USE OF FIVE WHYS IN PREVENTING CONSTRUCTION INCIDENT RECURRENCE

Antti Leino[1] and Sacha Helfenstein [2]

ABSTRACT

In 2005 and 2009 Skanska Finland recognized an opportunity to improve its incident prevention through incidence reporting and the use of the Five Whys technique in accident investigation. A two-phase safety programme approach was adopted resulting in augmented safety awareness and engagement, as well as a more appropriate and actionable representation of underlying incident causes through organizational learning. The paper promotes the linking of new concepts to the lean construction discourse, and serves as interesting case about the move towards a zero waste culture for a large organization.

KEYWORDS

Safety improvement, Incident, Last Planner, Five whys, Resilience, Lean Construction

INTRODUCTION

Employees in the construction industry suffer from poor Health and Safety (H&S) performance, with 1,300 workers killed in the European Union each year (EASHW 2004). Beyond the human mischief, this implies a vast economical problem. Losses may account for up to 8.5% of a construction project's costs (HSE 1993).

From lean production point of view, workforce injuries and the resulting disruption to the work progress represent waste in construction projects. The relationship between lean production and safety performance has been explored in several papers, and it has been shown that by integrating lean principles and tools in the production planning safety risks may be mitigated (e.g., Saurin et al. 2002). On the other hand, in dynamic systems such as the construction business, workers' freedom for adaptive modifications may lead to human error (Rasmussen 1994). For this reason, efforts have been made to innovate methods and reduce human error, e.g., through visual management (Saurin et al. 2006). Walsh and Sawhney (2004) demonstrate through agent-based simulation the impact of management policies and expectations. Current best practice discussions suggest that the proper approach to safety is not to impose more rules but to change the system's behaviour into being safer (Bertelsen 2004).

However, underneath systemic challenges, the struggle to improve construction safety records may also be a reflection of a fundamental problem in understanding the accident process (Schafer et al. 2008). One of the tools to engage the organization in the finding of incidence underlying causes is The Five Whys. It is a heuristics geared

[1] Manager for Safety Development, Business Unit Skanska Finland, P.O.BOX 114, FI-00101 Helsinki-Finland, Phone +358 40 866 8551, antti.leino@skanska.fi

[2] Research Coordinator, Agora Center, P.O.Box 35, FIN-40014 University of Jyväskylä , +41 78 787 8564, sacha.helfenstein@gmail.com

at revealing causes of a problem by asking "why?" at least five times in succession until reaching an actionable cause to support problem solving (Ohno 1988). The Five Whys is a step in the A3 Problem Solving tool that is commonly used as a team exercise (Hafey 2010). To the construction industry The Five Whys has been introduced through the Last Planner™ initiative (Ballard 2000).

In the lean construction literature, the discussion of organisational learning from incidents in order to prevent recurrence is still very marginal. Also the use of Five Whys is not reported in this context. The aim of the current paper is to describe how the construction organisation Skanska Finland is adopting incident investigation and communication as part of a comprehensive incident prevention initiative, including the Last Planner™ initiative and the Five Whys tool. The study also offers preliminary observations and results from the development.

BACKGROUND

Skanska Finland, part of the Skanska Group, one of the world largest construction companies, has 3200 employees and a similar amount of workforce through contractors, engaged in 200 simultaneously on-going projects. Skanska Group has published a strategic ambition to move toward zero accidents and as part of this mission, it has recorded its fatal accidents globally since 2002 including all safety performance indicators with common metrics since 2005. The core problem to date remains to effectively prevent recurrence of serious incidents across the Group.

So far the implementation of the zero accidents program including Last Planner™ (LP) showed encouraging results in terms of better employee satisfaction and H&S performance (*anon* et al. 2010). Since 2007 also the Five Whys as part of LP initiative was promoted in the organisation. Beyond its case-by-case analytical value, a core prospect was that the Five Whys could stimulate the incident learning process, starting with for those who carry it out (Hafey 2010), and spreading across the organization, to finally enrich the overall safety awareness and culture.

