ASSESSEMENT OF KANBAN USE ON CONSTRUCTION SITES

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ABSTRACT

Due to the lack of skilled labour and the difficulties in managing material flows during the execution of site works, construction companies (mainly in the northeast of Brazil) are looking for ways to facilitate communication between management teams and workers and gain control over material consumption and flow. In this context, the Kanban System is a technique that may contribute to minimise this problem, increasing the productivity, reducing wastes as well as maintaining within the set budgets.

This paper presents the assessment of the implementation of kanban systems in construction sites aiming to identify improvement opportunities for a better use of the system and also to establish a set of necessary conditions for its implementation and use.

A literature review aimed at studying the Toyota Production System principles and its relationship with kanban system was performed. From the literature review a checklist was created as a method of evaluation. Three construction sites in the city of Salvador-Bahia-Brazil that use the kanban system for the supply of materials were analysed. The checklist for evaluation includes issues related to tools and concepts inherent with the kanban system, these being: a) mechanisms for loss reduction, b) mechanisms of achieving continuous improvement, c) tools to increase communication and transparency, d) just-in-time, e) production and pull streaming.

The main contribution of this paper is the identification of the degree of kanban system implementation on the building site studied and its opportunities for improvement. Also, the necessary conditions and guidelines for implementation were established.

KEYWORDS

Lean production, Kanban system, material supply management.

INTRODUCTION

In view of the large growth within the construction sector, showing GDP values that almost doubled between 2006 and 2010, many big challenges have arisen, related especially to skilled labour deficits in all regions of the country such as masons, carpenters, plumbers, painters and other qualified professionals in all areas.

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Besides the skilled labour deficits, another difficulty is presented within the material supply chain. The major industries were not expecting such a rapid growth within the sector and are struggling to meet there quests within the time required for the site works, forcing companies to plan and make requests much in advance. Increased competition and technological changes are forcing businesses to rethink their methods and production systems in search of improving productivity levels and increasing competitiveness.

Materials management serves the purpose of providing the right materials when needed at an acceptable cost. This involves specifying required materials, acquiring them materials from suppliers and distributing them to construction sites (Arbulu et al. 2003). Failing to allow a continuous flow of materials will have a negative affect on labour productivity and project costs as well as increasing waste. Thus, material management is a vital part of the production system for a construction project (Khalfan et al. 2008).

Due to the lack of skilled labour and the difficulties in managing the material flow for the execution of works, construction companies, mainly in the northeast of Brazil, such in Bahia and Ceará, are looking for ways to facilitate communication between management teams and workers and gain control over material consumption and flow. In this context, Kanban System is a technique that may contribute to minimise this problem, increasing the productivity levels, reducing waste and also maintaining within budgets.

Kanban is a lean approach developed in the automotive industry as a mechanism to pull materials and parts throughout the value stream on a just-in-time basis. “In Japanese, the word kanban means ‘card’ or ‘sign’ and is the name given to the inventory control card used in a pull system” (The Productivity Press Development Team 2002). The aim of a ‘pull’ system is to produce only what is needed, when it is needed, and in the right quantities. A particular type of kanban is called supplier kanban which transmits a replenishment signal to outside suppliers (Arbulu et al. 2003).

Despite the understanding that the kanban system is a technique that could improve material flow, its use in the city of Salvador-Bahia is still limited. Therefore, the main objective of this paper is to assess the implementation of kanban systems in three residential construction sites in the Salvador–Bahia-Brazil, aiming to identify improvement opportunities for a more efficient use of the system and also to establish a set of necessary conditions for its implementation and use.

KANBAN SYSTEM

Kanban is an operation method taken from the Toyota Production System. The idea emerged as a piece of paper that was divided into three categories: (1) information collection, (2) information transfer, and (3) product information. The kanban carries information both vertically and laterally within Toyota and between Toyota and colleagues (Ohno 1988).

According to Ohno (1988), the idea emerged in the mid 50’s from the American supermarkets, where goods bought in boxes were passed using a card containing information on the amount and types of goods purchased. When the purchase department received these cards they could quickly replace the purchased goods on the shelves.

