ACCIDENT RATE DOWN FROM 57 TO 9 IN FIVE YEARS

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ABSTRACT

This paper describes what has been done during 2005-2009 in order to dramatically improve company safety performance, where the accident rate has been taken down from 57 to 9 lost time accidents per million work hours. It also describes how the safety program and production management program are tightly coupled together.

There is a lot of research and praxis available on construction safety programs. However, the safety community may have overlooked the importance of managing uncertainty, which is one of the cornerstones in Lean Construction.

Lean aims at reducing unreliability by introducing several tools that control uncertainty. These sorts of tools need to be in place also to structure safety management at construction site. They provide a platform for right risk assessment at right time, worker involvement, organisational learning and securing that there are no safety constraints in place.

Using lean production management systemises adequate task planning for high risk jobs, makes use of workers knowledge, challenges unsafe acts with a non-blame perspective and improves communication and learning from errors. Lean seems to improve safety culture.

This paper begins by explaining safety programs and maturity of different safety cultures. Then it provides data and cases both from the safety and the production management program in Business Unit Skanska Finland from the last 5-years. Finally, it concludes that without quality production management it is not possible to achieve low accident rates. It is also arguable vice versa; high accident rates indicate non-quality production management.

KEY WORDS

Safety, Safety culture, Accident rate, Production management, Last Planner System.

INTRODUCTION

Poor safety performance in construction is a problem. In the Finnish construction sector approximately 10 fatal and a total of 18 000 accidents occur yearly. Averagely one accident causes two weeks absence from work. Most of the incidents are caused by falls from height, slips or trips (23 %), stepping on or being punctured by a sharp object (19 %), losing the control of a machine or tool (15 %), physical overload (14 %) or eruption of a substance (12 %). (FAII, 2008)

16 % of all accidents in Finland occur in construction although only 7 % of the Finnish work force is working in the sector (Statistics Finland 2008). The accident rate in construction is over two times higher than the average rate. During the last ten years the safety performance in Finnish construction has not improved. (FAII, 2008)

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Business Unit Skanska Finland (BU) with 2900 employees is a construction company that has its roots in local market. The operations were set up by a group of experienced Finnish construction professionals in 1994. The company safety culture mirrored the general construction market culture in Finland.

A management system for health and safety (OHSAS 18001, 2000) includes planning, doing, checking and acting. How did the organisation cover these issues?

In 2004 the organisation was not aware of its health and safety performance status. There was no commonly agreed on metrics for collecting and comparing accident data. Some statistics were put together once a year.

At the business unit level there was a fixed, yearly risk assessment. Every project produced their review document on potential problems including health and safety. This work was done in the last phase of the production planning before construction work started. The list of potential problems was revisited occasionally. Quite often they missed the health and safety risks.

Since there was no structured safety initiative development or implementation, the organisation prioritised meeting the basic legislative requirements. Safety organisation was drawn up accordingly. There were no full-time safety professionals.

Safety was assessed as part of the quality audits. The audits were carried out by quality managers that did not have competence or resources to focus on safety issues.

Use of safety performance indicators was inconsistent. Accident reporting did not result in systemic learning. No regular feedback on safety performance was available at BU level. Neither there was any systematic interaction between construction sites dealing with repetitive risks and their management.

There was the management system for quality that was complying with the ISO 9000 requirements. A part of the system also covered occupational health and safety issues. The integrated system had been certified according to the OHSAS 18001 guidelines by an external auditor.

The BU performance lead to the following results in 2004. There were 317 lost time accidents. This calculates the accident rate of 57 accidents per million work hours. The organisation was satisfied with the performance and did not believe in or drive intentionally towards zero accidents.

Organisation's culture is a perspective for analysis and it focuses on organisation's shared beliefs, attitudes and norms (Kjellen, 2000). It describes "who and what we are, what we find important and how we go about doing things round here" (Hudson, 2001). Safety culture tells the way safety is perceived, valued and prioritised in the organisation. As safety is such a complex phenomenon, obviously a strong safety culture is needed for excellent results. What is the real commitment in the organisation? How an individual behaves when no one is watching?

