

BENEFITS OF VISUAL MANAGEMENT IN THE TRANSPORTATION SECTOR

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ABSTRACT

This paper explores the benefits of Visual Management (VM), a fundamental sensory information management strategy in the lean production system, in the transportation sector in England. Lean construction and VM have recently gained momentum in England’s transportation construction supply chain with high efficiency targets.

VM in construction is a scarcely researched topic, particularly outside the building construction context with its quantitative and qualitative benefits. The recorded benefits of four different visual tools/systems (visual workplace structuring or the 5S, visual performance system, visual specification/indicator and visual control) from one highways construction and one metro station upgrade project in England were presented through an action and case study research effort.

The findings show that VM systems can contribute to (i) increased self-management, (ii) increased coordination, (iii) increased PPC through better promises, (iv) easier control and (v) improved site conditions in transportation projects. Although both qualitative and quantitative data were collected to triangulate the findings, the main limitation of the research is in abstracting the benefits or contributions of a particular VM tool from an overall improvement in the projects’ performance. Some future research opportunities for VM in the transportation sector were also discussed in the paper.

• KEYWORDS

Visual Management, benefits, lean construction, transportation sector, England

• INTRODUCTION

Lean construction has increasingly been finding a place on the agendas of the transportation sector in England with ambitious operational efficiency targets (Network Rail 2010; Drysdale 2013). One of the fundamental elements of lean construction is Visual Management (VM), which is a visual (sensory) information management strategy. There are some specific characteristics of VM (Greif 1991); (i) the information in VM is presented to create information fields, from which people can freely pull information in a

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self-service fashion, (ii) the information need is determined ahead of time to prevent information deficiencies (pre-emptive approach), (iii) the information display is integrated into process elements (space, machinery, equipment, components, materials, tools, gadgets etc.) and (iv) the communication is simple and relies little or not at all on verbal or textual information. VM increases the communication ability of process elements or process transparency (Formoso et al. 2002), which translates into simplification in decision making and control, increased coordination through stimulation of informal contacts, broadened employee engagement and autonomy (self-management), and a rapid understanding of problems (Moser and Dos Santos 2003).

Galsworth (2005) proposed a general classification of VM tools, i.e.: (i) information giving; (ii) signaling; (iii) response limiting /controlling and (iv) response guaranteeing. In practice, a visual workplace, in which VM is realized, can be created by sequentially adopting the 5S workplace structuring, visual standards (e.g. standard operating sheets), visual measures/indicators (e.g. performance boards), visual controls and visual guarantees (Galsworth 2005).

Although the literature on VM in construction has been accumulating, the VM discussions have been predominantly conducted for the building sector to date (Formoso et al. 2002; Alves et al. 2009; Tezel et al. 2015). Moreover, the discussions still mainly revolve around VM's conceptual benefits and the applicability of some conventional and IT based VM tools in construction, particularly in building construction projects (Alves et al. 2009; Barbosa et al. 2013; Sacks et al. 2013). However, apart from some generic VM systems, such as the 5S, VM solutions can be highly context-specific (Liff and Posey 2004). Therefore, this paper aims at exploring the benefits of VM, as per the theoretical propositions by Formoso et al. (2002) and Moser and Dos Santos (2003) on the benefits of VM, in the transportation sector in England over four different types of VM tools/systems identified by Galsworth (2005) (i.e. the 5S, visual performance systems, visual specification/indication systems and visual control systems).

• RESEARCH METHODOLOGY

A mixed research approach, including action and case study research, was adopted to explore the benefits of VM in the transportation sector. Action research is used in real situations, rather than in contrived, experimental studies, since its primary focus is on obtaining knowledge while solving real-life problems (Brydon-Miller et al. 2003). Case studies, on the other hand, are suitable for studying phenomena in their real-life contexts (Yin 2003). The visual systems illustrated in this paper were investigated within two construction projects from the transportation sector in England; Project 1 and Project 2.

Project 1 has been executed in northern England. It is one of the major improvement projects in England's strategic highways network to be delivered by 2020. The project is comprised of 3 individual sections and it will cover an approximately 27 kilometers long corridor with 11 junctions and 2, 3 and 4 lane carriageways along the route. A number of cameras, information signs, signals on gantries and additional lighting columns have been installed in a live traffic situation on the route as part of the project to relieve the

congestion. The estimated cost of the project is 289 million US\$. The works commenced in July 2014 with a planned completion in September 2017.

