

Visual Management in Lean Construction

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Abstract:

Organisations are increasingly forced to work more efficiently by their environments. One of the responses to these pressures is lean thinking, which was first embodied in the form of lean production in Toyota. Visual management is an important element in the lean production system. This paper briefly defined the role of visual management in lean thinking, in connection with lean construction as the reflection of lean thinking in the construction industry. The lean thinking, lean production and the lean construction concepts were briefly explained. A detailed literature review on the visual management topic, its theoretical and practical aspects within the lean production/construction context was presented. Some identified research opportunities in construction were proposed at the end of the paper.

Keywords:

Lean construction, lean thinking, lean production, visual management.

1. Introduction

As the work environment becomes more and more complex, the need for connecting human efforts with processes and the organization's strategic goals become more important. Visual management and its elements offer this link through transparency (Koskela, 2000) and discipline (Hirano, 1995; Galsworth, 1997) imposed on the workplace, which help people understand conditions, abnormalities and expectations at a glance. Lean thinking eliminates any buffer that hides the problems in a production system (Monden, 1997; Liker, 2004; Mann, 2005). Visual management is used to communicate this tightly connected, more transparent conditions created in a lean environment to groups of people. Visual management and its elements create an information field for people to pull the necessary information from (Greif, 1991). Visual management influences, directs, limits and guarantees human behaviour (Galsworth, 1997). This quick and easy understanding is the key to self-control, empowerment, workplace discipline and improvement in a contemporary workplace, which directly contributes to the organizational survival and development.

Lean production integrates visual management into its processes extensively. Practically, it is primarily used to influence behaviour in a desired fashion, to communicate organizational strategies and objectives, to display standards and measures visually, to control production and inventory, to monitor processes, to realize quality at source, to increase safety and machine reliability, to organize workspaces and territories, to reduce unnecessary motion and waiting, to manage the human resources issues, to provide close, relevant, day-to-day

information, which is needed for the management/execution and the continuous improvement of the production system. This paper aims at outlining the lean thinking, lean production, lean construction and the visual management concepts. The practical aspects of visual management in the lean environment are explained briefly. The paper presents the past research related to visual management in the lean construction environment. The identified research opportunities for the future are presented at the end of the paper.

2. Lean Production

The lean production term is the collective synonym for the production system which was first developed in the car manufacturing environment. It takes its theoretical roots from the lean philosophy that was crystallized in the lean production system at the Toyota Motor Corporation for the first time (Womack et al., 1990). It basically aims at providing high quality, low-cost products in time. The system is also known as the Toyota Production System (T.P.S), or non-stock production, or just-in-time production (J.I.T).

The English term “lean production” was first coined by a member of the International Motor Vehicle Program team, led by the economists James P. Womack and Daniel T. Jones at the Massachusetts Institute of Technology and published in their books – “The Machine that Changed the World” (Womack et al., 1990).

The theoretical principles of the lean production system were proposed by different authors similarly (Ohno, 1988; Womack and Jones, 2003; Liker, 2004). They are briefly: identification of value, flow of production factors in cellular production units and pull driven production. The production system constantly aims at improvement and efficiently working.

Liker (2004) proposes a lean production framework than can be seen in Figure 1. The two important columns of the framework are J.I.T production and Autonomation (Jidoka). J.I.T basically prevents overproduction via the pull-driven production mindset and reduces inventory (Ohno, 1988). Autonomation helps to implement and sustain a reliable/effective production by integrating quality-at-source into processes. These columns are based on and connected to people through visual management.

