

TRANSPARENCY IN CONSTRUCTION SITES

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ABSTRACT

Lean construction involves a set of concepts and principles that aim to increase the efficiency of the construction production process. Transparency is one of these processes, which can be defined as the ability of a production process to communicate with people.

The objective of this paper is to evaluate the use of transparency practices on construction sites and identify a set of transparency practices that help reduce construction site deficiencies related to organisation, productivity, and production planning and control.

This paper uses the exploratory research method based on five case studies in the city of Salvador-Bahia-Brazil and another case study in the city of Fortaleza in Ceará, Brazil, using document analysis techniques, interviews and direct observation for data collection.

The main findings show a low level of transparency practices implemented within the construction sites visited. This indicates a great potential for improvement through using such practices, particularly when compared to the higher level of implementation of such practices found in the case study in Fortaleza. It was also observed that the transparency practices tend to contribute directly or indirectly towards the three expected improvement areas: improved construction site organisation, increased productivity levels and a more efficient production planning and control (PCP).

KEYWORDS

Lean Construction, transparency, production planning and control, organization and productivity

INTRODUCTION

The construction sector has grown hugely over the last few years in Brazil. More precisely, in 2010 and 2011, the construction sector grew 11.6% and 4.8% respectively (DIEESE 2011). However, despite the rapid growth, construction companies continue suffering from severe problems which are mainly related to construction management. Until now, construction site organisation has received little attention in the Northeast of Brazil, such as in the states of Bahia and Ceará. Most decisions are made during the construction process as and when the problems occur.

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Throughout all regions of the country, labor productivity levels have reduced due to the increased number of buildings under construction and the lack of skilled labour. Finally, production planning and control still presents many deficiencies.

In this context, the application of lean construction principles can help construction companies to reduce waste and improve efficiency. One of these principles is the transparency process (or its parts) which can be defined as the ability of a production process to communicate with people (Formoso et al. 2002).

The application of process transparency principals during construction represents a substantial change in production management as it aims to transform the traditional “silent” processes into ones that communicate in an active manner. In conventional communication, information is “transmitted.” However, when using the transparency theory, nothing is transmitted: the network of information (information field) and its respective access is created in such a way that the information is obtained quickly without the need to ask (Formoso et al. 2002).

Using practices that increase process transparency on construction sites can also be seen as a way of improving three aspects considered as “indispensable” for the efficient progress of a construction process, these are: construction site organisation, productivity and PCP (Production Planning and Control).

Therefore, the objective of this paper is to evaluate the use of transparency practices on construction sites in the city of Salvador, Bahia, Brazil and also identify a set of transparency practices that can help reduce the construction site deficiencies related to organisation, productivity, and production planning and control.

VISUAL MANAGEMENT AND TRANSPARENCY

Visual management can be defined as a management system that tries to improve the organisational performance by connecting visual organisation, principals, objectives and culture with other management systems, work processes, working elements and stakeholders through directly stimulating one or more of the five human senses (vision, hearing, touch, taste and smell) (Liff and Posey 2004).

According to Tezel et al. (2010), visual management is based on the principal that people are generally attracted to things that they can see. Visual management is well accepted in Japanese companies and is presented by means of warning signs, slogan, indicator lights, cards (kanban) and visual display units, etc. The aim is to use visual resources as a way of making communication simple and appealing (Tezel et al. 2010).

Colour management is an extension of visual management that produces a visual contribution at a low cost and has a useful psychological effect. Japanese companies are known to be very good in using colours as a means of identifying work stations. For example, Toyota and Fanuc’s production lines use coloured boxes and light signals to control their production flows (Tezel et al. 2010).

On the other hand, transparency involves a separation of the information network and the hierarchical structure of giving orders, in other words, it increases self-control, both of which are considered as identical in the classical organisation theory (Grief 1991). According to Santos (1999), transparency consists of management actions that use visual controls that are able to determine the progress of a particular process thus resulting in a reduction of the interdependence between activities. It includes creating a work layout that promotes visibility of the work flows and

ongoing activities, incorporation of information about production and process management, maintenance, organisation and cleaning of construction sites and other actions that foment the visibility of the production attributes through measurements and indicators (Santos 1999).