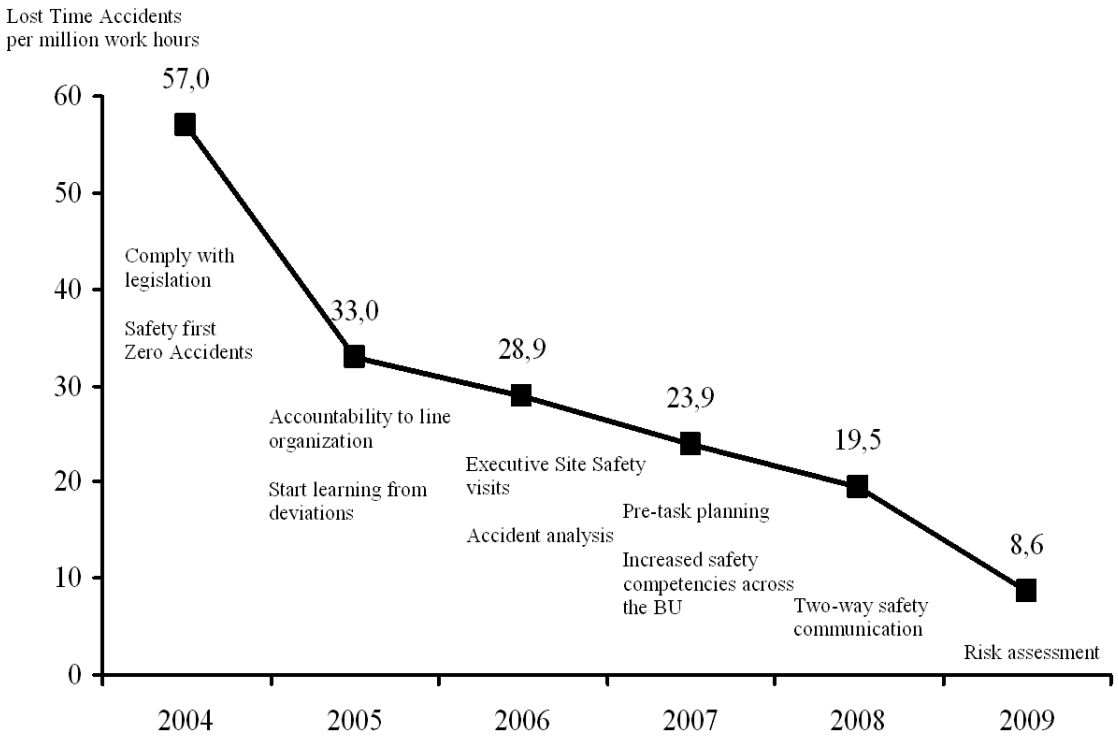

Figure 1. BU Skanska Finland's lost time accident rate and the yearly actions

Safety culture can be changed through an evolutionary process. Van der Schaaf (1991) has distinguished three different types of safety cultures that determine the organisation's ability to prevent the recurrence of accidents: traditional safety management culture, risk management culture and systematic safety culture. The same kind of division has been presented by DuPont (2010), a chemical company that has worked over two centuries developing its safety performance. DuPont sees the journey in improving safety culture reflecting the maturity of the organisation, often referred as the Bradley Curve. Moving forward from just being reactive brings the organisation to "dependent" phase. After that the organisation transfers to "independent". Finally, excellence in safety requires "interdependent" safety culture.

In 2004 Skanska-group stated that it aims to be the world leader in construction related safety performance. This brought BU Skanska Finland to realize that there was an urgent need to change the safety culture from reactive to more mature state. The most important yearly actions are illustrated in picture 1.

Very soon the BU production planning procedures were questioned; how do they support the aim of achieving zero accidents target.

FROM TRADITIONAL SAFETY CULTURE (2004-2005)

Causes of errors are attributed to inattention and carelessness on behalf of the workers (Van der Schaaf, 1991). Organisation is moving from reactive to dependent (DuPont, 2010).

