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INVESTIGATION OF VISUAL MANAGEMENT CASES IN CONSTRUCTION BY AN ANALYTICAL FRAMEWORK FROM MANUFACTURING

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ABSTRACT

Along with the progress of globalization, speed and efficiency have become more critical for any industry than ever before. In this sense, the concept and methods of lean management, promoting these performances, have been deployed from manufacturing, its origin industry, to other industries. This paper deals with this management style in the construction industry, called lean construction. In particular, visual management (VM) as one effective tool in this scheme is focused on. A number of VM cases, 306 in total, was collected from both construction and manufacturing sites and investigated by the so-called 5W1H analytical framework developed in the manufacturing industry. Obtained results suggest that the VM cases in construction have common attributes such as purpose and location, target to attain, users' attributes, timing to use and elemental technologies for case development. A comparison analysis of the VM cases from construction and those from manufacturing was also carried out, for a mutual transfer of this technology between these industries.

Keywords: Lean management, Construction industry, Visual management, Technology transfer, 5W1H analysis

1 INTRODUCTION

Visual management (VM) has recently been implemented in various organizations of a value chain irrespective of the industry. The reason of the diffusion must be that VM contributes to quick problem-finding and -solving. Anyone can easily develop and implement its methods. However, an uncontrolled development of technologies for VM has occurred recently If a situation like this is going to continue, VM will not come up to our expectations. Based on the recognition, in order to

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realize a smooth implementation, Murata and Katayama (2010 a, b, 2013 and 2014) proposed how to reuse implemented cases to a production system. Two types of the case reuse were described in the past study. One is a case reuse within one industry. The other is a technology transfer between industries. The past study mainly focused on the former type. In this paper, the latter type of study is considered. Particularly, a comparison between VM in manufacturing and VM in construction is going to be discussed.

2 RESEARCH BACKGROUND

2.1 Strategic visual management

Strategic visual management (SVM) is based on Murata's and Katayama's (2010a) work which proposed a technology transfer system for developing the scheme of Kaizen (Imai 1986), continuous improvement (CI) (Lillrank 1989) and lean management (Womack 2003). SVM is VM's extended version from the viewpoint of a technology life-cycle management. This means, not only the development and utilisation of relevant cases but also the reuse of those cases concretely is included. Thus, in SVM, there are four research categories; 1) Design, 2) Accumulation, 3) Transfer and 4) Education, as shown in Figure 1.

The first category is for discussing how to design a useful technology. It is a basic problem in SVM. VM is confused with a mere notice board. Light-hearted design and implementation of VM will invite simplistic result and unessential management. A systematic procedure is needed for designing effective technology.

The following three research categories are for the lifecycle management of VM technologies.

The second category is for how to manage VM case-base considering the reuse of implemented cases. For this category, Murata and Katayama (2010a) proposed a framework of the case-base by people-oriented case-based reasoning (CBR) (Carbonell 1982). It consists of five phase utilisation procedures of the case base; 1) a clarification of a problem to be solved by VM, 2) a retrieval of useful cases in a case-base, 3) a development of new case for identified burden by referring a selected case, 4) an application of the developed case to identified burden and 5) a registration of the implemented case in a case-base.

The third category is for a reuse phase of implemented technologies. Two types of this phase were described in the past study (Murata and Katayama, 2014). One is the technology reuse within one industry. The other is the technology transfer between industries. The latter type is focused on in this paper. And then, a technology transfer between manufacturing and construction is considered In particular.

The researches of the fourth category are not found in the past studies. In the future, material development will be necessary to inform knowledge about VM: a) the need for VM, b) the effect of VM and c) how to design related technologies.

2.2 Visual management in lean construction

Lean construction was born from the Toyota Production System (TPS), which was renamed as lean management. Sacks et al. (2010) illustrate this concept as follows: "As in the TPS, the focus in lean construction is on reduction in waste, increase in value to the customer, and continuous improvement". The TPS has developed many useful methods. VM is one of them. Andon and Kanban are representative examples. VM is used in construction sites, too.