The practical impacts resulting from transparency on a working environment can be summarised in the following manner: simplification and increased coherence in decision making, stimulation of informal contact between the different hierarchical positions, contributions towards introducing decentralisation policies, assistance in extending workers' involvement and management autonomy, increased efficiency in production programming, simplification of the production control systems, quicker understanding and response to problems, and finally, greater motivation among workers towards improving being able to visualise errors (Moser and Santos 2003).

Transparency concepts and efforts in adapting the visual management practices of industrial operations into the construction environment have stimulated much research on visual management in construction. Koskela (2000) defines the transparency theory in construction as creating and maintaining an uninterrupted flow of information. According to the author, transparency can produce the following benefits within a production process:

- Reductions in the interdependence between production units;
- The use of devices enables immediate visual recognition of a production process status;
- The process becomes directly observable through appropriate layout and signalling;
- Process information can be incorporated into working areas, tools, containers, materials and information systems;
- Working environments are maintained clean and organised;
- Renders invisible attributes of the process visible through measurement.

Tezel et al. (2010) have published studies that list a number of visual management practices which can be used on construction sites with the aim of increasing transparency, as shown in Table 1. This work sought to analyse the practices identified by Tezel et al. (2010) that are being correctly implemented on construction sites in the city of Salvador and how these are improving managerial processes.

RESEARCH METHOD

This paper uses the exploratory research method based on case studies and prioritises document analysis techniques, interviews, and direct observation for data collection.

Research was divided into two stages, the first consisted of a literature review from which practices adopting the transparency principals and their benefits to users were established.

Based on the information obtained in the literature review, the second stage evaluated the transparency practices being used correctly on five different higher - middle class residential building development construction sites in Salvador and whether these practices were providing the benefits expected. Table 2 presents a description of the construction projects used in the study and the person interviewed.

Table 1: Transparency Practices (Tezel et al. 2010)

Transparency Practices	
Colour coded helmets with additional written information	Board displaying the number of accident free days Signs indicating dangerous hazards
Cards displaying policies and security procedures	Signs identifying different areas (deposits, workstations, etc.)
Identification of construction elements (building floors, beams, columns, etc)	Signs showing mandatory protective equipment for each working area
Identification of elevators (Functions and admissible weight limits)	Colour coded waste storage containers
Identification of stocked materials using standardised stickers	Material flow routes marked and separated from pedestrian pathways
Isolation of site areas with welded wire fencing	Material acquisition in a grouped and classified manner;
Posters identifying the responsibility of each workstation	Kanban Cards (Production Control)
Prototype displays	Display of real time and planned time for each activity
Identification of hand barrows	Display of material samples with their respective specifications and location
Fully informative projects available where services are performed	Control board showing the stock level of materials and tools
Boards showing work teams and performance of individual members	Boards showing the progress of the construction in bar graph format
Andon System (Control Panels);	Supplier assessment tables
Heijunka Box to control mixer production	Control tables for tool and equipment possession
Monthly printed calendar showing events and important milestones	Signs indicating employee of the month
Performance indicator tables such as for PPC	Use of transparent glass to seal the walls and doors in the office areas

To confirm the transparency practices being used by the building firms on construction sites and their respective improvements, the following sources of evidence were adopted:

- **Direct Observation:** visual identification and analysis of the practices used on construction sites using a checklist of the transparency practices selected during the literature review.
- **Photographs taken on site:** photographic registration of the practices being used and construction site organisation.
- **Semi-structured interviews:** analysis of the site managers' point of view on the improvements provided through using transparency practices. The possibility of implementing other transparency practices that were still not being used on their sites was also discussed.

The expected improvements on construction sites that were analysed in this work are presented below:

- **Construction Site Organisation:** it is understood that better use of the available physical space enables workers to work more efficiently with machines and in a safer manner, particularly through minimising labour forces and the transportation of materials and components (Frankenfeld 1990).

- **Productivity:** this work is linked to the efficiency of production systems (Souza and Araújo 2001), which can also be related to the efficiency of resource use, defined by Neely et al. (1996), as “Efficiency is a measure of how economically the firm’s resources are utilised when providing a given level of customer satisfaction.”
- **Production Planning and Control:** the process of introducing the improvements into the organisational and temporary aspects helps reduce non value adding activities and increase production reliability (Bernardes and Formoso, 2002).