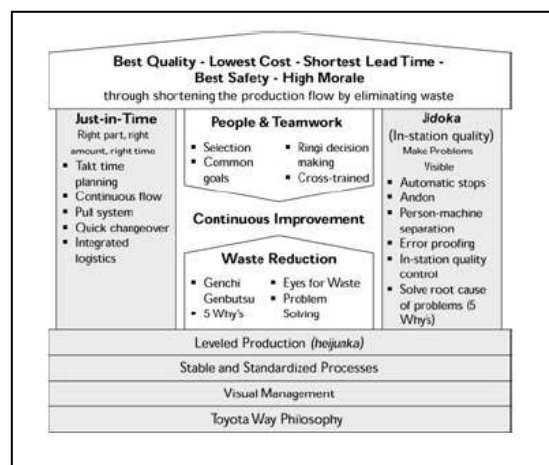


Fig. 1. The Toyota Production System Model (Adapted from Liker, 2004)

3. Lean Construction and T.F.V Approach

The lean production philosophy, which had contributed to the development of various industries, took the attention of the people in the construction industry as well. Especially, since the early 1990s, a “lean construction” concept has been tried to be created and promoted. The most notable of the organisations that have been working solely for the development of the lean thinking in the construction industry are the Lean Construction Institute (L.C.I) of the U. S. and the International Group for Lean Construction (I.G.L.C). Lauri Koskela was the first to clearly introduce the lean movement in manufacturing to the construction industry in his seminal report (Koskela, 1992). He hosted the first conference of the I.G.L.C in Espoo, Finland in 1993. A group of researchers at the conference adopted the name “lean construction”.

A concise definition of lean construction is a “way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value” (Koskela et al. 2002). There are two distinctive approaches; one is defining new management methodologies for the construction industry, based on lean thinking and the other is trying to adapt the proven lean manufacturing methodologies to the construction industry. The Last Planner system can be an example for the former. Construction differs from manufacturing in many ways. Construction produces uniquely large end products that cannot be transported or stored. On the other hand, it is a project base business in which temporary production processes move around the end product. Its fractured, project-based nature hinders long-term relationships. Salem et al. (2006) briefly summarize these differences that result in a high degree of uncertainty in construction: on-site production, one-of-a-kind production and complexity.

The deficiencies in the current practice of project realization in construction have been discussed intensively. Lean construction proposes the Transformation-Flow-Value (T.F.V) approach for construction to improve its performance. Incorporating in craft production, mass production, lean production and value generation approach, Koskela (2000) proposed the T.F.V approach for a wider understanding of construction. He argues that the current practice in construction heavily emphasizes the transformation view and should be expanded to cover the other two views as well. The T.F.V approach can be seen in Table-1

Table 1: The Main Principles of T. F. V. Concept (Adapted from Koskela, 2000)

Concept			
	Conversion(Transformation)	Flow	Value
P r i n c i p l e s	Decomposition: The transformation process can be decomposed into sub processes which are also transformation processes. Cost minimization: The cost of total process can be minimized by minimizing the cost of each sub process. Buffering: It is advantageous to insulate the production process from external environment through physical and organizational buffering. Value: The value of the output of a process is associated with the cost of inputs to that process.	Reduce the share of non-value adding activities: Try to eliminate the reasons of waste that were defined by Shingo, Womack and Jones. Reduce the lead time: Basically, eliminating non-value activities will cause a reduction in the lead times. Reduce variability: Variability increases the lead time. Simplify: Reduce the number of components in a product or the number of steps and linkages in a material and/or information flow. Flexibility: Increase mix flexibility, volume flexibility, new product flexibility and delivery time flexibility. Transparency: Increase transparency by making the main flow of operations from start to finish visible and comprehensible to all employees.	Requirements capture: Ensure that all customer requirements, both explicit and latent, have been captured. Requirement flow-down: Ensure that relevant customer requirements are available in all phases of production, and that they are not lost when progressively transformed into design solutions, production plans and products. Comprehensive requirements: Ensure that customer requirements have a bearing on all deliverables for all roles of customer. Capability: Ensure the capability of production system to produce products as required. Measurement of value: Ensure by measurements that value is generated for customers.

Transparency is an important aspect of production flow and it is realized through visual management according to the T.F.V approach (Koskela, 2000). The transparency effect of visual management on a production system and its other attributes will be discussed in the next section.