Tezel et al. (2010) reported 187 VM cases in the construction sites of high-rise buildings in Brazil. These cases are classified into the following 18 groups:

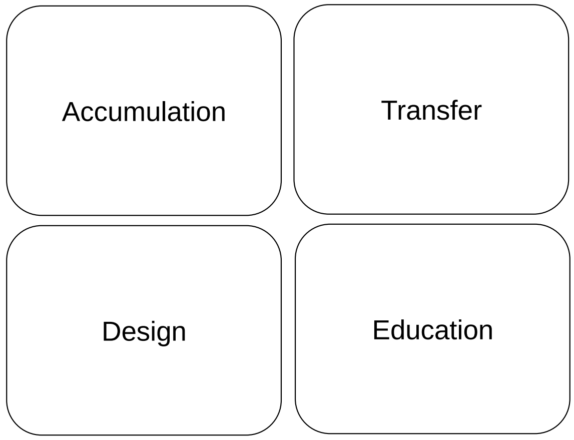

Figure 1: Research categories of strategic visual management (SVM)

1) Site layout and fencing

2) Standardisation of the workplace elements

3) In the warehouse

4) The 5s

5) In the elevators

6) Pull production through the Kanban

7) Production levelling through the heijunka box

8) In-station quality (jidoka) through the andon

9) Prototyping and sampling

10) Visual signs

11) Visual work facilitators

12) Improvisational visual management

13) Explaining the work schedule

14) Performance management through visual management

15) Distributing the system wide information

16) Human resources management

17) Safety management

18) Poka-yoke (mistake proofing) and prefabrication

However, a case can belong to two or more categories because cross concepts are contained in the categories. For example, 2) Standardisation of the workplace elements and 13) Explaining the work schedule refer to the purposes of VM but 3) In the warehouse and 5) In the elevators refer to the locations for using VM. In turn, 4) The 5s, 6) Pull production through the Kanban and 18) Poka-yoke (mistake proofing) and prefabrication represent also tools of VM. In order to effectively transfer the abundant cases of this report on various construction sites, a systematic classification of them will be necessary.

3 METHODOLOGY

3.1 5W1H analytical framework

Generally, a case study aims at disclosing the characteristic of an investigated organization. The analysed object of this paper is smaller than that of a general case study. It is a case, which is developed by VM's own tools and their implementation on the collaboration site. Through the analysis of many VM cases, it will be possible to understand the management capability of this site including VM.

Murata and Katayama (2010a) proposed an analytical framework for the VM cases in manufacturing by 5W1H (Why, What, Where, Who, When and How) questions as follows. This paper quotes this framework to investigate the VM cases on a construction site one by one.

The 5W1H analytical framework for VM cases;

- Why did you implement this case?
- What was visualized by this case?
- Where did you use this case?
- Who use the case?
- When did you use this case?
- How did you realize this case?

The keywords of a VM case extracted by the framework are also stored in a database like Table 2. They are extracted by the framework in manufacturing. Hence, constructed database will become a significant information source for comparing the VM in manufacturing with the VM in construction. And then the result of this comparison will constitute a base for VM technology transfer between the two industries.

3.2 Research procedure

The research procedure of this paper consists of four steps; 1) selecting the cases, 2) analysing the selected cases, 3) organizing the analysed data and 4) discussing the characteristics of the analysed cases.

In the first step, the cases were selected from the ones presented in Tezel et al. (2010). A selected case should have had a clear photograph and an explanation of its features. In the second step, all of the selected cases in the first step were investigated. It was performed based on the 5W1H analytical framework explained above. Six words from each case were extracted for each question. In the third step, the analysis result of the second step was listed in the form of a table. With regard to the design of the table, each question was put in the horizontal direction of the table like Table 2. The number of each case was put in the vertical direction of the table. In the fourth step, the characteristics of the analysed cases were discussed through comparing the keywords of the cases. The initial comparative analysis of the VM cases in construction and those in manufacturing was also carried out.