For Shingo (1989), the main feature of the kanban system is that it reduces stock, replenishing only what was sold by the store, instead of using an estimated refuelling system. By using kanban, the production workers begin to work for themselves and make their own decisions. Kanban also helps eliminate waste, and allows proposals for improvements (Ohno 1988).This author presents a list of functions and procedures for kanban use, as shown in Table 1.

Table 1: Functions and procedures of the Kanban system (Ohno 1988)

	Functions of Kanban		Rules for use
1.	Provide information on catch and transport.	1.	The subsequent process picks up the number of items specified by the kanban in the previous trial.
2.	Provide information on the production.	2.	The initial process produces items by the quantity and sequence indicated on the kanban.
3.	Prevent overproduction and excessive transport.	3.	No item can be produced or transported without a kanban.
4.	To serve as a command for manufacturing the goods displayed.	4.	Serves to fix kanban goods.
5.	Prevent defective products by identifying the process that produces them.	5.	Defective products are not sent to the following procedure. The result is 100% goods free from defects.
6.	Reveal problems and maintain inventory control.	6.	Reduce the number of kanbans increases their sensitivity to problems.

The objective of using a kanban card containing information is to not allow any doubt about the quantity, time and location during the distribution, by providing the necessary information about the product thus avoiding super production (Monden 1984).
According to this author, the following information is essential and must be contained within the kanban cards:

- Specification of the part to be produced or transported;
- The quantity to be produced or transported;
- The process responsible for the production and use of the specified part (the previous trial and subsequent);
- Storage place.

In building construction, two types of kanbans can be used: production and transportation Kanbans and only transportation Kanbans (Heineck et al. 2009). The first one refers to the production and transportation of the mortar in the site and the second refers to the transportation of materials that are not produced in the site, such as bricks and ceramic tiles (Heineck et al. 2009). The production kanbans are made of plastic paper which contains information such as: quantity of mortar to be produced, type of mortar, delivery floor number and delivery time. The transportation Kanbans are similar to the production ones, and contain information such as the quantity of

material to be transported, delivery floor number and eventually, the draw of the material to be transported (Heineck et al. 2009).

The main benefits of using kanban in building construction are: waste reduction, such as mortar, improved labour and manager engagement due to the decentralisation of decision-making, increased labour autonomy with regards the distribution of materials and mortar, reductions in operational flow and better control of material inventory according to demand (Heineck et al. 2009).

PRINCIPLES BEHIND KANBAN

Kanban can highlight four basic lean construction concepts: just-in-time, continuous improvement, continuous flow and pull production system.

- **Just-in-time** means work without inventory, "The process should be stocked with only the items required in the quantity needed, when needed - Just-on-time, at the right time, without the generation of stock" (Shingo 1989).
- **Continuous flow** means that the production flows should not stop. Its continuity must be guaranteed through a systematic short term, medium and long term plan, which determines that a product should be produced when required (Koskela 1992).
- **The pull production system** is characterised by a requested production, thus preventing the use of inventories, leading to bigger and better job performance (Koskela 1992).
- **Continuous improvement** means the pursuit of excellence and is a valuable tool to control and improve processes that must be the domain of all employees, being related to process control and the development of administrative, technical and operational project standards (Koskela 1992).

RESEARCH METHOD

The study was conducted with the aim of evaluating the kanban system implemented on three sites involved in the development and construction of residential buildings for the higher middle class in Salvador.

Data was collected through structured questionnaires covering concepts and tools applied to the kanban system. The visits were scheduled in advance and carried out with the project manager. The checklist was applied via interviews and field visits with the aid of a camera to record the accuracy of the data collected. Table 2 presents the characteristics of the construction sites studied.

Data analysis was divided according to the basic Kanban principles and tools, these being: (a) Mechanisms to reduce waste; (b) Mechanisms to achieve continuous improvement; (c) Tools to increase communication and transparency; (d) Just-in-time; and (e) Continuous flow and pull production. The questions were evaluated as “yes”, “no” or “not applicable” answers, from which a percentage of implementation for each major item was calculated. The data was analysed separately for each construction site and then a comparison was made between the sites.

