using the DMS and will receive a summary and confirmation, for example in the form of a transport planning and daily transport list. Fig. 5 shows the barcode implementation of DMS for product control.

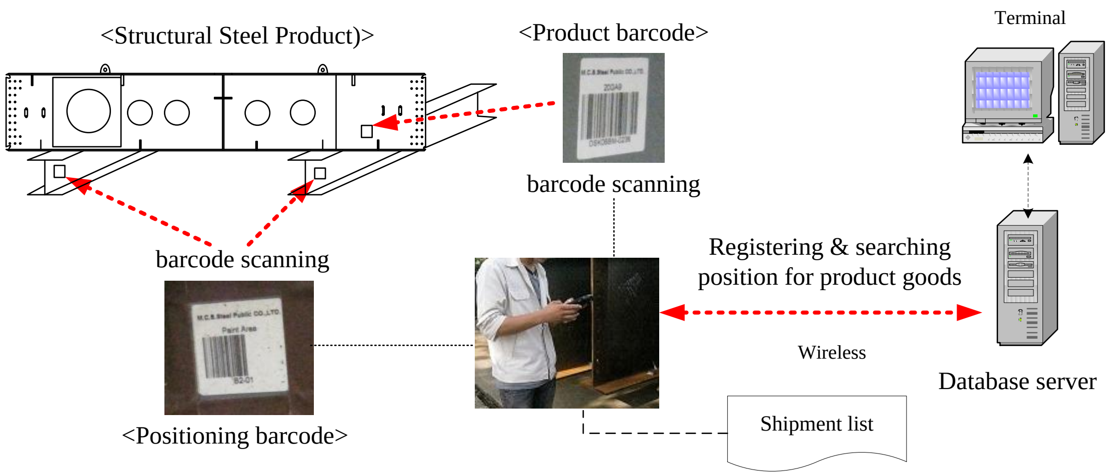


Fig. 5 Barcodes implementation of DMS for product control

5. DEVELOPMENT OF PRODCUTION MANAGEMENT SYSTEM

Considerations for a technological approach

It is difficult to develop an integrated system to manage all aspects of production progress for structural steel. Management objectives in each production steps have to take in to account the various shapes and features of the material, the part, and the semi-finished or finished product. We also have to consider which unit to attach a barcode to, for effective control and monitoring. As it is practically impossible to manage all parts by attaching barcodes, we must consider management in terms of technology and economics. Experts have categorised structural steel product such as flanges, webs, and brackets which are important load supporting structures, and which need to be managed strictly. Smaller components required to maintain the shape of steel members which are less important in terms of their tracking.

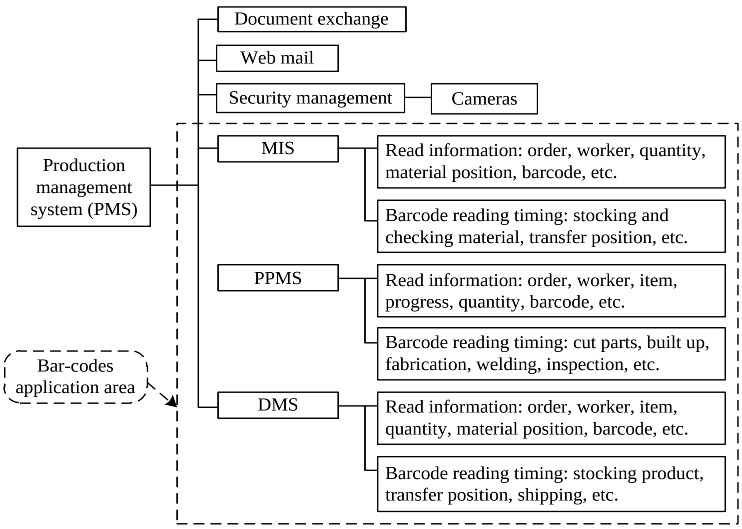
The most serious problem is that steel parts are heated during their assembly, welding, and straightening, which can burn the barcode and RFID tags.

Development of a production progress management system (PPMS)

Based upon our findings above, we will now examine production management by attaching and reading barcodes after the build up of parts. Build up for major parts during structural steel production, means that they become a manageable unit, and that the status of the object can be changed from parts to structural steel product.

Currently, information on production status and reports, are controlled as a production lot unit, and is input in to an information system by each team leader directly. This can be improved by using barcodes, attached to structural steel products, to read the specific information for production status automatically. The information added by the team leaders concerns only component identification, and production status cannot be clearly understood until working groups or individual workers add their specific information about the real time status of production in the factory.