Table 2: Main Characteristics of the Project involved in the Study

Construction Site	Main Characteristic of the Project	People Interviewed in the Study
A	Vertical construction site, with two building with seventeen floors each. The land area for construction is 6,026.00m ²	Production manager
B	Vertical construction site, with six building with twenty floors each. The land area for construction is 31,000.00m ²	Production manager
C	Vertical construction site, with two building with twenty-eight floors each. The land area for construction is 10,335.00m ²	Production manager
D	Vertical construction site, with two building with twenty-one floors each. The land area for construction is 4,180.50m ²	Production manager
E	Vertical construction site, with two building with ten floors each. The land area for construction is 12,600.00m ²	Planning Manager

EVALUATION OF TRANSPARENCY PRACTICES IMPLEMENTED ON CONSTRUCTION SITES

A total of thirty-one transparency practices were analysed. The number of transparency practices used by each construction site varied between seven and eleven, representing 22.58-35.48% of the total. No great differences were found between the number of transparency practices used by the different construction sites analysed. Table 3 presents a summary of the results obtained from the study.

It can be seen that only four of the thirty-one practices analysed were found in all five of the construction sites visited, these are: (1) Identification of the construction elements; (2) Signs indicating dangerous hazards; (3) Signs indicating different site areas; and (4) Signs showing the mandatory protective equipment for each working area. All four of the practices are related to site organisation.

Practices such as “Prototype displays” and “Material acquisition in a grouped and classified manner” were used by 80% and 60% of the construction sites respectively. Another fourteen practices were identified in one or two of the construction sites

analysed, giving a total of 64.5% of transparency practices identified in at least one of the construction sites studied.

However, eleven transparency practices were not identified in any of the construction sites representing 35.5% of all thirty-one practices analysed (Table 1), four of these are related to construction site organisation, another four related to productivity and the other three are related to Production Planning and Control.

Interviews with site managers revealed practices that could potentially be implemented. The potential practices considered as interesting and that could present some benefits were identified and are shown in Figure 1.

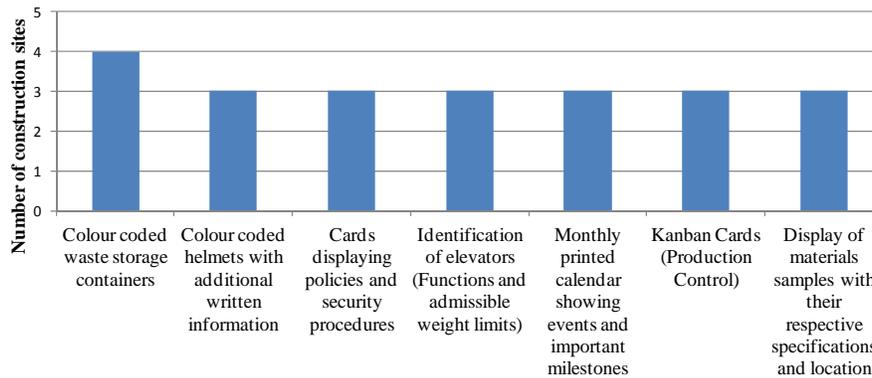


Figure 1: Practices that had Greatest Potential for Implementation

It is worth mentioning that two of the construction sites visited used signs identifying elevators and another three identified this as a potential, stating that such practices were still not in place due to the stage in which the construction was at (the construction was either at an initial phase, where freight elevators were still not be used or at the end of the construction phase where the building's own elevators were being used).

Another point worth mentioning is that two of the eleven practices not used on any of the construction sites visited were also not mentioned by any of the interviewees as interesting practices with a potential of being implemented in the future. These were: "Isolation of site areas with welded wire fencing" and "Posters identifying the responsibility of each workstation."

A construction site in the city of Fortaleza, Ceará, Brazil was also analysed, which was taken as a "Benchmark" reference for the implementation of lean construction practices. Twenty of the thirty-one practices on the checklist were identified on this construction site, as shown in table 3. Only three of the eleven practices not identified in any of the five construction sites in Salvador were also not being used by the construction site in Fortaleza, these being: (1) Signs indicating employee of the month; (2) Posters identifying the responsibility of each workstation; and (3) Boards showing work teams and performance of individual members.