As Kjellen (2000) describes, an organisation's culture is a perspective for analysis focusing on an organisation's shared beliefs, attitudes and norms, i.e., it describes "who and what we are, what we find important and how we go about doing things round here" (Hudson 2001). This means that an organisation's safety culture tells the way safety is perceived, valued and prioritised, as well as enacted in the organisation. While generic models for safety, health and environment information systems have been presented (Kjellen 2000) much of the existing safety problems may indeed arise from a lack of recognition of the dynamic and dependent nature of construction work (Schafer et al. 2008). Therefore it is interesting to study how the Five Whys incident reporting relates to improvements in safety culture and resilience engineering (Hollnagel et al. 2006).

From the viewpoint of lean construction, system resilience is achieved through continuous monitoring of system performance and "how things are done" (Schafer et al. 2008), meaning it cannot be simply integrated by using more procedures, guidelines, personal protective equipment and barriers. Nor can it be achieved by a centralized, top-down management approach, but affords distributed responsibilities.

This concept coheres with the fundaments of people-based safety (Geller 2005), where safety improvements in essence necessitate proper stakeholder knowledge and will. This means, the right conditions need to be put in place to nurture worker's

knowledge of and about, as well engagement in accident prevention. While safety knowledge is often hampered people's habituation to a certain risk environment and superficial explanatory models, their will to engage in safety improvement, is further hampered by lacking opportunities to assume ownership for the organizational processes concerned. Tools like incident reporting and The Five Whys technique promised to be relatively intuitive in adoption while helping to overcome important hurdles to the building up of safety knowledge - mainly through guiding construction workers' attention to and thinking (or learning) about safety and its antecedents. Finally, by embedding this in the LP initiative safety stakeholders should be able to appreciate themselves as process and change agents.

Nevertheless, the Five Whys is often associated with pinpointing deterministic cause-effect relationships. Cognitive systems engineering (Rasmussen et al. 1994) challenges this straightforward analysis by claiming that causal attribution to an accident is a social construction. Therefore, the purpose of using the Five Whys in the organisation was not to identify exact root causes, but rather to challenge investigators to look beyond usual causes, i.e., to deeper underlying and contributing factors. Accident investigation should try illuminate unsafe acts in the context of preconditions for unsafe acts, unsafe supervision and organizational influences as proposed by Rasmussen (1990).

Concretely, whereas in the past the majority of the accident causes in the Skanska accident reports referred to human error at that time - thus blaming the operator - the organisational understanding of accident sequences (e.g. Heinrich 1980) or organisational contexts (e.g. Reason 1997) was relatively weak. People did not care and understand as much as they should about their and others' safety for a variety of socio-psychological reasons, such as work task automation (Reason 1990), "Groupthink" (Darley and Latane 1968; Janus 1982), classic cognitive biases such as actor over-attribution or recency effects (Ebbinhaus 1913; Ross 1977), or, importantly, because improper volume and representation of incidents impedes learning and problem-solving through deep analogies (Gick and Holyoak 1980).

To sum up, in 2005 and 2009 Skanska Finland recognized an opportunity to improve its incident prevention through incidence reporting and the use of the Five Whys technique in accident investigation. In this report we shed light on how the company's recent safety initiatives helped to augment individual and organisational understanding of safety issues, how in parallel safety awareness and culture was stimulated, and what indications of improved safety performance can be found.

SKANSKA FINLAND SAFETY PROGRAM

The Skanska Finland company safety policy prioritises the minimisation of risks of fatal accidents, lost time accidents as well as serious incidents that had potential of fatal injuries. A safety information system according to Kjellen (2000) was established in Skanska Finland to support this target. It aims at a learning organisation through careful data collection, investigation, data processing, analysis, distribution and fact-based decision making.

In the following, the initiated safety program launched in 2004/2005 is reported over two phases:

- Phase 1: Launch of systematic incident reporting

- Phase 2: Evolution into a more comprehensive closed-loop method including reporting, causal investigation and learning, and process change.

PHASE 1: LAUNCH OF SYSTEMATIC INCIDENT REPORTING

Prior to the launch of systematic incident reporting the organisation was in a state of lacking awareness of its health and safety performance. Statistics were put together once a year or ad-hoc, and an inclusive safety culture was in its infancy.

Method

In 2005 the organisation launched systematic learning from safety deviations (*anon* et al. 2010). The campaign and electronic safety information system was set to collect as many safety observations as possible from the workforce. This was to increase safety communication and intervention on hazardous conditions and actions.