4. Visual Management

Visual management can be defined as a management approach that attempts at improving organisational performance. This is achieved by connecting and aligning organisational vision, core values, goals and culture with management systems, work processes, workplace elements, and stakeholders, by means of stimuli, which directly address one or more of the five human senses. These stimuli render transparency and impose discipline, through providing immediately necessary, quality information, which helps people make sense of the organisational context at a glance. By the term “visual”, it is meant that any stimulus communicated through one or more of the five senses, yet “visual” stimuli constitute the major part. It is like the neural system of lean production. It is partly a communication system that tries to eliminate the short-comings of the classical organizational communication model. It provides necessary, relevant, true, immediate answers to the people’s questions at work, in order to eliminate their dependence on other identities for information. It helps people make sense of the conditions and the context of the organisation they work in, by clearly displaying the required information that connects them to the organisation.

This understanding helps people attribute themselves to the organization through strengthened awareness. People can understand what the right way to do a task is, what performance measures are used to assess their efforts, what kind of impacts their efforts create on the organisational performance, where the correct places of the materials, equipments and the machinery are, what skills the people in the organisation possess, and many more, by merely looking around, just at a glance.

Visual management is generally understood within the organisational transparency concept in a production flow. According to Greif (1991), transparency means a “separation of the network of information and the hierarchical structure of order giving, which in classical organization theory are identical.” This view, transferring information to the “doer” in order to grant self-control, binds visual management to management-as-organizing (Koskela, 2001). Santos et al. (1998) define transparency as “the ability of a production process (or its parts) to communicate with people” It is needed to make the main process flows visible and comprehensible from start to finish by measuring and public displaying of information (Koskela, 2000). Problems, abnormalities and wastes can be easily recognizable to take remedial measures via transparency. Koskela (1992) proposes six principles to increase process transparency: reducing the interdependencies between production units, using visual devices to enable immediate understanding of the process status, making the process directly observable, incorporating information into the process, keeping a clean and orderly workplace, and rendering invisible attributes visible through measurement

Additionally, visual management is a control practice that enforces discipline over a workplace. It helps organizations to develop and sustain a discipline in flow by influencing, directing, limiting or guaranteeing people’s behaviours (Galsworth, 1997). Discipline can be defined as “making a habit of properly maintaining correct procedures.”(Hirano,1995). Anyone, even a newly hired, inexperienced employee, should be able to distinguish between normal and abnormal conditions at a glance and start taking the correct steps, developing intuitive, habitual correctness, without being dependent on other identities. Mann (2005)

states that visual management connects people to processes, and at the same time reflects people's adherence to the expectations of processes, by transforming the abstract concept of discipline into directly observable concrete practices. It is a simple, low-cost tool, yet it offers some advantages over complex I.T systems with its immediate, widely accessible, flexible, inexpensive and responsive nature. Visual management and I.T systems can be employed in some sort of combination to support one another. For a detail comparison of these advantages see Mann (2005).

Visual management aims at creating an information field from which people can immediately pull information when they need it (Greif, 1991). The flow of correct, timely, relevant information is not spoiled by organizational structure, organizational politics, technical shortcomings etc. This field will hopefully be enriched as people start to share information (or their tacit knowledge), in other words, as people move from the stage of getting answers to the sense of giving answers publicly (Galsworth, 1997). The information field is created by locating necessary visual information, generally aimed at a group of people, to the shared locations, where it is most relevant. The information that is closely related to a workstation is positioned close to that workstation. If the information concerns larger groups of people, it can be placed in largely shared areas. This information is expected to be proactive in nature, preferably also effectively answering questions people have even not yet thought of and influencing people in a desired direction. As abnormalities, problems, wastes in processes, standards, workplace organization, abilities of people etc. become obvious to anyone, with enabling management, synergetic improvement propositions from anyone can be received to keep the system flexible, learning and improving.

In lean organisations, visual management is highly involved in solving problems/kaizen practices, information systems, performance measurement, management accountability, process monitoring, workplace organization, quality management, visual instructions/standards, key performance indicators, value analysis, territory/facility marking, production/inventory control, machine maintenance, safety management, organizational learning, employee management and improvement (Saurin et al., 2006; Aik, 2005; Mann, 2005; Liker, 2004; Monden, 1998; Hirano, 1995). This indicates that visual management acts as an enabler for other flow attributes (reliability, density, accuracy, regularity), aimed in an organisation.