The first safety action plan was initiated in the BU Finland based on the findings from an international benchmarking tour in four other Business Units. The key messages were that safety will be the first priority in the organisation and today's performance is not acceptable. The commitment to zero accidents target was said out clearly from the top management: "Every person who works on a Skanska site is entitled to go home safely at the end of each day."

Firstly the BU needed to make sure that the operations complied with legislative requirements. Fall prevention and protection was prioritised.

The meeting procedures were changed. All operational site meetings needed to start with safety on the agenda.

Safety is a line management responsibility. The operational success is now measured not only in financial terms, but also how the safety targets are met. Safety was tightly coupled into bonus plans. New reporting procedures were set. Line directors need to report personally their accidents to the management team. Quarterly reports include also safety performance.

Use of hard hats and safety shoes were set mandatory for the whole duration of the project.

Organisation started to learn from deviations. Procedure for collecting as many safety observations as possible from the work force was started.

The discussion on compliance broke out. Is safe work execution a condition for work? Can we require the use of personal protective equipment from our workers from our sub-contractors? What should happen if someone does not comply? Stuart Graham, CEO Skanska Group, commented this in Skanska Management Meeting in 2006: "I have heard rumors that safety costs, in other words, it destroys outperform margins. Well designed job sites are more productive and safer. When someone is killed or badly injured productivity goes to zero. This really destroys outperform margins and employee morale."

Discussion continued on the deviation that safety records revealed. What key issues do we need to do to improve? The general discussion within the BU found two main factors: there should be more safety leadership in the line management and better behaviour and mindset among the workforce.

ADOPTING RISK MANAGEMENT CULTURE (2006-2007)

In risk management culture errors and accidents are considered to be mismatches between the operator and his environment (Van der Schaaf 1991). Organisation is moving from dependent to independent (DuPont, 2010)

Safety action plans focused on executive site safety visits, accident analysis, pre-task planning and safety competencies in 2006-2007.

Executive site safety visits is a procedure that maintains high level of senior line managers visibility devoted to health and safety in the projects. The procedure was piloted in management team workshops. The key message was that all senior managers have to intervene whenever there is a violation against the Skanska safety policy. Violations also need to result in consequences.

There were several severe accidents, even fatal ones that shook the organisation. The organisation had to take a look not only at the immediate causes of the accident, but also find intermediate and root causes. This revealed weaknesses in the state of safety standards and competencies, but also in the state of implementation and execution of the standards.

More mature decision-making was seen for prevention. Accident and safety observation data began to work. Preventative decisions on procedures could be taken based on facts from the data. Pre-task planning was also seen as a key factor in success. Safe Job Analysis was agreed to be the procedure to involve the workforce in preplanning of high risk work.

A safety organisation was established to increase safety competencies across the BU. More safety personnel were recruited. Expert network was created to ensure that each site had access to safety expertise.

Leading performance indicators increased their importance in accident prevention. By taking a look at the leading indicators one could anticipate the likelihood of incidents. Best performers could be rewarded more easily by using leading indicators instead of just lagging ones, such as accident history.

At the same time there was development work and testing going on for last planner™ system.

HOW THE LAST PLANNER™ GOT TO BU SKANSKA FINLAND

The production management research and development effort started in 2005, with a wide range of fact gathering about the current state. We interviewed various stakeholders, measured inventory and batch sizes, lead times, and production and supplier reliability. One of the key findings came when we studied the production reliability. This took place on two commercial refurbishment projects. The average reliability of the daily plans was 67% and 68%, respectively. Moreover, 80% of the reasons for failure were either unrealistic next day plan or prerequisite work was not completed. As a general contactor, we could directly impact on the planning related failure. Therefore, it was further explored how to improve production reliability.

2006, the company decided that each of our nearly 200 construction projects have to measure production reliability, there was very little instructions given how to measure or no common templates. The purpose was to "wake-up" and get attention. About 60% of projects measured production reliability. At the same year, a large supply chain management initiative was launched in collaboration with University of California Berkeley. It aimed to develop and production and supply chain management concepts and tools.