To capture data for accident/injury compensation at construction sites there was an online reporting protocol set for the organisation in 2006. The web-based reporting was made mandatory in order to improve data quality and to get the European statistics on accidents at work (ESAW 2003) coding in place. For the own staff all accidents requiring medical aid are collected through the system. The reports include information on the place, time, type and severity of injury, causes and preventive measures (Figure 1).

Results and Discussion

The adoption of the accident reporting was fully implemented in the organisation. Safety observation submission rates rose between 2005-2009 from a 363 to 1778 [Nb. of observations per 1 mio. labor hours], and coinciding with it, general and specific safety discourse quickly spread through all organization levels (*anon* et al. 2010).

ESAW codes were now equally reported, but a key observation was that practically no qualitative information on causes and preventative measures were registered in the system during 2007-2009 (Table 1). The reported causes included only primary causes including “human error” – with the majority of the preventative actions referring that “the operator needs to be more careful”. This is in line with Van der Schaaf et al. (1991) statement that in traditional safety culture causes of errors are attributed to inattention and carelessness on behalf of the workers.

Table 1. Number of reports that were collected during 2007-2009.

	Accidents	Serious near miss incidents	Causes	Preventative actions
2007	253	0	3	44
2008	261	0	2	38
2009	115	0	2	1

Note: During the years 2004-2008 only fatal accidents or accidents with serious injuries were investigated and learning shared in the organisation.

The launch of Phase 1 of the Skanska safety program initiated an organizational transition from a state of poor safety awareness and low engagement to a state of

growing safety and risk awareness, and thereby laying the ground for an evolving safety culture. However, no effective learning and change process was encouraged yet. At best, there was some implicit learning taking place. But, with the focus being pre-dominantly on human error, there was also a clear risk for learning being driven by inapt conclusions and emerging safety disengagement. Therefore, additional tools needed to be integrated to support incident analysis and the industrialization of actions based on gained insights.

Further on, cause classification of incidents was not uniform, which additionally undermined preventative actions. As the literature presents several ways to categorise causes, it was decided that a general causal coding of CIRAS model (Davies et al. 2000) should be used as template: *technical*, *proximal*, *intermediate* and *distal*.

PHASE 2: INTEGRATION OF LAST PLANNER AND THE FIVE WHYS

Method

In 2009 the LP concept was integrated to the organisation's management system. One of the tools introduced with it was the Five Whys. This brought the opportunity to develop a new procedure for accident and serious incident investigation. Some other investigation models were tested earlier with weak results. The Five Whys seemed to have potential with its relative simplicity. After some piloting and good response a Skanska Finland template was put together.

A simple A4 flash report is widely used in safety engineering. Influenced by the LP process, the new report comprised the following elements:

1. Describe what has happened (what, when, to whom, near miss/injuries/severity)
2. Assess failures in constraint removal in the weekly work plan – were preconditions for safe work in place (design, materials, work group, machinery/tools, workplace, conditions, safe job analysis)?
3. Use the Five Whys to find the underlying causes and preventative action
4. Categorise causal codes with CIRAS model (technical issues (technical), worker (proximal), management (intermediate), management system (distal)).

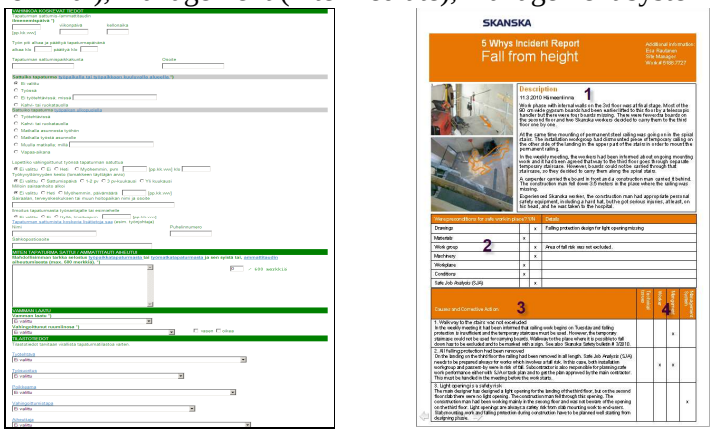

Figure 2. Snapshots of Web-based reporting protocol (left) and Five Whys Incident Report (right)

A safety information system utilising Five Whys incident reports was established according to the Figure 3. The Five Whys incident reports are disseminated across the organisation in order to increase collective awareness on safety concerns. The reports are attached to internal news bulletin and printed at each site to both foremen and workforce facilities. Further, site representatives are advised to discussed the reports during their weekly workforce meetings.