Project 2 was completed in southern England as a part of an ambitious plan for upgrading 72 underground metro stations over a 7-year period from 2013 within an estimated budget of 501 million US \$. Project 2's scope covered the upgrade of 5 metro stations of the total 72 with a cost of circa 36 million US\$. The site works included replacement of the life expired mechanical, electrical, fire and communication systems as well as failing roofs, walls and floor finishes and defective staircases. This had to be done at night when the stations were closed, in confined areas and with constrained access. The actual site works were executed between February 2014 and January 2015.

The investigated VM tools/systems include one visual workplace order or the 5S effort, one visual performance system, two visual specification/indicator systems and one visual control system. The 5S was implemented as an action research effort by the authors at Project 1. The 5S is the name of a systematic workplace organization method that uses five steps: sorting, setting-in-order, sweeping, standardizing and sustaining. The benefits of the remaining VM tools were studied as separate implementation cases at Project 1 (i.e. the visual performance system and the visual specifications/indicators) and Project 2 (i.e. the visual control). The benefits were recorded using both qualitative (i.e. semi-structured questionnaires, interviews or informal discussions) and quantitative (i.e. time-motion study, trend analysis and calculating the percentage of non-value adding activities in traffic management etc.) data collection methods. The following sections briefly describe the benefits and implementation characteristics of the VM tools.

- **RESEARCH FINDINGS**

- **5S IMPLEMENTATION PILOT**

A 5S implementation pilot project was executed in the storehouse of Project 1 as per the requests by Project 1's management. The benefit measurement parameters were chosen as comparing the item transaction times of the most demanded items (the time was measured from the demand of a storehouse item from a storehouse personnel by a worker to the handing out of the item to the worker) in seconds, saved floor space in meter square and recorded number of health and safety hazards before and after the 5S pilot. The item transactions times were measured for an experienced (>5 years) and inexperienced (<5 years) storehouse personnel to better reflect the reality. The condition of the storehouse before and after the 5S can be seen in Figure 1.



Figure 1: Storehouse condition before (a) and after (b) the 5S pilot

The recorded benefits of the 5S include some significant improvements in item transaction times, floor space savings and an improved overall health and safety condition of the storehouse. See Table 1 for the benefits of the 5S pilot after the implementation.

Table 1: Recorded benefits of the 5S pilot at Project 1

		Before the 5S		After the 5S		Time savings after the 5S	
		Inexperien ced Pers. (Sec)	Experienc ed Pers. (Sec)	Inexperien ced Pers. (Sec)	Experienc ed Pers. (Sec)	Inexpe rience d Pers. (Sec)	Experienced Pers. (Sec)
Item Transaction Times	Batteries	67	57	37	29	30	28
	Hammer	48	70	35	27	13	43
	Oil	111	80	40	27	71	53
	Paint brush	87	67	63	26	24	41
	Safety gloves	146	86	63	38	83	48
	Safety googles	75	80	55	38	20	42
	Safety vest	136	60	60	42	76	18
	Safety helmet	203	85	50	40	153	45
Space		Available Floor Space (m2)		Available Floor Space (m2)		Floor space saving (m2)	
	Floor Space	15		18		3	
Health and Safety		Number of hazards		Number of hazards		Number of cleared hazards	
	Trip and Fall Hazard	3		0		3	

The pilot 5S project implementation in the storehouse lasted for 3 months between October-December 2015. The warehouse personnel’s approach to the implementation process in terms of cooperation and compliance with the requirements from the authors was positive in general. They also stated their content with the improved layout and situation and that they would continue experimenting with the 5S steps at the storehouse during the implementation repeatedly; yet the authors’ drive, leadership and impulse had also been constantly necessary during the implementation process. After seeing the benefits, the Project 1 management has been working to sustain and disseminate the 5S to the rest of the project areas.

