PRINCIPLE OF TRANSPARENCY APPLIED IN CONSTRUCTION

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ABSTRACT

Transparency is one of the foundations of excellence in manufacturing and a fundamental step to construction companies searching for excellence in their production systems. It can be simply defined as the ability of a production process (or its parts) to communicate with people. It is a move from the usual silent production process to a more communicative one.

The traditional 'conversion model' has contributed to the lack of transparency in construction. This mental model understand production systems as a set of transformations of inputs into outputs. In contrast, other alternative models, see production as a system composed of 'operation flows' (machine or man) and 'process flows' (information or material) (Gilbreth 1911, Shingo 1989, Koskela 1992). When construction is seen as a flow, the demands for better capability to handle vast amounts of information is bigger. Thus, the application of the principle of transparency is a key point to make viable the flow model.

In this context, the present paper tries to demonstrate the practical and theoretical implications of the principle of transparency in the construction industry, using examples from Brazil and England.

KEY WORDS

Lean construction, transparency, visual management.

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INTRODUCTION

Transparency is one of the foundations of excellence in manufacturing and a fundamental step to construction companies searching for excellence in their production systems. Put simply, transparency is defined as the ability of a production process (or its parts) to communicate with people. It is a move from the usual silent production system to a more communicative one (Santos and Hinks 1997). In the strict theoretical sense, transparency means the separation of the information supporting production systems and the physical production itself (Greif 1991, Koskela 1992).

The manufacturing literature shows a vast list of advantages of the implementation of transparency at the organisational and at the operational level such as simplification, motivation, rapid understanding of information and so on (Greif 1989, NKS 1991). In contrast, the construction industry is far behind in the use of this principle. Construction companies usually have few visual mechanisms to inspire, instruct or motivate workers to carry out their jobs more effectively, efficiently and safely.

The traditional conversion model has contributed to this lack of transparency. This traditional mental model understands production systems as a set of conversions of inputs into outputs. Within this model the conversions can be divided into smaller conversion activities and the output of each conversion is associated with the value (or cost) of the inputs. Also, it admits that the optimisation of production systems is obtained through the minimisation of cost of each of those conversion activities (Koskela 1992).

In contrast with the traditional model, other alternative philosophies of Operations Management understand construction as a system composed of ‘operation flows’ (machine or man) and ‘process flows’ (information or material), which must generate value to the end customer. This flows, in turn, are composed of processing, waiting, transporting and inspecting activities (Gilbreth 1911, Shingo 1989, Koskela 1992).

When construction is viewed as a flow many factors that before were considered unimportant, come to the surface and become very important to the production effectiveness. Thus, the flow have to be easy to understand, otherwise managers and workers would prefer to came back to the traditional conversion model as soon as they face the enormous amount of information related to the flow model. Therefore, the production activities have to be more transparent in order to make this model viable. The next sections discuss the various approaches for implementing transparency on production systems in the construction industry.

APPROACHES AND PRACTICAL EXAMPLES

The next subsections deal with the approaches for implementing the principle of transparency. The discussion is restricted to those approaches which directly relate to the production activities on site, particularly those under the spectrum of actions of workers and managers on site. Obviously there are other approaches to increase the transparency such as those at the organisational level: increase of informal contact outside of the hierarchy; overlap of responsibilities; participation of production personnel in improvement projects; visits of top managers to the shop floor level, etc. (Greif 1989).

REDUCE INTERDEPENDENCE OF PRODUCTION UNITS

When two or more different gangs of workers have to carry their task in the same area, without careful attention to flows, the normal situation is an increase in the disruptions and clutter, with a direct effect in quality, cost, delivery and flexibility. Great quantities of materials, equipment and workers moving within the same area makes it difficult to understand and control such environments. One of the approaches to reduce this interference is to reduce the interdependence of production units in order to allow the right timing and space between them, without breaking the positive interactions for improvement that may exist between them.

When analysing the flow on any site one should to pay attention to the great number of macro and micro interdependencies present in the construction activities. After many witticisms, it is possible to say that most of them are sequential and have their origin at the design phase. For instance, Figure 1 (left) shows a housing site in Brazil where, according to the usual practice of the company, the bricklayers had to wait for the carpenters to make the upper-sill of windows. The result of this dependence was carpenters and bricklayers moving in the same area, wasting time and materials as a result.