5. Visual Systems and Visual Elements

Galsworth (1997) indicates that visual management is realized by visual systems that consist of one or more visual elements. These elements are consciously designed to structure human behaviour. The elements have different power index which depends on the extent to which the message they send is likely to be obeyed and the potential risk or loss if we decide to ignore it. These elements, in ascending order of their power indexes, are as follows (Galsworth, 1997):

Visual Indicator: Gives only information. It only tells and tries to influence. The human control of disobedience is high. The consequence of disobedience is minimal. See Figure 2.



Fig. 2. The Visual Indicator

The commonly used visual indicators in a lean environment are team boards, departmental boards, charts, logs, plates, tags, photos, electronic visual models, films, value stream maps etc. When these elements are used for control purposes at workstations and processes, they generally include the expected state, the real state, the performance indicator (measure), the reason of deviation and the measures taken as a template. Within this template, they provide a basis for continuous improvement.

Visual Signal: Signals and grabs your attention with visual stimuli. It expects people to listen and directs their behaviour. The human control of disobedience is moderate. The consequence of disobedience may be high. See Figure 3.



Fig. 3. The Visual Signal

In the lean environment, quality control tools such as the andon and autonomation can be good examples for the visual signal. The andon signals visually and audibly to call a team leader in case of an abnormality in a line or at a workstation. When a machine stopped, it is a direct and effective visual signal for action. The culture of stopping production is the strength of lean production.

Visual Control: Controls and limits human response in terms of height, size, quantity, volume, weight, width, length and breadth. Human control of disobedience is almost none. Generally it integrates the message into the physical environment, leaving people not many options for response. See Figure 4.



Fig. 4. The Visual Control

Bordering, outlining, marking, color-coding, the safety, the production, and the maintenance kanban (signalling cards) are some of the tools utilized for the visual control in lean production.

Visual Guarantee: Guarantees and allows the correct response only. No intentional or unintentional errors. Human control of disobedience is none. It adds high discipline. All the information one needs is built through mechanically or electronically into the machine, material or environment itself (Poka-Yoke devices – Zero Quality Control). See Figure 5.

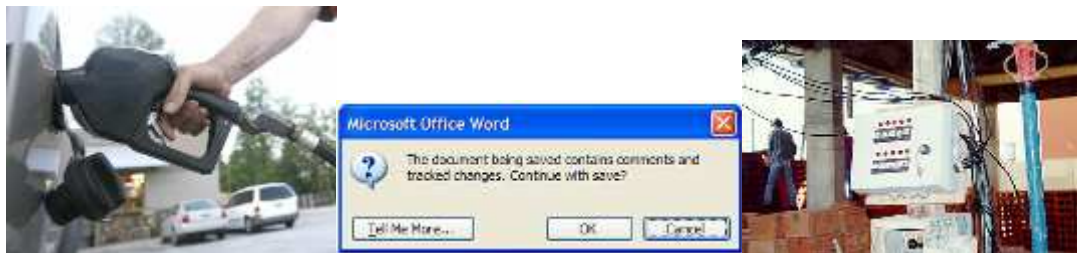


Fig. 5. The Visual Guarantee

A Poka-Yoke device can guarantee the expected quality or the disciplined in a process at the expense of sacrificed transparency (Galsworth, 2004).