● **TEAM PERFORMANCE BOARDS**

In Project 1, the management wanted to have an integrated visual system to monitor and coordinate their construction project teams’ performance. Also, the management found that the project’s meeting routines within their teams were inefficient in identifying and solving problems and needed more focusing. Therefore, an integrated visual performance board and a team meeting system were developed in cooperation with the team members. The management’s ultimate aspirations was that the senior management team could walk around the office every day and observe or participate in each and every teams’ stand up meetings where they would discuss the days tasks and existing performance. The generic template includes a task promise section (made in public with owner, date and status), the ownership of the task section, the what needs to be done by when section and a team continuous improvement section along with each team’s past performance figures (see Figure 2). The teams have their regular daily stand-up meetings around the boards.

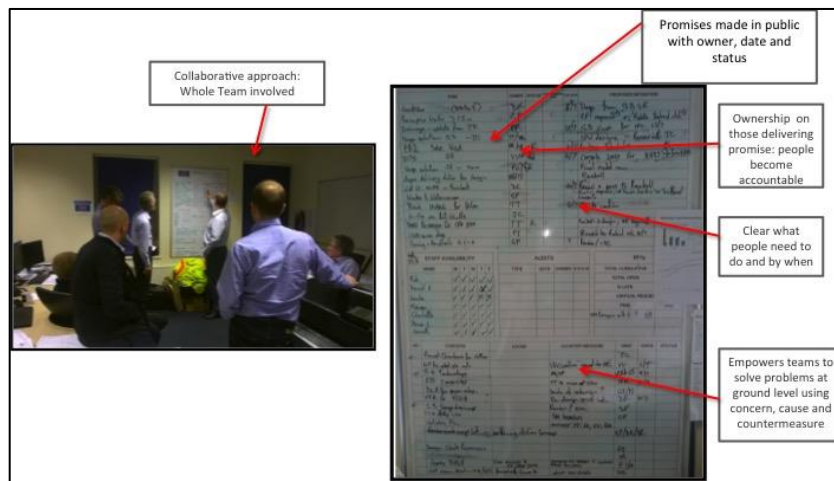


Figure 2: Team performance board

The first benefit recorded after the implementation of the boards is a reduction in the average duration of the team meetings. Previously, the meetings would take around 2 hours (120 minutes) on average per week with some minor deviations for each team. With a more focused and systematic daily meeting approach via the visual boards, the total weekly meeting duration was calculated to take approximately 50 minutes on average for the teams (calculated over a 10 week period after the implementation of the performance boards). After the implementation of the visual boards in June 2015, the overall Plan Percent Complete (PPC) of the teams has shown a general upward trend in time with an average PPC of 76% (see Figure 3). To capture insights from the team members on the boards, an open-ended questionnaire about the visual performance boards was distributed online among the teams for improved anonymity. The collected 10 responses from different team members were mostly positive, giving rich insights: “we have started to take our promises more seriously”, “people started to think more carefully before making any promises”, “enables meeting focus/structure and makes them more efficient”, “they are a great platform for the team to engage in conversation and communicate with each other”, “gives

awareness of what other members of the team are doing”, “they are engaging and give a solid understanding as to where each of our individual team members are up to with tasks”, “we can refer to the boards if a team member is not in the office and we need some information”, “the boards display dates for upcoming works and act as a simplified schedule”, “clear, visual management so everyone can see the actions and discussion points”, “we can see what tasks the team members are carrying out, also we can prioritize tasks which involve input from multiple team members”, “communication about what is being achieved, identifying what needs to be changed.” The team members mainly complained that people could easily get away from the meetings around the board, underlining the importance of monitoring the use of the boards for its sustaining.

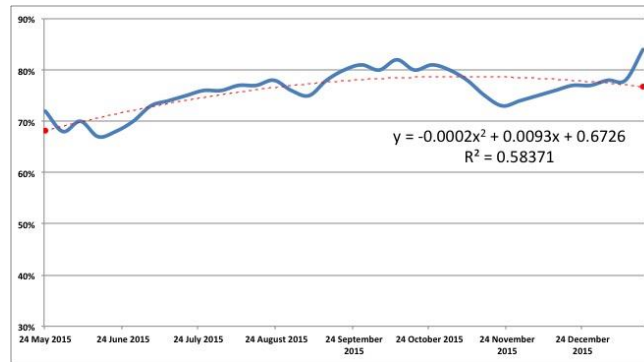


Figure 3: Gradual increase in the teams' overall PPC

• TRAFFIC MANAGEMENT COORDINATION BOARDS

While improving a busy highways network in a live traffic situation, permanent and temporary traffic management become highly critical issues. Most of the time, contractors face serious monetary penalties by their contracts for the number of closures they incurred. Therefore, maximizing the utilization of the working window with value adding actives during a closure is of primary importance to contractors.