4 ANALYSIS RESULTS

4.1 Selecting cases (step 1)

Tezel et al. (2010) illustrated 187 cases. They are mainly used on multi-story building construction sites in Brazil. 165 cases, which are possible to analyse, were selected from the report. A summary of these cases is shown in Table 1. It shows a number of cases in every 18 of Tezel's categories. The number of cases in each category are 7, 43, 11, 8, 7, 5, 2, 7, 9, 7, 7, 6, 4, 9, 12, 6, 8 and 7. The largest number of cases is 43 of 2) standardisation of the workplace elements. This category has eight sub-categories; 2)-1 the colour coded helmets, 2)-2 marking the transportation routes, 2)-3 locating and identifying the construction materials, 2)-4 creating a clean and neat workplace, 2)-5 the identification of the spatial elements, 2)-6 already grouped and classified construction materials, 2)-7 the identification of the transportation hand barrows and 2)-8 the identification and order in the workstations. The number of cases in each sub category is 3, 8, 7, 8, 8, 4, 2 and 2.

4.2 Analysing selected cases (step 2)

165 selected cases were analysed. Two analysis examples are introduced as follows.

Table 1: Number of Analysis Cases

Categories of cases by Tezel et al. (2010)	Number of analysis cases
1) Site layout and fencing	7
2) Standardisation of the workplace elements	43
3) In the warehouse	11
4) The 5s	8
5) In the elevators	7
6) Pull production through the Kanban	5
7) Production levelling through the heijunka box	2
8) in-station quality (jidoka) through the andon	7
9) Prototyping and sampling	9
10) Visual signs	7
11) Visual work facilitators	7
12) Improvisational visual management	6
13) Explaining the work schedule	4
14) Performance management through visual management	9
15) Distributing the system wide information	12
16) Human resources management	6
17) Safety management	8
18) Poka-yoke (mistake proofing) and prefabrication	7

Figure 2 shows the picture of case No. 86 which belongs to the category of 8) in-station quality (jidoka) through the andon. Andon is one of the famous VM tools in manufacturing, too. In particular, it is an important mechanism to support jidoka in the Toyota Production System.

In this case, it is used for informing the state of each floor in the building under construction. It offers three colours, i.e., green, yellow and red to notice present conditions on a floor. The use of it consists of several steps. If a floor is operated normally, the green light stays turned on. The yellow light is turned on by the workforce, if they anticipate any disruptions in the flow in the near future. It is kind of a warning for the management. The red button is pressed when the production is stopped altogether. Actually, workers turn on/off the lights. Managers/ operators go to check the situation and help the workers on a corresponding floor, if the red or yellow light buttons are pressed by the workers. The analysis result of this case by 5W1H analytical framework is as follows;

● Why did you install this case?	Detecting an abnormal of each floor in early stage
● What was visualized by this case?	An abnormal condition
● Where did you use this case?	Monitoring room
● Who use the case?	Workers
● When did you use this case?	On the job
● How did you realize this case?	Andon with three colours

Figure 2: Example of Analysed Case (No. 86) (after Tezel et al., 2010)

Figure 3 shows the picture of case No. 157 which belongs to the category of 17) Safety management. A VM tool like this case is used in manufacturing sites too.

In this case, it is used for warning for the use of health and safety equipment, which are an earmuff, protective googles, protective clothes and boots. These are informed by not only in writing but also through a drawing in the signboard. The colour of the signboard is orange. The colour draws operators' attention. The analysis result of this case by 5W1H analytical framework is as follows;

- Why did you install this case? Perfect safety equipment
- What was visualized by this case? Safety equipment
- Where did you use this case? On the door of a workshop
- Who use the case? Operators
- When did you use this case? All day
- How did you realize this case? Orange-coloured signboard

Figure 3: Example of Analysed Case (No. 157) (after Tezel et al., 2010)

4.3 Organizing analysed data (step 3)

The analysis result of 165 cases is organized in a table format. A part of it is shown in Table 2. Of all the images of the results, four kinds of purposes for VM are mainly considered; 1) Abnormality detection in early stage, 2) Operational safety, 3) Smooth operation and 4) Prevention of a simple mistake in material utilisation. Table 2 indicates a part of the analysis results of Tezel et al. (2010)'s first category (1) Site layout and fencing's cases). The purpose of all these cases is to indicate and ensure "no entry". But these cases are realised by various tools such as fences, paints, nets and signboards. Also, the colour of the cases vary; they are white, red or blue.