These visual elements come together in different forms at different organisational layers. They generally complete and support each other systematically. Galsworth (2004) claims that in order to create a visual workplace, which she defines as “self-explanatory, self-ordering, self-regulating, and self-improving”, that speaks the language of lean production so that, “what is supposed to happen does happen, on time, every time, day and night.” She proposes a hierarchical framework that can be seen in Figure 5:

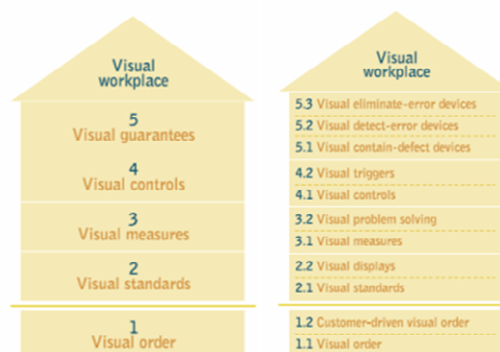


Fig. 5. The Visual Workplace Model (Adapted from Galsworth, 2004)

6. Research on Visual Management in Lean Construction

In the lean construction literature, it is observed that the general tendency is to adapt the proven lean manufacturing tools for the construction industry. Dos Santos and Powell (1999) discuss the applicability of Poka-Yoke devices in the construction environment and identify a

gap for research in this area. Formoso et al. (2002) evaluate the obstacles in the application of the transparency principles in the construction environment through six case studies in the U.K and Brazil. Dos Santos et al (2002) identified the importance of the visual elements in the cell production attempts in construction. Arbulu et al. (2003) show an application of the kanban in on/off site material supply. Kemmer et al. (2006) display an application of the andon and the heijika box in a high-rise building construction. Saurin et al. (2006) identify the link between safety management and visual management. Jang and Kim (2007) show an application of the kanban in production control and safety with the Last Planner System in construction.

7. Research Opportunities

Research opportunities are abundant for the construction environment. Firstly, the application of visual management in dynamic production systems such as construction presents an important research opportunity. The end product of a construction activity is generally the very spatial area that visual management targets. This fact makes it more complicated to modify the workplace area of a construction workstation. Moreover, workstations change in nature and location around this end product in time. Therefore, it requires more dynamic visual elements in nature that move along with workstations and possibly change forms as construction progresses (Formoso et al., 2002).

Secondly, researching the applicability of the visual workplace framework proposed by Galsworth (2004) in the construction environment can make an interesting research project. Galsworth (2005), later elaborated and explained that framework in detail. The framework offers a guide for visual management researches as well.

Thirdly, a research on disciplined construction site/shop floor/office, order- visibility investigation, in relation with 5S in the construction environment can be conducted. 5S is an extensively used methodology in today's shop floors and offices that generally provides a basis for further initiatives like the just-in-time production system in a visually ordered, clean and maintained workplace. Detailed information about 5S can be found in Galsworth (1997) and Hirano (1995).

Investigating the standardisation needs in the construction environment and proposing some relevant poka-yoke devices is another research opportunity (Dos Santos and Powell, 1999). Poka-Yoke devices highly standardise outcomes. These devices were extensively used and promoted by the industrial engineer Shigeo Shingo. A significant amount of literature can be found about this topic, especially from the manufacturing point of view. In order to conduct a research like this one, it is essential to identify the practical standardisation needs in construction first. It may also require electro-mechanic redesign of some construction elements or introduction of new construction methods/elements.

Closely analysing the relationships between visual management and other management approaches, in relation with the construction industry may provide a strong reference point for other researches on visual management. It was found that the definition of visual management and the explanation of the relationships between visual management with other management topics are not clear and satisfactory enough in the literature.

The applicability of visual management in I.T in the construction environment would make a combined research effort. Mann (2005) identified the differences between I.T systems and the visual elements. Provided that they are used together, they can possibly contribute to the ease

in use and the effectiveness of one another. Different possibilities of the combined utilization of the two can be researched.