From the assessments of this work and the literature review, proposals for improvements were made, which were then delivered to the construction manger of each site.

Table 2: Main Characteristics of the construction sites involved in the case studies

Project	Main Characteristic of the Project	People Interviewed in the Study
A	Vertical construction site, containing one building with sixteen floors. A transportation kanban was used for the ceramic laying activity.	Production manager
B	Vertical construction site, with two fifteen floor buildings. A production and transportation kanban was used for mortar supply.	Production manager
C	Vertical construction site, with two fifteen floor buildings. A transportation kanban was used for the ceramic laying activity.	Production manager

EVALUATION OF THE KANBAN SYSTEM ON THE CONSTRUCTION SITES

Table 3 describes the kanban systems used in the three projects analysed.

Table 3: Description of the Kanban System used in the different case studies

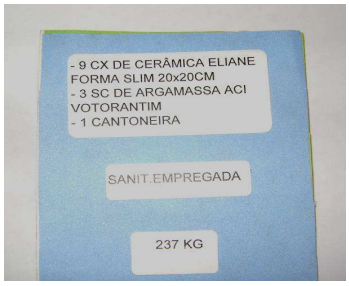
Project	Kanban System	Brief Description of Kanban System
A		In project A, a transportation kanban was used for the ceramic laying service. Kanban worked as follows: cards were made by representing the kit of materials needed to perform the service in each room, as shown in the figure aside. The quantity of each material, the specification, the place of application and the total weight of the kit is specified on each card.
B		The project B uses the kanban system only for the mortar supply, while the ceramic blocks for building the brickwall are delivered without any control. For the mortar, the bricklayers receive little cards identifying the mortar specification, where the mortar should be discharged and the time it should take to be produced and transported to the job.
C		The project C uses the kanban system for the transportation of the ceramic laying service. The idea came about as a result of the high number of personalised apartments. Each colour has a meaning. The cream card is for the floor covering, the red card is for wall cladding and the blue card for the adhesive mortar. The cards hold information such as the amount of material, the apartment to be coated, rooms and material specification.

Figure 2 shows a comparison of the use of the kanban system among the three projects studied. Similar findings between construction site A and C could be observed.

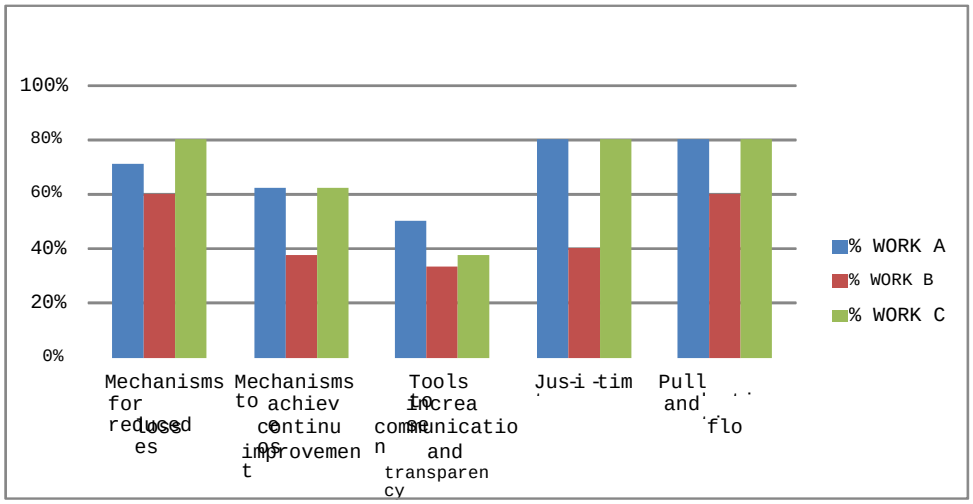


Figure 1: Comparison of the use of the kanban system in the projects studies

Concerning the mechanism for reducing material and time losses, good practices in the three projects studied were identified, such as the use of kanbans cards to control the material stocks. At the end of the working day, the construction projects put the input data into their stock system about the amount of material used which helps them to establish and control the minimum stock levels necessary for the service.