4.4 Discussing characteristics of analysed cases (step 4)

4.4.1 Result of 5W1H analysis

Six attributes of the VM cases in construction sites are discussed based on the analysis result of this paper from each category of the 5W1H framework. The summary of the result is as shown in Table 3.

Table 2: A Part of Analysis Results

No.	Tezel's category	Why	What	Where	Who	When	How
1	Site layout and fencing	No unauthorized entry	A border with a site	A border between general road and a site	Residents around a site	All day	White fence
2	Site layout and fencing	No entry	A border with hazardous proximity	A border with hazardous proximity	Manager/Operator	On the job	Red paint
3	Site layout and fencing	No entry	A border with hazardous proximity	A border with hazardous proximity	Manager/Operator	On the job	White fence
4	Site layout and fencing	No entry	A border with hazardous proximity	A border with hazardous proximity	Manager/Operator	On the job	Blue net
5	Site layout and fencing	No entry	A entrance of a room	A entrance of a room	Manager/Operator	On the job	Signboard

Table 3: A Summary of Findings by 5W1H Analysis

5W1H	Findings
Why	● There were a lot of cases for managing the safety of workers on a construction site such as a prohibition from entering a hazardous proximity and prevention of an infectious disease and so on. ● Many cases are to prevent from mistaking required material for another one. ● On the investigated site, various people such as customers, building material suppliers and a public institution officials are going in and out all the time. As a result, the main purpose of the analysed cases is an announcement of a basic rule on the site.
What	● The main visualized objects are an information for safe and reliable operation. ● Examples are the name of a building material, matters to be attended to in operation or in case of an emergency, a hazardous proximity, an operation area, the direction of movement and KPIs for safety.
Where	● The cases are put in several places such as pathways, an operation area, a yard for building materials, a shed for building materials, an administration office and a meeting space. ● Some cases are used in an elevator used for conveying materials, an elevator for people and stairs because construction sites for high-rise buildings were investigated.
Who	● Most cases are used for all workers in the site. The main purposes of these cases are safety in operations, the 5S and employee training. ● Some cases are utilised for workers who perform the management of building materials and troubleshooting of a machine.
When	● Most cases are used on the job. ● Some cases are developed for specified operations such as the utilisation of a tool, the conveyance of building materials and opening and locking up a lock with a key. In particular, they are needed at the time of the start and end of these operations.
How	● Most elemental technologies are notices in the form a poster, a pictorial poster and a picture etc. ● There were several marks to easily inform of the progress of a plan with a coloured chalk and a marker pen because the state of a construction site changes every day. ● Some barriers which limit the access to an area and a pathway were found. Examples are barricades, fences, nets etc.

4.4.2 Initial comparison of cases between two industries

Table 4 shows the initial comparative analysis of the VM cases from construction and those from manufacturing from the perspective of elemental VM technology. For manufacturing, ten representative cases, which are a part of 141 collected VM cases from chemical plants in Japan (Murata and Katayama, 2014), are used. As a result of the comparison, with regard to operational safety, it seems that the construction industry has richer tools than manufacturing industry. In particular, various physical barriers such as a barricade, a fence, a net for prohibiting entry to an area and a pathway are considered as original tools of the construction industry. With regard to smooth operation, the manufacturing industry has richer tools than the construction industry. As for the characteristic elemental technologies in the manufacturing industry, there are 1) cover plate for maintaining the operating order, 2) indication for informing of the present condition of the switch, 3) float water level indicator, 4) gauge for maintaining an appropriate flow. These are for supporting related operations directly in the chemical plant. On the other hand, a mark for easily informing about the progress of a plan is an original elemental technology in the construction industry.