8. Conclusion

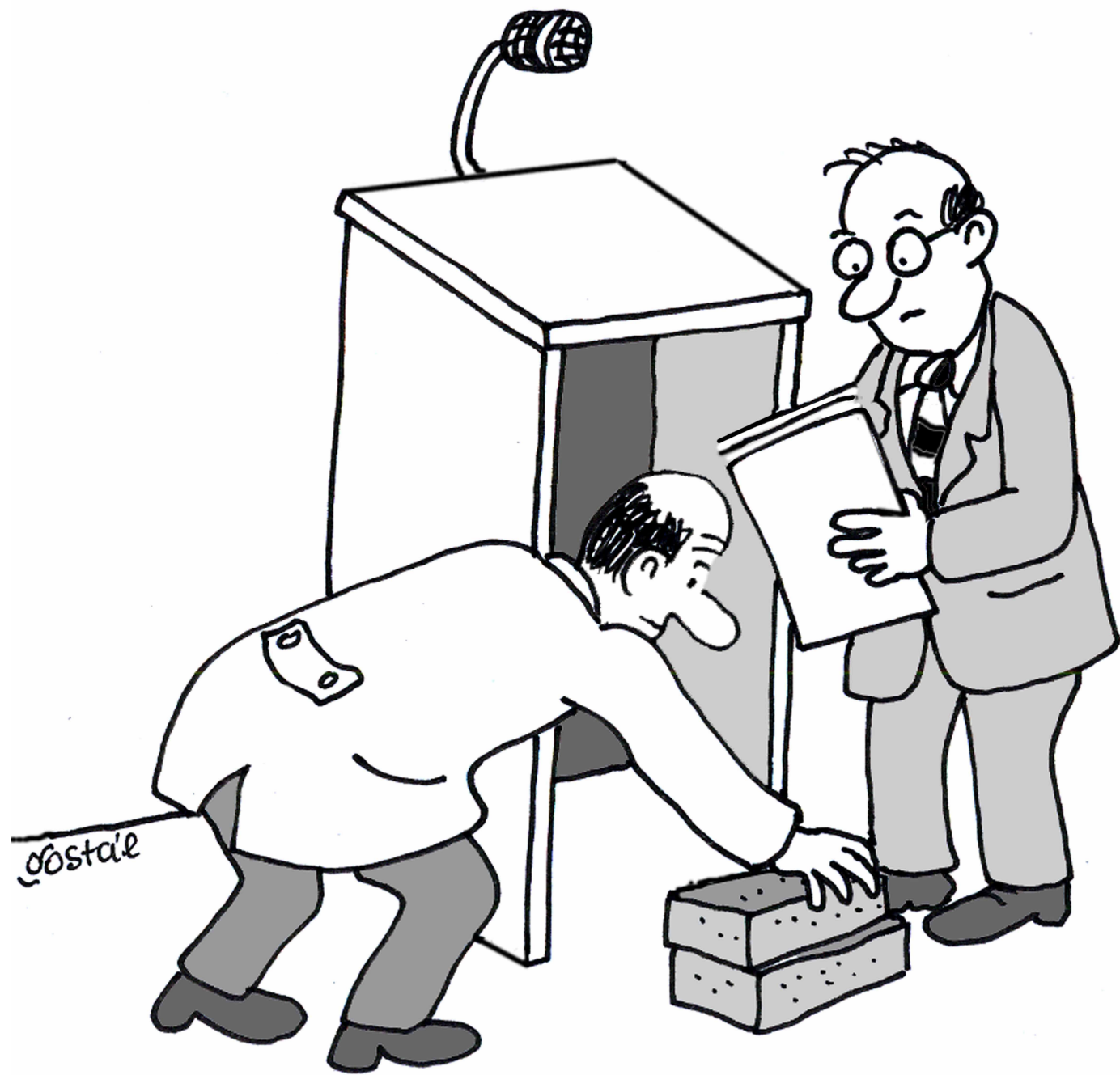
Visual management as an organisational performance improvement effort has been used in offices and shop floors to support work tasks and to connect different elements of an organisation to one another. It renders transparency and imposes discipline in a work environment by providing quality information at a glance. It has been employed systematically, especially in manufacturing shop floors and offices in different forms. We are surrounded by visual elements in our daily lives and essentially, as human beings, we are easily stimulated by the elements that directly address our five senses. The construction industry has some room for development through visual management as well. The past research efforts were mainly found to be an adaptation of the proven lean production methodologies to the construction environment. Some future research opportunities were identified in this paper after a detailed literature review. The most distinctive challenge in that sense seems the necessity of developing a systematic visual management effort in a highly dynamic/complex production system such as construction.