Despite this positive point, it was observed that none of the sites analysed preformed an in depth study of the physical flow seeking to reduce non-value added activities such as transportation. Most construction site layout plans are developed based on the experience gained by site engineers and foreman. Another problem observed was that none of the construction sites used a tool for identifying problems or whether the worker was using more material than necessary. Therefore, the construction sites did not show any concern for documenting problems or taking action in order to improve the production process.

With regards seeking to achieve continuous improvement, project A and C have an interesting systematic evaluation of the production teams that perform the different services. In both projects, the employees are trained to follow procedures, each group of employees has a target to achieve, and inspections are carried out systematically. They are rewarded when the service is finished in time and with quality. Despite the faults detected by the quality system, none of the construction sites seek to understand the causes of failure. According to Ohno (1997) the problems should be treated from the root of the cause, as only then can you prevent them from reoccurring.

Communication and transparency are the main problems that were identified in the projects studied. None of the construction sites provided design and planning information to the workers, noting that they were not encouraged to learn about the project and had difficulties in performing the process according to the plans and the design. If any doubt arises, the person in charge must be located and brought to the

site, wasting time when waiting for information to arrive which also creates a dependence on the construction site managers. A good practice identified in project B was the use of flags as a way of communicating the presence of a material (green flag) or the need for more material (red flag) (see figure 2). Another good practice identified in project C was the use of a board with performance measurements related to the quality of the service which was place in the lunch room.

Figure 2: Use of flags for communication about materials

When analysing the Just-In-Time concept, none of the construction sites had a schedule plan for material delivery from suppliers. According to the interviewees the difficulty lies with the suppliers who cannot perform their on-time deliveries, which ends up forcing the construction site to accumulate stocks.

Concerning pull production and continuous flow, all projects generally sought to perform a production balance, by establishing a production rate for each task and align the packages of the kanban system with the weekly planning schedule. However, none of the projects carried out monitoring of the weekly planning or tried to record the causes of failure of some of the activities. Therefore, there is no feedback about the accomplishment of the packages established within kanban cards.

IMPROVEMENT OPPORTUNITIES

Many improvement opportunities for using the kanban system in the different construction projects studied were observed, especially when compared with the literature review and another construction site visited in Fortaleza-Ceará, Brazil.

With regards the mechanisms to reduce waste, as first proposed, construction sites could create a worksheet that records any problems if the workers need to use more material than expected. This tool is important because it helps create a database about the use of resource in the construction process, identifying the most frequent problems that increase waste.

Besides this, the construction site layout could be better signposted. A study of the physical flows also indicating the distances to be travelled should be included. The project could create a framework to establish the minimum inventory, at least for the most important materials such as cement, bricks, sand and gravel. This would facilitate stock control.

With regards the mechanisms to achieve continuous improvement, it was observed that all construction sites had a quality control system and performed a systematic inspection of services, but none of them sought to find the root causes of the problems. The form could include acceptance limits for a particular service and where are marked is placed as a complaint or non-complaint. Another way of implementing continuous improvement is the learning process gained by using prototypes, creating also a catalogue of important information and the solutions found within each case.

As an improvement opportunity in the Just-in-time principle, the construction sites should implement a weekly planning control, which is also an example of the production pull system where recordings should be made with regards the causes of non-fulfilment of planned activities, thus the main problems that occur on the construction site can be identified and solved accordingly. Despite the Last Planner System being well known in Brazil, there is still some resistance with its use by construction companies in Salvador, Bahia-Brazil.

It was observed that all the construction sites implement a long-term planning system, which could help construction projects better negotiate a materials delivery schedule with suppliers, thereby reducing the construction site inventories.

According to the continuous flow and pull scheduling principle, the flow of activities should not stop. In the long-term planning, a rate with little variation between the activity cycles should be given. The amount of services performed should be determined by the successor customer service. The line of balance is an example of a tool to be used when the work has a repetitive character.

NECESSARY CONDITIONS FOR IMPLEMENTING KANBAN

After performing the studies, it was possible to identify a set of necessary conditions for implementing the kanban system, such as Planning and Production Control, planning of the construction site layout, staff training and labour motivation.