Safety specialists are used to review the report before it is published, as well as in complex cases to help investigation. No uniform training was offered to the organisation to carry out the investigation and reporting.

Reports are also analysed in the safety managers meeting and discussed in the risk committee, and if necessary also in the safety leadership team meeting. Further, they have been used in the design of meetings regarding property development organisations, safety trainings as well as communication and negotiations with supply chain partners. Finally, the procurement unit uses the reports to share learnings among the Nordic countries.

Results and Discussion

During 2010-2011 268 investigations and a respective number of flash reports were published (Table 2). The reporting coverage was very high, with accidents needed to be reported within five working days. Remarkable was that for the first time the organisation received any qualitative information on subcontractor accidents and serious near miss incidents. As also the incumbent claim reporting continued (see Phase 1: Method), the system allowed to follow up every week that all required Five Whys incident investigations were published.

In a systematic safety culture accident investigation and preventative measures address not only immediate causes, but also intermediate and root causes (Van der Schaaf et al. 1991). By the new reporting procedure the situation massively improved in the organisation. In 2011 incident reports contained on average 2.3 causes per reported incident (Table 2) as opposed to the just “blaming the worker” (Phase 1).

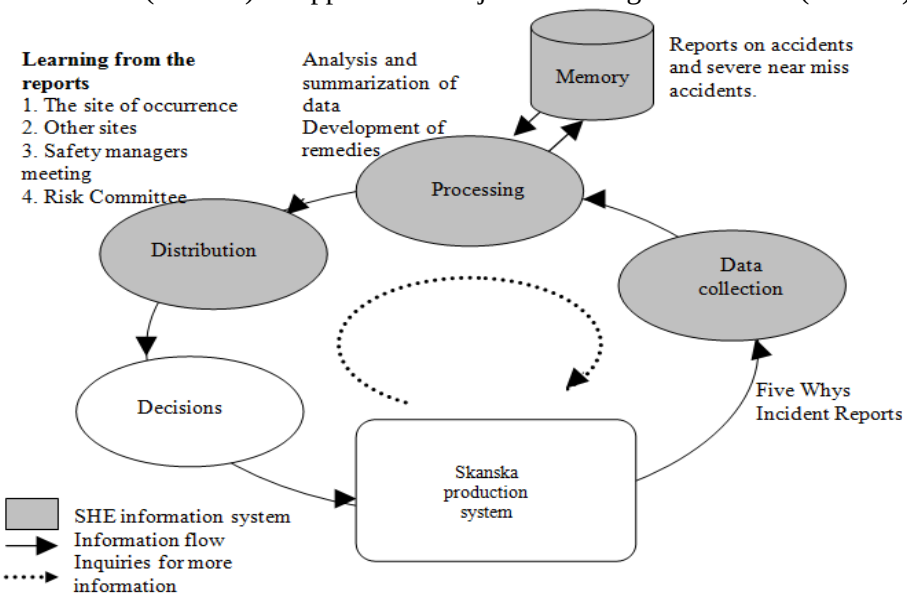

Figure 3. Safety information system utilizing the Five Whys incident reporting

Table 2. Number of reports collected during 2010-2011

	5 Whys Incident Reports	Lost time accidents	Serious near miss incidents	Reported causes	Reported causes in average per report	Reported preventative actions
2010	117	78	39	232	2,0	195
2011	151	102	49	343	2,3	311

Even an escalation can sometimes catalyse the investigation process. For instance, sometimes it may be more fruitful to "blame the foreman" for the creation of circumstances with increased risk at work. And then, through the Five Whys process, ask *why* this creation took place. Hence, the transparency and open dialogue required by the procedure is a true learning exercise and driver for cultural change, with the prejudicial focus on individuals changing quickly to more systematic viewpoint. Therefore the investigation challenges all stakeholders to find rational contributing causes in the production process and the organisation.

As part of the reporting template, the site team now also assesses failures in constraint removal in the weekly work plan. This was to review potential weaknesses in the LP process, and to reset the investigation paradigm (see Question 2 of the A4 flash report depicted in Figure 2). Collected frequencies are depicted in the Table 3.