2007, a systematic development of production management started on 3 laboratory sites (commercial, residential, and civil). We adapted Last Planner™ (Ballard 2000) to current project management proceedings and applied so called infection model to deploy Last Planner™. In the infection model project crews are invited to learn from a site that masters Last Planner™. 2008, the tools of production management were clearly defined and development of production management tools was frozen. A systematic deployment with help of support organization started.

2009, a systematic deployment of production management started by the line management. The production management consists of five tools, from these 93% of projects used weekly plans and 26% used 5 whys analysis, on average 56% of all five tools were used. Also in 2009, we integrated the safety program to the production management program.

Several papers have been published on the relationship between lean production and safety performance. In their 2002 and 2007 papers, Saurin, et al propose a model and terminology for describing the relationship. In their 2005 paper, Mitropoulos, et al propose that safety is an emergent property of production systems. Walsh and Sawhney's 2004 paper is also relevant, as it demonstrates through agent based simulation the impact of management policies and expectations. Skanska's integration of safety and production management built on that literature, in the belief that safety, quality, time and cost—the performance variables targeted by production management—cannot be managed independently, as they are consequences of the way work is designed and executed within a sociotechnical system.

During the last five years, all together hundreds of people have been involved. Approximately, 180 projects have been carried out using this integrated approach, and there have been more than 40 company-level workshops.

TOWARDS SYSTEMATIC SAFETY CULTURE (2008-2009)

Causes of errors are analysed in relation to the total work context. Accident investigation and preventative measures address not only immediate causes, but also intermediate and root causes (Van der Schaaf 1991). Organisation is independent or interdependent (DuPont.)

Safety action plans focused on communication, training and better health and safety risk control in 2008-2009.

Enabled by the new safety organization, several actions at the site level could be facilitated. Tool-box-training is a method for bringing regular safety trainings to the site to meet the current need for training. There are training packages for example on the following topics: how to carry out safe job analysis for high risk work, order and tidiness, take five minutes for your personal risk assessment and manual handling and transportation of loads. The safety professional who is conducting the tool-box challenges the workforce to discuss and make suggestions for improvement. Site management agrees on action based on the discussion.

Executive site safety visits emphasize now more discussion with work force instead of just going through the construction planning and walking across the site.

The process for health and safety risks management is integrated to new last planner™ production management model. The idea is to ensure right risk identification and assessment at the right time.

In the search for improvement the five-whys-technique is also adapted to incident investigation. All lost time incidents and severe near-miss-incidents are communicated to all other sites in the format of one-page-flash report. Learning and safety awareness is promoted also by disseminating regular Skanska Safety bulletin. It e.g. presents lessons learnt from safety observations and recognizes good practices.

During the years there were two international workshops where the last planner™ and safety integration was discussed and action plans agreed.

During the 2009 Skanska safety week the production management system and safety integration was reviewed and discussed by the senior management. There were almost 70 site executive safety visits during the week.

DATA AND METHODS

The BU safety performance is measured by lost time accident rate (LTAR): LTAR is a normalized frequency rate of reported lost time accidents. It is calculated as follows: (Number of lost time accidents times 1,000,000 hours) divided by (total labor hours). The reduction in the LTAR can be seen in the figure 1.

LTAR is compared against the safety observation rate and safe job analysis rate in figure 2. Safe Job Analysis Rate (SJAR) a normalized frequency rate of Safe Job Analysis done. It is calculated as follows: (Number of SJAs times 1,000,000 hours) divided by (total labor hours for own and subcontractors).

Safety Observation Rate (SOR) is a normalized frequency rate of Safety Observations done. It is calculated as follows: (Number of SOs times 1,000,000 hours) divided by (total labor hours for own and subcontractors).