PLANNING AND PRODUCTION CONTROL

Preparing the Production Planning and Control (PPC) is the first step to achieve an effective and efficient production process, where goals can be established. The design and the implementation of the kanban system is strictly related to the horizons of the PPC.

In the long-term planning, global work packages are defined, which is very important for designing the kanban system cards. The cards should be made according to the amount of services defined in the work package. The long-term horizon is intended to plan the purchase of materials, equipment and labour, besides guiding the medium-term plan (look ahead planning). Using the line of balance can help the project to define the global work packages.

In the look ahead planning, the main objective is to analyse constraints to determine what must be done in order to make a service ready to be executed. At this

level, the kanban system should be detailed, with the cards and packages to be executed already established, as well as the mechanism for system control. It is essential to consider the core concepts, such as just in time, transparency, pull system, continuous flow and continuous improvement.

In the short-term planning (weekly planning) work packages are defined and their execution is often monitored using the PPC measure (Percent of Plan Completed), which is defined as the ratio of completed work packages with the total scheduled activities (100%). It is important to remember that during construction, monitoring of the PPC should be performed so that the causes of non-fulfilment of planned activities can be identified. At this level, kanban systems as well as mechanisms to reduce and control waste should be implemented and associated to the PPC tools.

PLANNING OF CONSTRUCTION SITE LAY OUT

The construction site corresponds to a fundamental part of the construction phase of the building project. The development of a construction site layout plan is essential to reduce waste and non - value adding activities. A study of both physical and labour flows taking the distances, waiting times and transport into account should be done when planning the construction site layout. This study is very important for the implementation of a kanban system.

In construction site planning it is also interesting to analyse all stages of the construction of the building from the foundations to the finishes using long-range planning systems to define the amount stock and its location on the construction site. The long-term planning together with the budget is directly connected with the choice of equipment to be used and is therefore essential during the design process. Yield data and time may affect the choice of equipment or quantities allocated.

STAFF TRAINING

After planning the whole system, the implementation should consider the training of the entire team, including production mangers, stockman and the workforce. To make everyone feel part of the system it is important that they also participate with the making up of the cards, as well as the control mechanisms, such as the Heijunka box and control charts.

LABOUR MOTIVATION

Worker satisfaction and training is also important for motivation and helps make the kanban system work. There are companies that use literacy programs, which turns the construction site into classrooms; they use incentive programs such as “employee of the month”, which are financial incentives and give professional recognition.

Some companies still add a series of other benefits such as: breakfast-stop self-service, regular health monitoring of their employees, social areas with appropriate layout and ceramic coatings, gifts to employees, employee access to supervisors and construction site managers, thus improving the quality of life on the construction site. All initiatives are important to create a connection between employees and the company.

CONCLUSIONS

The results showed that the kanban system implemented in Salvador is still being used in a very simple way. It was observed that most principles and concepts are not well understood by the construction managers. There is a limited use of tools and mechanisms aimed at (a) reducing wastes; (b) achieving continuous improvement; (c) increasing communication and transparency; (d) implementing just-in-time, continuous flow and pull scheduling. During the interviews with engineers, trainees and stockmen where asked what they thought about the system, all of whom responded positively and agreed that the system helps and facilitates the control of materials. However, it seems there is a lack of theoretical knowledge about the concepts and principles behind the tools.

In Salvador there are few studies and a small number of construction sites that implement lean construction tools, as there is still a resistance presented by company managers and directors, which can be considered as a barrier against the implementation of the kanban system and other lean construction techniques.

Moreover, there is still a difficulty in construction sites providing project information to workers, as most builders believe that labour is incapacitated and would be unable to participate of the kanban system.

When thinking about implementing a system such as kanban, companies must first have formulated a plan of how the steps will occur, then look into training employees to understand how the system functions, its importance and how to seek recovery.

The main contribution of this paper is the definition of parameters for evaluating kanban systems. Some barriers for implementation were identified and a set of necessary conditions for implementing the kanban system aimed at reducing the number of non-value adding activities was presented. Only three construction sites in Salvador were found to use such tools and so, the evaluation of the sample is representative for this city.

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