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Evaluation of HSE practices at construction sites in developing countries

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Preface

The Master thesis is written at the Norwegian University of Science and Technology (NTNU) for the the Department of Production and Quality Engineering (IPK) as a part of the study program MSc in Reliability, Availability, Maintainability and Safety. The task is written for SN Power and executed due to support of HOCHTIFF Construction AG in data collection processes. SN Power as a client for construction of a hydropower plant in Peru is interested in evaluation of HSE initiatives used by the company for construction safety management in developing countries.

The task is completed the spring semester 2012 and makes up 30 credits and is equivalent to 100% study load this semester.

Trondheim, 2012-06-11

Angelina Kurkova

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The great support for me was also provided by Omar Parraga, HSE inspector from Norconsult Peru, who organised and consulted me during Behavioural Sampling and distribution of the questionnaire. He provided a great deal of country specific information which has enriched this Master work.

I would like to thank Pedro Lanza from Constructora CHEVES S.A.C. for his time which he devoted to the interviews and debates with me and inspiration for my future profession.

A.K.

Summary

The main objective of this master's work was to investigate whether the HSE initiatives developed by the company are suitable for achieving good safety results at construction sites in contractual environment in developing countries. This has been conducted by evaluating these HSE initiatives implemented by the Principle Contractor at one of company's construction projects. The project is executed to build a run-of-the-river hydropower plant in the chain of the Andes in Peru. The evaluated HSE initiatives were safety inspections, Job Safety Analysis and reporting of unwanted occurrences at site.

The evaluation was conducted through analysis of the implementation of HSE initiatives and their immediate and long-term effects. HSE initiatives were checked to see if they had been implemented as planned and according to the best industry practices in construction safety in developing countries. The immediate effects of HSE initiatives were analysed to assess the quality of implementation of HSE initiatives and their contribution to achieving the good safety result at the project. The long-term effects were evaluated scrutinising a trend in injury rates, actual visual compliance at site and adequacy of safety climate at the project.

The results of the evaluation showed that safety inspections and reporting of unwanted occurrences have been implemented by Principle Contractor according to company's HSE requirements and the best industry practices. The implemented Job Safety Analysis routines did not satisfy company's HSE requirements. The evaluation showed that the achieved immediate effect of HSE activities is not satisfactory due to the delay with execution of remedial actions; moreover, the potential functionality of Job

Safety Analysis and reporting of unwanted occurrences was not fully used at the project. The long-term effect of the evaluated HSE activities was assessed as satisfactory. This was concluded based on that the measurement of safety climate has given a positive result, while a trend of the injury rate and the measurement of visual compliance to national safety regulations and international standards deviated from a desirable results.

The results of the evaluation were considered in the light of different internal and external factors which might influence implementation of HSE initiatives and overall safety at the project. The difficulties with the implementation of Job Safety Analysis can be partially explained by a low level of professional and safety education and consequently low demands to workplace safety by workers due to the current economic situation in the country. In addition, a strong hierarchy, typical for the national culture of this country, hindered a proper cooperation between supervisors and workers for execution of Job Safety Analysis. Further, contractor's general management did not allocate an HSE responsibility on supervisors and did not demonstrate importance of safety at the project. This also affected immediate and long-terms effects of Job Safety analysis, safety inspections and reporting of unwanted occurrences. The difficulties to achieve a positive immediate effect can be attributed mainly to lack of contractor's general management support in execution of remedial actions and human factors such as workers' and supervisors' level of education, religiousness and their attitude to risk-taking. The satisfactory long-term effect can be explained by a proper implementation of company's HSE requirements, effective work of contractor's HSE department and compliance to strong HSE requirements from International Finance

Corporation which provided a loan to the company for the project execution.

Therefore, it was concluded that company's approach of using the contract to implement its Policy on HSE in developing countries through HSE requirements to contractors is effective when it comes to long-term effects, but largely affected by economic situation, national culture, contractor's general management attitude to safety and human factors.

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1. Introduction

1.1 Background

SN Power operates construction sites in Asia and Latin America. The company has implemented a construction project management system that includes principles and practices in the management of health, safety and environment. The company also puts effort into promoting a healthy safety culture. These different initiatives are based on Norwegian experiences (basically from oil industry) and international standards and best practice. In order to have a high safety standard in the construction projects, SN Power strive for continuous improvement of safety initiatives.

Safety management at construction sites in developing countries has a number of challenges. Construction industry is one of the most dangerous industries due to high risks present in everyday operations (Mohamed et al, 2009, Holt, 2001; Hughes and Ferrett; 2008). Risks in contractual environment increase with the number of contractors (Olson, 1998). Location of the projects in developing countries constitutes country specific challenges such as deficient governmental safety regulations, inadequate infrastructure, lack of relevant accident data, and extensive use of unqualified labour, high labour turnover and low priority of safety (Kartan et al., 2000). All these factors make safety management more complicated and challenging for SN Power. The company executes safety management providing HSE requirements to contractors in the contract Specifications. However, these requirements have been developed based on experiences in construction safety in Norway, and therefore it is a question whether they are suitable for construction safety management in developing countries.