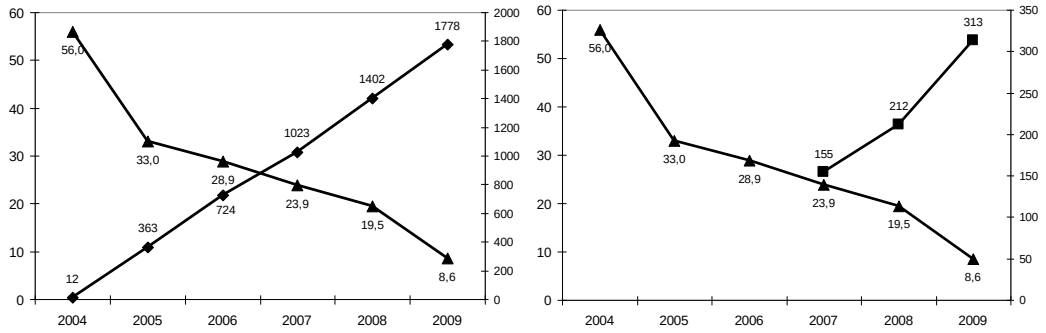

Figure 2. Yearly LTAR compared against the safety observation rate (left) and safe job analysis rate (right)

BU conducts yearly personnel surveys. The aim is to chart the employer image, organisation's functionality, work atmosphere, superior work and respondent's own tasks. Response rate has been approximately 70 %. Some results from the surveys are collected in table 1.

Table 1. Results of the BU Skanska Finland personnel survey from 2005-2009

Questions on the yearly personnel survey Scale: 1= I disagree … 5=I agree	**2005** N=2043	**2006** N=2165	**2007** N=2283	**2008** N=2400	**2009** N=1952
Well-being of personnel is taken care of in BU	3,1	3,4	3,5	3,7	3,6
I know what is expected from me in my work	3,9	4,1	4,1	4,2	4,2
I am able to influence on the contents of my work and its execution	N/A	3,6	3,9	4,0	4,0
I get regular feedback from my supervisor	N/A	N/A	3,2	3,4	3,6
My opinion is paid attention to in my work	N/A	3,6	3,8	3,9	4,0
My supervisor cares about me as a human being	N/A	3,5	3,8	3,8	3,9

RESULTS

This chapter presents some findings on how safety and lean approach was integrated in BU Skanska Finland during 2004-2009. These results are viewed from following point of views: How the lean gives structure to safe production management, organisation and how they address human factors.

STRUCTURE TO SAFE PRODUCTION MANAGEMENT

Initiative for lean production in the BU helped to step forward with safety performance. In 2005 there was a common view that accidents were products of missing leadership or wrong worker mindsets. At the same time lean piloting showed that there was a problem with production reliability.

Introducing standard production management process increased production planning at site level. It was possible to turn the old inflexible health and safety hazard identification and risk assessment procedure into a process that provided right risk assessment at right time and involved the relevant parties to the process. The new, integrated procedure consists of:

1. Master schedule: Reverse phase scheduling session serves as hazard identification. It involves all parties that are executing the phase. Safety professional (e.g. site safety representative) participates in the planning.

2. Six-weeks-look-ahead-plan: Hazards are identified in the 6-weeks-look-ahead plan. Assignment is given to a supervisor to either prepare construction pre-task plan or safe job analysis (SJA) for high risk tasks. Supervisor systematically removes constraints, including unsafe conditions.
3. Construction pre-task plan: High risk tasks require construction plan or SJA that is prepared with participation of workforce.
4. Weekly schedule: Tasks, which have safety constraints, are not included in the weekly schedule.
5. Task execution: Construction pre-task plan or SJA is part of the work briefing. Taking five minutes for personal risk management before task execution is encouraged.

Lean production management model has increased the workforce influence to the contents of the work and its execution (table 1). This has promoted participation in risk assessment delivering lots of right time prevention at the right place. It has also increased safety awareness through organisation. This can be seen also from the increased SJA rate (figure 2).

Safety and lean approach share the common goal of workplaces that are tidy and in order. BU Skanska Finland has adopted the 5S-principles in developing housekeeping.