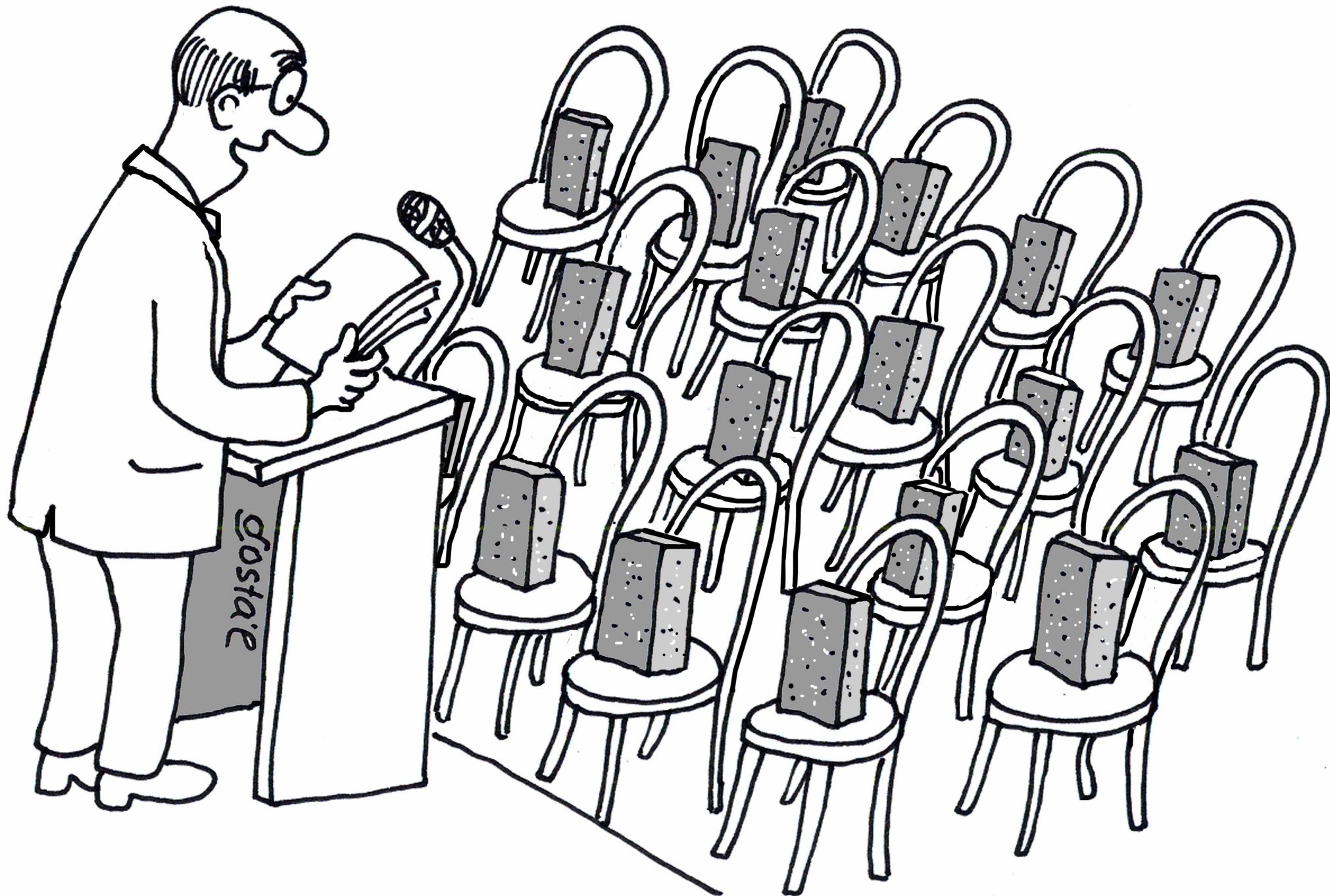
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