To improve the coordination and transparency in the utilization of the project's closures, Project 1 management adopted two visual coordination boards. The first board is for the night-time traffic management that was created to allow all construction teams to view 2 week look-ahead traffic management program in order to maximize the use of each closure (see Figure 4a). The second board, which is basically a large project drawing with magnetic traffic management related pins representing different traffic management actions, was put in use for the coordination meetings of the night-time traffic management personnel in the office to record and facilitate their discussions (see Figure 4b).



Figure 4: 2-week look ahead (a) and magnetic (b) traffic management boards

The first benefit identified from the implementation of the traffic management visual boards is in the downward trend in the percentage of the project’s closure working window waste, which corresponds to the total percentage of the work wastes or non-value adding activities during closures in the corresponding month (see Figure 5).

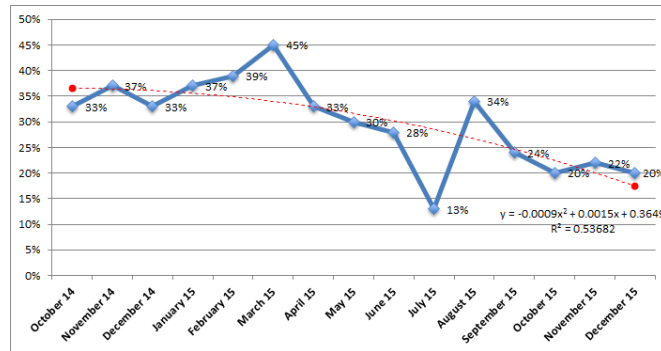


Figure 5: Decreasing percentage of non-value adding activities during the closures

As for the benefits of the boards, the following comments were recorded from 5 members of the traffic management team; “solve problems before they arrive”, “visibility for all”, “better coordinate and harmonize the teams’ works”, “it is good for planning the efforts beforehand”, “raises awareness of what other traffic management teams do”, “the teams can do better forward planning”, “helps link the night and day shift teams”, “solve problems before they arrive with better coordination”, “triggers coordination and discussion”, “the night and day shift people can see what is going on any time without asking”, “it enables all the foremen and supervisors to avoid clashes, the location of the next nights work and all are aware of the times get of e traffic management and when they can access their work location and when they need to complete works and leave site.”

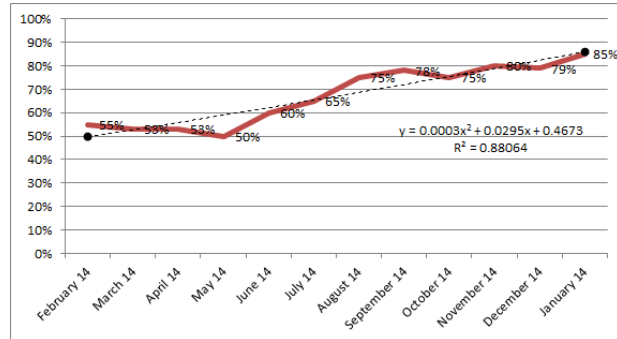
● **PROJECT CONTROL BOARD**

After the start of Project 2, the project management realized that they needed a way to manage and control the site at the activity level as per the Last Planner. Moreover, the PPC figures of the project from the Last Planner were hovering around 55% to 60%, which the project management wanted to increase. To tackle this issue, a 3-week look-ahead visual control board was introduced to the site (see Figure 6a). After the implementation of the

board in May 2014, Project 2 management recorded a steady increase in the overall PPC of the project to 85% (see Figure 6b).