Table 3: Transparency Practices Identified in Each Construction Site

	Visual Management Practices	SITES IN SALVADOR					TOTAL	% of Sites	SITE IN FORTALEZA
		A	B	C	D	E			
Site organisation	Identification of construction elements (building, floors, beams, columns, etc)	x	x	x	x	x	5	100%	
	Signs indicating dangerous hazards	x	x	x	x	x	5	100%	
	Signs identifying different areas (deposits, workstations, etc.)	x	x	x	x	x	5	100%	X
	Signs showing mandatory protective equipment for each working area	x	x	x	x	x	5	100%	
	Material acquisition in a grouped and classified manner		x	x	x		3	60%	X
	Identification of elevators (functions and admissible weight limits)	x	x				2	40%	X
	Identification of stocked materials using standardised stickers				x	x	2	40%	X
	Cards displaying policies and security procedures					x	1	20%	
	Colour coded waste storage containers	x					1	20%	
	Use of transparent glass to seal the walls and doors in the office areas	x					1	20%	X
	Colour coded helmets with additional written information;						0	0%	X
	Isolation of site areas with welded wire fencing;						0	0%	X
	Board displaying the number of accident free days;						0	0%	X
	Material flow routes marked and separated from pedestrian pathways;						0	0%	X
Productivity	Prototype Displays		x	x	x	x	4	80%	X
	Identification of hand barrows	x					1	20%	
	Fully informative projects available where services are performed					x	1	20%	
	Signs indicating employee of the month.						0	0%	
	Posters identifying the responsibility of each workstation;						0	0%	
	Boards showing work teams and performance of individual members;						0	0%	
	Andon System (Control Panels);						0	0%	X
Planning and Production Control	Display of real time and planned time for each activity;		x		x		2	40%	X
	Performance indicator tables such as for PPC		x	x			2	40%	X
	Monthly printed calendar showing events and important milestones;				x		1	20%	X
	Kanban Cards (Production Control);				x		1	20%	X
	Control board showing the stock level of materials and tools	x					1	20%	X
	Supplier assessment tables				x		1	20%	
	Control tables for tool and equipment possession	x					1	20%	X
	Heijunka Box to control mixer production;						0	0%	X
	Display of material samples with their respective specifications and location;						0	0%	X
	Boards showing the progress of the construction in bar graph format.						0	0%	X
	Total implemented practises	10	7	8	11	9			20

CONTRIBUTION OF THE PRACTICES USED

The contributions of all the transparency practices identified in at least one of the visited construction sites from the site managers' point of view are presented below.

CONSTRUCTION SITE ORGANISATION

- **Cards displaying policies and security procedures:** Helps indicate how site operatives should behave in dangerous situations.
- **Identification of construction elements (building, floors, beams, columns, etc):** Provides greater flexibility for people in transit, so that they can move in less time to the place where they carry out their services.
- **Identification of elevators (Functions and admissible weight limits):** Provides a means of disciplining operatives not to overload elevators or use them at the same time as when materials are being transported.
- **Identification of stocked materials using standardised stickers:** Facilitates visualisation and identification of materials and helps maintain areas clean and organised.
- **Material acquisition in a grouped and classified manner:** Grouping materials at the supplier eliminates stages such as stacking and unstacking of materials, especially during vertical transport.
- **Signs indicating dangerous hazards:** Drawing attention to dangers is an obligation if a construction site wants to improve the safety of its employees.
- **Signs identifying different areas (deposits, workstations, etc.):** Helps visualise areas and guide people through the construction site.
- **Signs showing mandatory protective equipment for each working area:** Draws attention to the obligation and necessity of using individual protective equipment thus protecting employees from possible accidents.
- **Colour coded waste storage containers:** Colour identification of containers is important as it helps employees to know where to throw different materials. It also facilitates the recycling process.
- **Use of transparent glass to seal the walls and doors in the office areas:** Using transparent glass helps people know who is present within the closed environment.

INCREASE IN PRODUCTIVITY

- **Prototype Displays:** Anticipates possible problems and incompatibilities so that mistakes can be corrected and the necessary changes made.
- **Identification of hand barrows:** Identification is necessary to prevent wrong mixes from being produced or using mixes in the wrong place which could cause future problems.
- **Fully informative projects available where services are performed:** Helps identify services that are being performed so that they can be seen clearly thus avoiding rework.