Having done some judicious planning and studies, the same company started to produce pre-fabricated under/upper-sills on site (right) using the spare time of labourers. These pre-fabricated parts were fixed by the bricklayers themselves. The outcome of breaking this dependence was a workplace more safe, easy to understand, and clean.

Figure 1: Reduction of Interdependence

USING VISUAL CONTROLS

Improvement activities would result easily when the existence of waste, abnormalities, or problems were perceived by everyone in the construction site. In this sense when a production activity is transparent everyone should be able to identify or avoid an eventual problem and, so, help the production's continuous improvement. In manufacturing, for example, visual controls are used to enable everyone to notice whether or not boxes of a certain item are where they should be, or if they have exceeded the limit line in terms of quantity. Unfortunately construction sites normally present very few of such visual controls.

Figure 2 shows examples of a few visual controls observed in construction. The picture at the left is a 'poka-yoke device'[5] (fool proof device). It has lights that shows to the operator which floor the elevator is at the moment and, also, it doesn't allow the movement of the elevator if the door is open. The photo at the right is simply a pipe used in the communication between the operator on the ground floor and the other workers upstairs[6].

Figure 2: Using Visual Controls

Despite the serious weakness in the of use of visual controls in general, the present research found a considerable quantity of visual controls focused on setting up locations and measures. The success of this devices in the case studies were basically dictated by how easy they were to install and update the necessary information, as Figure 3 shows. The left photo shows the tape used to guide the vertical distances of bricklaying courses and the right photo shows the use of spray paint to indicate the level where the bricklaying module starts.

Figure 3: Using Visual Controls

Another normal practice of manufacturing that deserves more attention from construction people is the practice of *setting up borders*. Without a border there is no way to tell that the space is a designated location for a specific item and, consequently, it is difficult to say when this item is not at its correct place. *It is silent* (Galsworth 1997). In this situation, the inability resulted to understand fast the process and operations flows becomes one more obstacle for obtain more agile production systems.

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5 Poka yoke devices guarantee 100 percent inspection in production systems. It takes over repetitive tasks or actions that depend on vigilance or memory (NKS 1987, Shigeo 1989).

6 Note that 'visual' here has a broad meaning, covering all senses.

MAKING PROCESS AND OPERATIONS DIRECTLY OBSERVABLE

In world-class companies the layout of machines and materials are planned to allow observation from as many angles as possible. Thus, workers can understand why the parts of the preceding workplace are getting late or why the next operation has stopped. Even for people not familiar with the production environment it should be easy to understand how the process works just by looking on the signals around.

In contrast with manufacturing, in the construction industry the product is normally fixed and the work-stations have to circulate around as the site develops. However, this shouldn't be used as a excuse to not apply the principle in construction. For instance, there can be considerable improvements of transparency just by planning the sequence to build the walls. If a careful planning of the sequence of construction is not in place, the image to be seen from an unload bay could change from the left photo to the right photo of Figure 4.

Figure 4: Making and Process and Operations Directly Observable

Appropriate layout planning can help people understand the process. In the manufacturing industry, for instance, some companies arrange the layout in cells and the overall process becomes much easier to understand and control. Figure 5 shows another example of how construction companies can let the production activity become more observable: the left photo is a fence that allows people to see what is happening at the site; the right photo is a device used to illuminate dark workplaces.

Figure 5: Making the Process and Operations Directly Observable

'Addressing' (giving visual names or symbols to places) is another key idea to let the production activities directly observable When the need to find a safety equipment arises (for example, locating a fire extinguisher when a worker needs one) it is always urgent,

with every instant of delay increasing the risk of loss. *In this moments lead times needs to be 100 percent value adding* (Galsworth 1997). Figure 6 shows two examples of addressing applied in construction: the left photo points the infirmary and the right photo points the fire alarm.

Figure 6: Making Process and Operations Directly Observable

INCORPORATING INFORMATION IN PROCESS AND OPERATIONS

To insert process (or operation) information in the workplace is a necessary step to reach a self-explaining production environment. The information needs to be helpful to workers but, in contrast to visual controls, the adherence to its content is voluntary. Defects display boards, defective storage part areas, general statistics about the process or even supplier's illustrative videos are examples of this informative role of visual communication. An example from construction is shown in Figure 7. In this Brazilian site the construction planning was explained to all workers and displayed in a big panel where everyone could see and understand his/her situation against the schedule.