According to the site assessments, the most common failure type is a lack of pre-task risk assessment. Therefore, more attention needs to be spent in the weekly work planning to identify risks, to prepare work areas and conditions, tools and machinery. Weekly identification process should better initiate more detailed risk planning for high risk activities.

Table 3. Reported constraint removal failures in the weekly work plan

Problem or deficiency in the constraint removal in the weekly work plan	Reporting proportions
Pre-task risk assessment	31 %
Work area or conditions	20 %
Tools or machinery	17 %
Design	10 %
Workforce	9 %
Personal protective equipment	7 %
Materials	6 %

Beyond the investigative benefits, our goal was also to find indications as to how the Five Whys concept and reports dissemination can benefit resilience engineering. Primary opportunities are to support the organisation to *expect the unexpected* and *spread engagement and ownership.*

Expect the unexpected: Reporting increases organisational awareness to recognize and manage unexpected events. It prepares people in the organisation to cope with surprises (i.e. unforeseeable events). Some examples are presented in Table 4.

Table 4. Five Whys Incident report on unexpected event

Title	Work that was carried on	Consequences	Cause	Underlying cause
24.1.2011 Serious near miss incident. Fall of a balcony slab.	A balcony slab was lifted from a truck by tower crane.	After lifting the first slab 1,0 m the another slab failed and fell.	Two slabs got lifted because they were frozen together.	In the precast factory warm slabs are stored on top of each other without disjointing them.

S*pread engagement and ownership:* The reporting template has inspired some site teams to report all medical cases and also other operational deviations. This is an implication of better causal understanding and prevention – a more holistic "zero waste"-culture; arguably a sign of resilience engineering. As Hollnagel et al. (2006) write, safety is not viewed as a system property but "…as something a system or organization does, rather than something an organization has".

GENERAL DISCUSSION

Since 2004 Skanska Finland gradually introduced a safety information system in the organization, which in 2009 was essentially augmented through the integration of the Five Whys. The major change with the inclusion of the Five Whys, was that it seemed no longer possible to report just "operator error" as kind of default incident cause. The new report procedure forces the site management to do an investigation beyond primary attributions, including assessment into precondition failures. The new procedure facilitates local and organizational learning on incident investigation.

The results compared to the old data show that the organisation has moved from traditional safety culture towards systematic safety culture. Systemic use of flash reporting in cases of serious near miss incidents and lost time accidents has improved the quality of investigations. Incident reports now cover several primary and underlying causes instead of mainly just blaming the operator. The top ones report up to 4 or 5 causes and respective action. The distribution of the Five Whys reports across the organisation has increased organisational transparency, awareness, open communication, and had helped to understand "system status" and hazard identification.

In fact, the reports form a data base displayed multi-usage potential. In addition to learning at site, the reports may be referred in design-meetings, own property development organisations, safety training sessions, supply chain communication, procurement and process development. Information in the reports is practical, visual and may even be formulated to increase engagement in safety; i.e. by using stories, showing people, the consequences of poor safety. They may be used also to communicate success, stories of excellence and cases where proper controls have saved lives. This is believed to pay-off in terms of learning to understand underlying incidence cause patterns or rules.

Learning from incidents with the Five Whys tool has improved the organisational safety culture and the understanding of incident causalities. Therefore the Skanska Finland is an interesting case about how a zero waste culture and organisational learning from deviations is put forward in a large construction organisation. Based on

the results of this study a recommendation is made: Organisational learning in all kinds of production deviations should be promoted with a similar information system.

Some regions have voluntarily adopted the procedure to also cover medical aid incidents and even some material loss cases without safety risk. This indicates improved prevention culture in the organisation.

The use of The Five whys in incident investigation have further revealed failures in the adaptation of the Last Planner™ process in the organisation. More systemic and comprehensive pre-task planning is needed in the LP process. These factors require adjustments to the way they are considered in the LP process; an issue that affords our future research attention.

Finally, the incident reporting also helped to reveal the dynamic and dependent nature of construction work – not only to the project team, but much of the workforce. Resilience safety engineering seeks for instance better expectation of unexpected events, and the Five Whys incident reporting data supports this objective to some extent. The new reporting procedure may help understanding the nature and causes of the incidents in order to effectively prevent accident recurrence. The database shows also that proper construction safety may not be just something that is placed into a system through rules and standards. Construction safety is something that needs to be continuously lived.