EFFECTIVENESS OF THE PRODUCTION PLANNING AND CONTROL

- **Monthly printed calendar showing events and important milestones:** Used by engineering teams to anticipate events and prepare resources.

- **Kanban Cards (Production Control):** Using Kanban cards increases the control of materials in the stockroom, increases production team autonomy and reduces possible mistakes in customised apartment cases.
- **Display of real time and planned time for each activity:** Helps visualise and anticipate problems so that appropriate measures can be taken thus preventing activities that are not going according to schedule from interfering with the construction deadline.
- **Control board showing the stock level of materials and tools:** Knowing how much available stock there is helps maintain minimum stock levels and prevents them from running out.
- **Supplier assessment tables:** Allows contractors to have better control of the progress of the enterprise.
- **Control tables for tool and equipment possession:** It is easier to locate tools and equipment when you know which employee is handling them at a particular moment.
- **Performance indicator tables such as for PPC:** Gives information and directions on construction site services. With this data new strategies through critical analysis can be defined.

CONCLUSIONS

This work helped disseminate knowledge about lean construction among the construction sites studied by initially observing the use of various visual management practices that promote project transparency and then by exploring the potential for introducing new transparency practices with site managers.

Upon analysing the five construction site case studies, it can be concluded that no great variation was found within the sites. The number of practices implemented by the construction site that adopted the highest amount of visual management practices corresponded to eleven practices representing a total of only 35.5% of all practices analysed.

However, when analysing the construction site in the city of Fortaleza which was taken as a benchmark, a total of twenty transparency practices in use were identified, representing 64.5% of the total. It therefore suggests that it is indeed possible for a larger number of practices to be implemented within the construction sites analysed.

From the interviews it was also possible to observe that site managers were interested in using many of the other practices that were still not being implemented on the construction sites within which they were working. It is therefore expected that a larger number of practices could be used on construction sites when further knowledge is gained by site administrators about the respective transparency concepts and their consequential improvements.

Future research should look into quantifying the improvements, mainly concerning to productivity. From the construction site observations and answers given during interviews, it was possible to detect that the use of such practices tends to contribute towards the three expected improvement areas, these being: improved construction site organisation, increased productivity levels and more efficient production planning and control (PCP).

Also future research should establish a set of strategies in order to implement transparency practices to improve Organization, Productivity and Production

Planning and Control. Concerning the practices related to Production Planning and Control, these ones may be incorporate in the implementation process of Last Planner System. The transparency practices concern to Productivity is closed related to the implementation of Kanban System for material supply. Finally, the transparency practices related to Organization may be easily incorporate in 5S tools or actions related to safety management in construction sites.

REFERENCES

- Bernardes, M.M.S. and Formoso, C.T. (2002). "Contributions to the evaluation of production planning and control systems in building companies". *IGLC 10*.
- Formoso, C.T, Santos, A. and Powell, J. "An Exploratory Study on the Application of Process Transparency in Construction Site". *J. of Const. Res.*, 1 (1), 35-54.
- Frankenfeld, N. (1990). *Productivity*. Rio de Janeiro-Brazil: CNI (Manuals).
- Grief, M. (1991). *The Visual Factory: Building Participation through Shared Information*. Portland, USA, Productivity Press.
- Koskela, L. (2000). "An Exploration towards a Production Theory and its Application to Construction". *PhD Dissertation*, Helsinki University of Technology, Helsinki.
- Liff, S. and Posey, P.A. (2004). *Seeing Is Believing: How the New Art of Visual Mgmt Can Boost Performance Throughout Your Org*. NY, USA, McGraw-Hill.
- Moser, L. and Santos, A.D (2003). "Exploring the Role of Visual Controls on Mobile Cell Mfg.: A Case Study on Drywall Technology". *IGLC 11*.
- Neely, A. et al. (1997) "Performance measurement system design: should process based approaches be adopted?" *Int'l. J. Prod. Econ.*, 46-47, 423-431.
- Souza, U.E.L. and Araújo, L.O.C. (2001). "Forecasting labor productivity for the internal mortar plastering job". *10th International Symposium*, CIB W65.
- Tezel, A., Koskela, L., and Tzortzopoulos, P. (2010). "Visual Management in Const.: Study Report on Brazilian Cases". *Research Report N 3*, Salford, England, SCRI.