The master work is focused on the execution of SN Power's HSE requirements by the contractor at one of SN Power's construction projects located in developing countries.

1.2 Objectives

The objective of the master's work is to investigate whether the HSE initiatives taken by SN Power at construction sites are suitable for achieving a good safety result in countries where SN Power operates and where the frame conditions differ from those where the initiatives were originally developed. The scope of work will be to evaluate the implementation of some specific HSE practices (safety inspections, Job Safety Analysis and reporting of unwanted occurrences (RUO)) by the Principle Contractor, HOCHTIEF Contraction AG, (in this thesis referred to as Contractor) at a construction project (in this thesis referred to as the Project) in Peru. SN Power formal requirement to Contractor will be used as criteria in the evaluation. The results of evaluation will be analyzed in light of the influencing factors such as work force qualifications, national legislations and national cultural differences. From this overall objective, research questions have been specified.

Research questions for a theoretical part of the research:

1. What HSE practices in construction proved to be effective in developing countries?
2. What potential influencing factors should be taken into account while implementing HSE practices at construction sites in developing countries?
3. What methods and criteria can be used to evaluate the effect of HSE initiatives taken at SN Power construction project? Are evaluation methods and criteria selected for the master's research suitable?

Research questions for an empirical part of the research:

4. How adequate have selected HSE practices been implemented by contactors at SN Power construction site? What are the immediate and long-term effects of each selected HSE practice?

5. How can influencing factors explain the achieved immediate and long-term effects?
6. How can the SN Power's HSE initiatives be improved in order to achieve HSE goals and objectives at construction sites?

1.3 Limitations

The scope of this research covers only selected HSE activities that are safety inspections, near accident reporting (RUO) and Job Safety Analysis. These activities are selected based on the availability of field information collected during field visit to the Project. Evaluation is focused on the selected HSE activities performed only by the Principle Contractor (further referred to as Contractor) and only within the Project. Only underground and surface works, excluding installation of transmission lines, are studied. Another limitation is that only Construction phase of the project is taken into consideration. The behavioural observations and the survey were conducted only for underground works. Nationalities of Contractor's employees are limited by the author to Peruvian only due to strong domination of Peruvian nationality among the employees.

The time frame for the task is 20 weeks and is equivalent to 30 credits. This represents 100% of the study load spring semester 2012.

1.4 Approach

In order to resolve master's work task the literature review is performed to resolve research questions No.1-3 and to form a proper theoretical basis for further analysis to resolve research questions No.4-6. Then analysis is conducted using the analytical model (See figure 1.1)

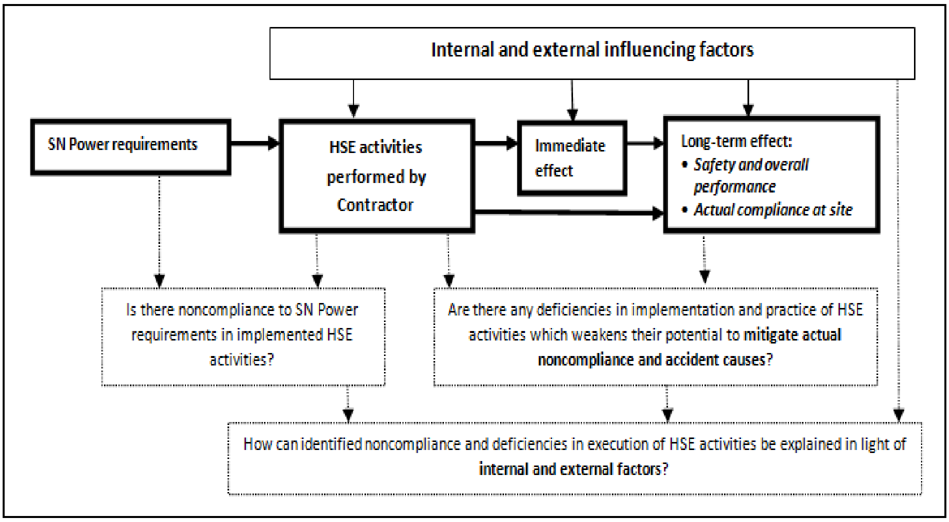


Figure 1.1 Analytical model

Research question No.6 is resolved with the use of the results of analysis. The detailed description of the method used for resolution of the task and criteria is provided in Theory chapter.

1.5 Structure of the Report

The structure of the report for the thesis and content of chapters is illustrated in Table 1.1.

Table 1.1 Structure of the thesis report.