(a)



(b)

Figure 6: Project control board (a) and the increase in the project PPC after May 2014 (b)

In figure 6a, the leftmost colour-coded column represents different project site areas (locations). The remaining columns on the board represent days, shifts and weeks (time) for the 3-week period. Bespoke cards were used by each subcontractor to write down and record their activities for a 3-week period on site. Those cards were called subcontractor activity cards and they included information such as the working area, date, activity, manpower and the duration. Each card was colour-coded to match the master schedule (e.g., blue for mechanical works, red for electrical works etc.). The cards then populated the 3-week look ahead boards based on the plans. At the end of every shift, the project's construction manager would review the progress of the shift and confirmed whether or not the activity had been completed. If the activity had been completed, the construction manager 'turned over' that activity card which had the colour green on the back of it. If the activity had not been completed, the activity card stayed as it was. The project team would need to re-plan and develop a follow-up strategy. There were several other cards that site contractors used such as the "ready for inspection" card or the "issue card" to communicate a problem that needed the management's attention.

In a semi-structured interview with two project and one construction manager of the project, the managers strongly agreed that the control board; (i) increased the coordination among different subcontractors, (ii) reduced the work and space clashes among different teams, (iii) helped the managers identify the bottlenecks in advance, (iv) triggered discussions among the work teams and (v) linked the Last Planner with the field personnel. However, the managers stated that the project could not use the board effectively to set the systematic base for the project's continuous improvement efforts.

• DISCUSSION

Particularly with the implementations involving a trend analysis over a period of time (i.e. team performance visual boards, traffic management coordination boards and project control visual board), it is hard to isolate the quantified benefit of a particular visual system to the overall performance from the rest of the other potential contributing factors that might play a role in the performance improvements. The trend analyses show the tendency

towards a positive contribution to the overall performance after the implementation of a specific visual system. Therefore, the quantitative findings were supported and elaborated by the in-depth qualitative findings obtained from the people actually involved in the use of those visual systems.

Improved work coordination, triggered project team discussions and better root-cause identification of problems, which translate to an upward trend in PPC figures, decreased waste in limited work-windows or in regular team meetings, come to the fore as the important and common qualitative benefits of some of those systems. The associated benefits of the 5S in item transaction times and floor area savings could be more clearly calculated in that sense. The systems also enable an easier control of the work context at a glance for the management.

It should be noted that all those successful implementations outlined were firmly supported by the senior management of the projects with a lean construction and VM vision. The senior management stated clearly to their teams that they wanted those visual systems to be developed and used in their daily work routines. Even though the personnel were left to decide on and experiment with the implementation phase to a degree, the implementations were essentially top-down, starting with the identification of a need by the management and developing with constant monitoring.

VM offers highly practical solutions to the situations that can be improved through increased transparency. However, the form and content of those visual solutions can change as per specific project conditions, project needs and people involved. Therefore, different visual solutions can be adopted even for the same problem in the transportation construction context in the future.

• CONCLUSIONS

This paper presents the captured benefits of four practical visual systems; visual workplace structuring (the 5S); visual measures (team performance visual boards); visual specifications/indicators (traffic coordination boards) and visual controls (project control visual board) with their implementation characteristics over a two-year period (2014-2015).

The findings confirm the VM benefits identified from the literature (Foromoso et al. 2002; Moser and Dos Santos 2003); (i) increased self-management, (ii) better team coordination, (iii) better promises or an increasing PPC, (iv) easier control for the management, and (v) with the 5S, an improved workplace conditions with decreased item transaction process times, savings in work spaces and a better health and safety condition.

VM in construction, particularly in the transportation sector, generally lacks empirical research. In that sense, future research can present new performance indicators or parameters for the quantitative benefits of VM systems for managers to evaluate their own VM efforts in a more varied way. Also, qualitatively, the perspectives of different organizational roles (i.e. managers, staff, construction workers) on the same visual system can be recorded for richer insights. The 5S can also be implemented in the transportation supply chain on a larger scale to spaces like offices, depots, lay-down areas, construction sites, laboratories, maintenance vans and warehouses. Also, VM benefits can be further investigated for the design and maintenance phase of transportation projects.

The main limitation of the research is the hardship in abstracting a benefit of a specific VM tool from an overall project/team performance. This research effort tried to overcome this issue by collecting both qualitative and quantitative data to support the statements. This limitation can also be partly overcome in future research efforts, when researchers compare projects or teams with and without an analyzed VM tool to better highlight or single-out the tool's benefits.

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