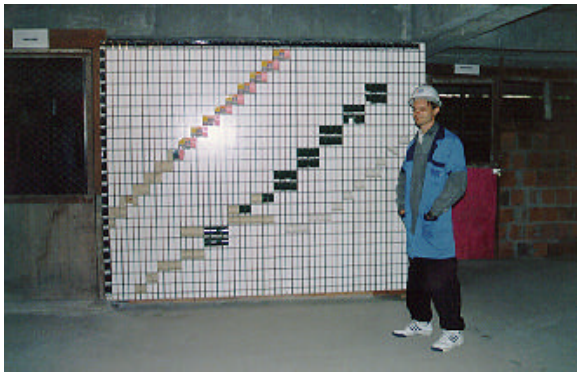

Figure 7: Incorporating Information in the Process/Operation

Another example of incorporation of process information to workplaces is shown in the Figure 8. The photo at the left is a board showing through drawings, the various possible compositions of mortar for this particular site. The photo at the right side shows a board with the recommendation of the day in terms of safety prevention.

KEEPING A CLEAN AND ORDERLY WORKPLACE

When a workplace is clean, safe, and orderly, the worker can relax and do his/her work quickly and effectively. People intuitively recognise that a clean, uncluttered, safe, and

well-ordered workplace is a much more productive environment. However, in the construction industry it is very common to see workers spending precious time searching, wandering, or waiting for the tools, materials, and information they need in order to do their work instead of adding value. Piles of unneeded or infrequently used materials and equipment get in the way of day-to-day operations and impede a smooth construction flow. Speed is hampered and long lead times become chronic.

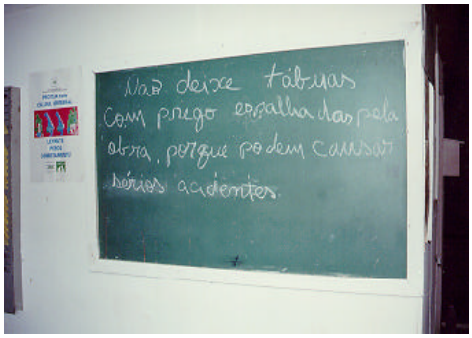

Figure 8: Incorporating Information in the Process/Operations

The most famous and successful method to keep a clean and orderly workplace is known as 5S. The term 5S refers to the five housekeeping practices that are part of the daily routine of every Japanese household - *seiri*: proper arrangement, organisation; *seiton*: orderliness, selecting locations; *seiso*: cleanliness; *seiketsu*: cleaned up, neatness; *shitsuke*: discipline, good conduct (Galsworth, 1997, Monden, 1993, Osaka, 1991).

Many companies in Brazil are applying 5S as the initial step in quality programs as the Figure 9 shows. The left photo is a home-made shelf to storage clothes, tools or any personal material that pertain to the workers. The photo in the right is another home-made device build to keep the worker's bicycles in a more organised way.

Figure 9: Keeping a Clean and Orderly Workplace

RENDERING INVISIBLE ATTRIBUTES VISIBLE THROUGH MEASUREMENTS

Transparency can be improved by establishing measurements that detect the efficiency and effectiveness of the conversion and flow activities. The practice of measuring the process helps to detect the problems as they occur, or even show critical situations before they actually become problems. Figure 10 shows how some construction companies use measurements to improve the transparency of the production system. The photo in the left is a board showing the number of days without accidents and the correspondent

benchmark of this site. The photo in the right shows a data collection about waste disposal (day, quantity and type).

Figure 10: Rendering Invisible Attributes Visible through Measurements

CONCLUSION

This paper is a contribution to those who are striving to detect new opportunities for improvement in construction processes by discussing the practical implications of increasing the transparency, using examples from two different countries to illustrate the arguments. During the data collection the researchers perceived a correlation between the state of process transparency and the apparent global efficiency of the production systems. However, more research have to be done to evaluate the effect of this principle on the cost, quality, delivery and flexibility of production systems. The link between this and other core principles of Operations Management also need further research since many of them are interdependent and, thus, cannot be applied in isolation.

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