REFERENCES

Ballard, G. (2000). "The Last Planner System of Production Control". *Ph.D. Diss.* Fac. of Engineering, Univ. of Birmingham, Birmingham, UK.

Darley, J.M. and Latane, B. (1968). "Bystander intervention in emergencies: Diffusion of responsibility". *J. of Personality and Social Psychology* 8 377-383.

Davies, J.B., Wright, L., Courtney, E., Reid, H. (2000). Confidential incident reporting on the UK railways: The CIRAS system, Cognition, Technology and Work 2 (3) 117–125.

EASHW (2004). "Building in Safety. Prevention of risks in Construction - in practice". European Agency for Safety and Health at Work.

Ebbinghaus, H. (1913). "On memory: A contribution to experimental psychology". New York: Teachers College.

European statistics on accidents at work (ESAW) (2003). Eurostat

Geller, E.S. (2005). "People Based Safety - The Source". Virginia, USA: Coastal

Gick, M. L., and Holyoak, K. J. (1980). "Analogical problem solving". *Cogn. Psych.*, 12 306-355.

Hafey, B. (2010). "Lean Safety. Transforming Your Safety Culture with Lean Management". CRC Press, Taylor & Francis Group

Heinrich, H. W., Peterson, D., and Roos, N. (1980). *Industrial Accident Prevention*. New York: McGraw-Hill.

Hollnagel, Erik, David D. Woods, and Nancy Leveson. (2006). "Resilience engineering: concepts and precepts". Aldershot, England: Ashgate.

HSE, (1993). "The costs of accidents at work", Health and Safety Executive, HS(G)96 , UK.

Janus, I.L. (1982). *Groupthink* (2nd ed.). Boston: Houghton-Mifflin.

Kjellén, U. (2000). *Prevention of Accidents Through Experience Feedback*. Taylor & Francis. New York. pp. 122

anon; Elfving, J., Ballard, G. (2010). "Accident Rate Down From 57 To 9 In Five Years", *18th Ann. Conf., Intnl Group for Lean Construction*, Haifa, Israel, July 14-16, 2010, Proceedings pp.243.

Ohno, T. (1988). *Toyota Production System: Beyond Large-Scale Production*. Productivity Press, Portland, Oregon.

Rasmussen, J., Pejtersen, A.M., Goodstein, L.P., (1994). "Cognitive System Engineering". John Wiley & Sons, Inc. New York.

Reason, J.T. (1997). "Managing the Risks of Organizational Behavior." Hampshire England: Ashgate.

Reason, J. (1990). *Human Error*. Cambridge: University Press.

Ross, L. (1977). "The intuitive psychologist and his shortcomings: Distortions in the attribution process". In Berkowitz, L. *Advances in experimental social psychology*. 10. New York: Academic Press. pp. 173.

Saurin, T.A., Formoso, C.T., Guimaraes, L.B.M., and Soares, A.C. (2002). "Safety and Production: An Integrated Planning and Control Model." *Proc. of 10th Ann.Conf. of Intnl Group for Lean Construction (IGLC-10)*, Gramado, Brazil.

Saurin, T.A., Formoso, C.T., and Cambraia, F.B. (2006). "Towards a Common Language Between Lean Production and Safety." *Proc. of 14th Ann. Conf. of Intnl Group for Lean Construction (IGLC - 14)*, Santiago, Chile.

Schafer, D., Abdelhamid, T. S., Mitropoulos P., Howell G. A., (2008). „Resilience Engineering: A New Paradigm For Safety In Lean Construction Systems" *16th Ann. Conf., Intnl Group for Lean Construction.*

Walsh, Kenneth D. and Anil Sawhney (2004). "Agent-Based Modeling of Worker Safety Behavior at the Construction Workface". *Proceedings of 12th Annual Conference of the International Group for Lean Construction*, Helsingør, Denmark, August 3-5, pp. 779.

Van der Schaaf, T.W., Lucas, D.A., Hale, A.R. (editors) (1991). *Near-miss Reporting as a Safety Tool*. Oxford: Butterworth-Heinemann.