ORGANISATION

The weekly routine of the lean model serves as a platform for workforce participation and safety management. Weekly meetings enable learning from normal work (feedback from weekly safety inspections, safety observations) and deficiencies (near-miss incident and accident reports). This motivates continuing with safety observation. The rising trend can be seen from the observation rate in the figure 2. Next week's activities and their safe way of execution are gone through, which creates the culture of commitment.

Better two-way communication has improved relations between workforce and supervision: more feedback is given and the opinions of the work force are better valued (table 1).

Traditionally safety management has been a function of maximising certainty. This has quite often brought conflict between production planning and execution and safety procedures. From a lean perspective safety management is about managing uncertainty. This results in more reliable construction both with fewer disturbances, deficiencies, material losses and incidents. Lean approach shares and "amplifies" the message of an advanced safety culture: participation delivers commitment. Safe task execution should rather be pulled than pushed. This brings the opportunity to challenge unsafe acts with a non-blame perspective.

Weekly meeting with workforce is also the place for safety tool-box trainings and communicating company-wide good practises.

Lean has helped in defining management responsibilities, thus reducing the probability of risk situations caused by lack of planning. It also gives structure to competency management, including core health and safety competencies.

ADDRESSING HUMAN FACTORS

The two approaches - both lean and safety have a value-base. Lean aims at zero waste and safety aims at zero injuries. Processes and organisation as such do not deliver

these results, but the people in the organisation. Human factors, such as values, beliefs, attitudes need to be addressed to attain excellence.

Better learning processes serve both safety performance and operational efficiency. Safety awareness in the BU has improved after adapting 5-whys-framework for incident investigation and executive site safety visits. During the visits senior managers are advised to discuss the risks with the workforce and to find strategies to remove constraints that prevent safe task execution.

The maturity of organisational culture goes hand in hand with the operational discipline. What are the implications of poor operational discipline - regardless if it concerns production planning or enforcing safety procedures. Open discussion and company actions on these create the culture.

CONCLUSIONS

In search for safety excellence construction company BU Skanska Finland has gone through a transition in its safety culture. The culture has changed from traditional to systematic. Part of this process has been the use of lean production management.

Based on the findings during the five years implementation, it reasonable to say that lean production management has supported the change in the safety culture.

Traditionally safety discipline has focused on maximising certainty. Safety planning tools for hazard identification and risk management have been separate from production planning. This has created conflict with the production targets and methods. Most probably this has been due to inflexible tools, which have not been used right-timely and not involving relevant parties. This may be one of the reasons for construction sector's safety underperformance. This should be studied further.

Opposite to traditional safety management that maximises certainty, lean approach introduces a useful framework for controlling construction safety hazards by managing uncertainty. Continuous risk assessment is carried out at right time and place involving relevant parties. The process reduces the likelihood of having safety constraints in place before the work starts. Framework supports communication and learning from both normal work and deficiencies. It allows challenging unsafe acts with a non-blame perspective. Lean seems to improve safety culture.

Common challenges that lean production management and safety share, is how human factors are addressed. Creating an advanced, shared safety culture is not about just developing safety part of the culture – a more holistic approach is needed, e.g. in the search of learning culture. As a part the culture, there needs to be consistent implications to non-complying with the procedures of the management system. Future challenge for the BU is to standardize leader work including safety planning and follow-up routines. Safety competencies across the line management need to improve.

BU Skanska Finland will continue the journey towards zero accidents with having the LTAR-target of 1,4 in 2015. Safety performance is now perceived as being an indicator for operational efficiency. New areas to be researched within safety and lean construction are building information modelling, prefabrication and logistics.

Further research needs to be conducted also between concept of resilient organisation and lean construction. Resilient safety engineering (Hollnagel 2006) and lean seem to share same components: flexibility, learning from deviations and awareness of system status.

Integration between the two will continue. The experience from BU Skanska Finland shows that without quality production management it is not possible to achieve low accident rates. It is also arguable vice versa; high accident rates indicate non-quality production management.

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