During our research, we considered the use of time stamps as a way to measure productivity. In order to do so, barcode reading times must be decided through simulation and based upon previously findings. Thus, we focused on the work progress of each steel product and the operation of workgroups in the factory, to decide what specific information is available from reading timings. For example, in the case of box columns, fabricating diaphragms (commonly embedded in a box column to retain column shape as well as to distribute shear force), must be assembled during the building up of major parts, where as beams are fabricated in an orderly way. However, these work tasks are usually performed by different workgroups in each case. Thus, barcode reading times can be defined by the component passing from one workgroup to another. It is not necessary to monitor all work tasks during structural steel fabrication. But this information can be used to respond to changes in orders from the GC. As a result, PPMS is developed according to analytical results to consider specific timings. Fig 5 of (a) shows timings monitored in a PPMS system. Fig 5 of (b) is a new type of barcode applicable in the fabrication shop. In order to improve recognition and to support information, the barcode contains much information for production, such as project, item, production lot, drawing, type of product, and so forth.



(a) System architecture

(b) Barcode sample

Fig. 6 Development of PPMS and a new barcode

System integration as a serviceable web based application

All small systems can be integrated on a web based application system, named the Production management system (PMS) in order to support production management efficiently. The class diagram of the PMS system is composed of data tables and shows relationships using an arrow diagram in Fig. 7.

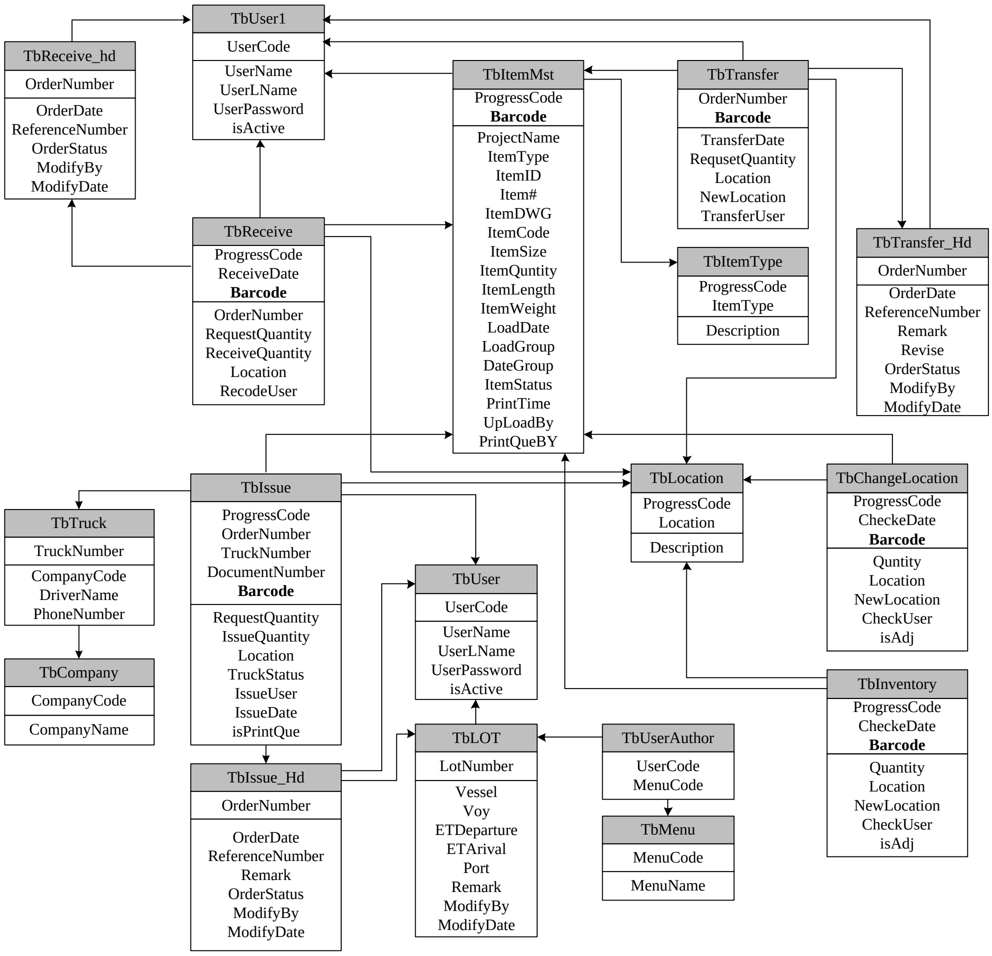


Fig.7 Class diagram for PMS

6. Conclusion and future Research

This paper introduced issues to develop an integrated management system for structural steel production through the case study of a steel fabrication shop. Firstly, the detailed steel production process in a steel fabrication shop was analysed. We also tried to review the practical problems of extending barcode application into the whole production works of the factory. Lastly, dealing with the integration of existing small systems we described the system architecture of a web based application.

In this paper, we have covered the development progress of a fabricator's production management system. In the near future, we intend to investigate the informational relationship with construction site and more practical issues, in order to develop a fully integrated system from design stage to erection at construction site. This will include tests and quantifiable results for the efficiency of the proposed system.

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