5 CONCLUDING REMARKS

For advancing a study on SVM, which is VM's extended version from the viewpoint of a technology life-cycle management, a number of VM cases, 306 in total, was collected from both construction and manufacturing sites and investigated by the 5W1H analytical framework, which was developed in the manufacturing industry. In particular, this paper reported the analysis result of 165 VM cases on construction sites from Brazil. Through the discussion of the analysis results, it was found that the VM cases in construction sites have characteristics in common from six perspectives. Moreover, initial comparison analysis of the VM cases of construction and those of manufacturing was also carried out from a technological perspective. The obtained result suggest that manufacturing and construction can strengthen each VM system by a mutual transfer of this technology between these industries.

Table 4: Initial comparison of VM cases between two industries

Main purpose of VM	Elemental technology of VM in construction sites	Elemental technology of VM in manufacturing sites (Murata and Katayama, 2014)
1) Abnormality detection in early stage	● Andon	● Colour code for informing of the present condition of the pressure value
2) Operational safety	● Poster for informing about safety equipment ● Barrier prohibiting entry to an area and a pathway	● Label prohibiting entry to the tower
3) Smooth operation	● Mark for easily informing about the progress of a plan ● Notice for informing about the point of an operation	● Cover plate for maintaining the operating order ● Indication for informing of the present condition of the switch ● Float water level indicator ● Gauge for maintaining an appropriate flow ● Structure of the pump ● Plate for informing of separated points of the piping ● Layout of the drain valves in the plant
4) Prevention of a simple mistake	● Notice for informing about the place of building materials	● Pair marks for distinguishing similar pairs of piping

6 REFERENCES

[1] **Carbonell, J.G., 1982.** Experiential Learning in Analogical Problem Solving. *Proceedings of the National Conference on Artificial Intelligence (AAAI-82)*, Pittsburgh, PA, August 18th–20th, pp. 168–171.

[2] **Imai, M., 1986.** *Kaizen: the Key to Japan's Competitive Success*, Random House, New York.

[3] **Lillrank, P. and Kano, N., 1989.** *Continuous Improvement – Quality Control Circles in Japanese Industry*, Ann Arbor, MI, University of Michigan.

[4] **Murata, K. and Katayama, H., 2010a.** Development of Kaizen Case-base for Effective Technology Transfer: A Case of Visual Management Technology, *International Journal of Production Research (IJPR)*, 48(16), pp. 4901-4917.

[5] **Murata, K. and Katayama, H., 2010b.** A Study on Construction of Kaizen Case-base and Its Utilisation: A Case of Visual Management in Fabrication and Assembly Shop-floors, *International Journal of Production Research (IJPR)*, 48(24), pp. 7265-7287.

[6] **Murata, K. and Katayama, H., 2013.** A Study on the Performance Evaluation of the Visual Management Case-base: Development of an Integrated Model by Quantification Theory Category III and AHP, *International Journal of Production Research (IJPR)*, 51(2), pp. 380-394.

[7] **Murata, K. and Katayama, H., 2014.** Performance Evaluation of Visual Management Case for Effective Technology Transfer, Symposium *Proceedings of 18th Cambridge International Manufacturing Symposium: Capturing value from global networks: implications for manufacturing, supply chains and industrial policy*, Moeller Centre, Churchill College, University of Cambridge, Cambridge, United Kingdom, September 11th-12th, 11 pages in USB.

[8] **Sacks, R., Koskela, L., Dave A. B., Owen, R., 2010.** Interaction of Lean and Building Information Modeling in Construction, *Journal of Construction Engineering and Management*, 136(9), pp 968-980.

[9] **Tezel, A., Koskela, L. and Tzortzopoulos, P., 2010.** *Visual Management in Construction: Study Report on Brazilian Cases*, University of Salford.

[10] **Womack, J.P. and Jones, D.T.,** 2003. *Lean thinking: Banish waste and create wealth in your corporation*, Free Press.