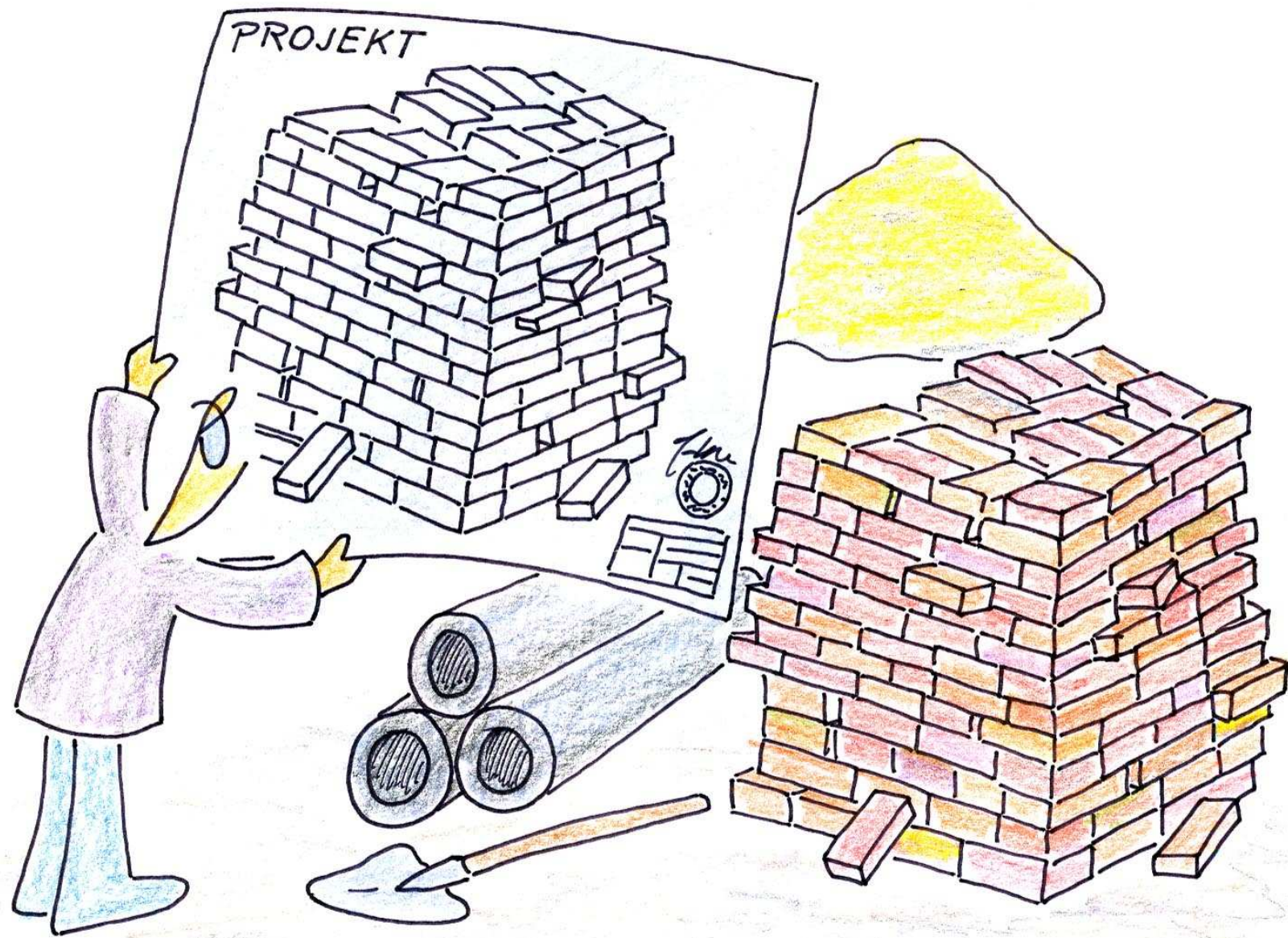
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