<table>
<tr><th>Process</th><th>Chapter</th><th>Content of the chapter</th></tr>
<tr><td rowspan="2">Task description</td><td>1. Introduction</td><td>Background of the task, master’s work objective, main tasks to resolve, limitations, methods</td></tr>
<tr><td>2.Study object</td><td>General information about construction sites, contractors, overall HSE targets, selected for evaluation HSE practices</td></tr>
<tr><td>Literature review</td><td>3.Literature review</td><td>Review of best HSE practices in construction in developed and developing countries, review of influencing factors and evaluation research</td></tr>
<tr><td>Methods development. Data sources and analysis</td><td>4.Methods</td><td>Development of evaluation methods and criteria for evaluation. Description of the execution of tasks within the research (including questionnaire and observation procedure)</td></tr>
<tr><td rowspan="3">Analysis</td><td>5.Results</td><td>Presentation of results of analysis of empirical data from the construction site</td></tr>
<tr><td>6.Influencing factors</td><td>Analysis of results in light of influencing factors</td></tr>
<tr><td>7.Discussion</td><td>Resolution of research questions with the help of analysis of the results in the light of literature
Analysis of methods used for the research</td></tr>
<tr><td rowspan="2">Proposals for improvement</td><td>8.Recommendation</td><td></td></tr>
<tr><td>9.Conclusion</td><td></td></tr>
</table>

2. Background

In this Chapter the study object is presented. As it is mentioned in the Introduction, this research is conducted in cooperation with SN Power. SN Power is a "renewable energy company that invests in emerging markets" (www.snpower.com). SN Power (further "the Client") has operating hydropower plants and projects under construction in several countries around the world. The Client provided an opportunity to perform the evaluation of HSE practices performed by Contractor in construction of a run-of-the-river hydropower plant in Peru. The project is called Cheves (further "the Project").

2.1 Description of the Project

The Project is a hydropower project situated in Lima Province on the river Rio Huaura, about 130 km by air north of Lima. The Project is located in a mountainous area and utilises a public road with unstable ground and a serpentine layout. The Project involves a significant amount of underground works to build a tunnelling system inside of mountains belonged to the Andes (Figure 2.1).

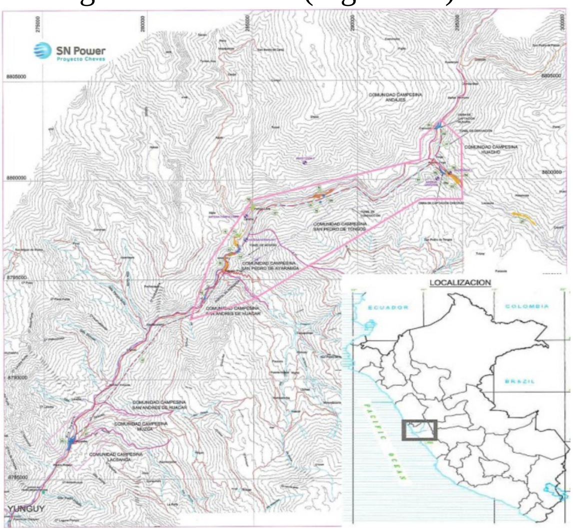


Figure 2.1 Layout of the Cheves project

The work related to construction started in May 2010 and are planned to be finished by the end of 2013. The trend of the number of working hours including contractors and personnel of the Client is showed in Figure 2.2

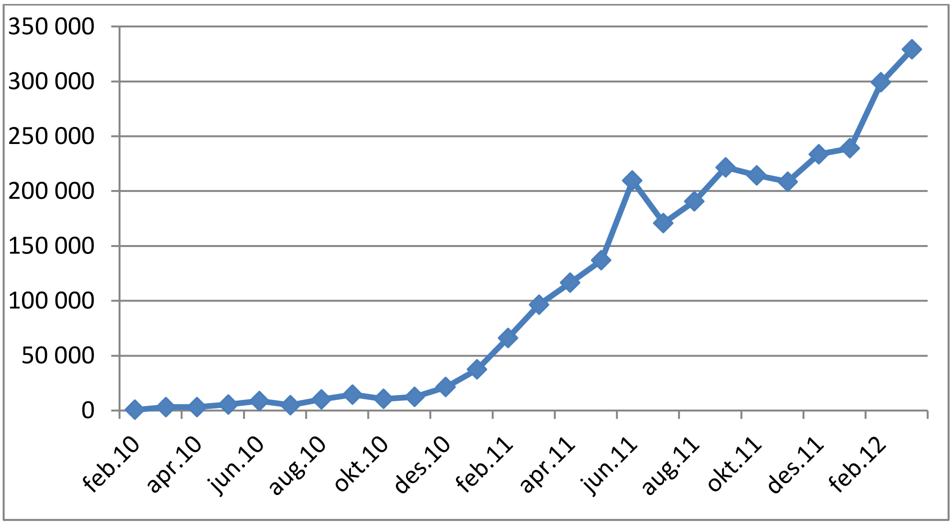


Figure 2.2 Number of working hours per month at the Project from start of construction until end of study period

The project receives 100% investment from the Client and this important factor is discussed in Chapter 6 of this research. Once it is put into operation, the Project will add 168 MW to the Peruvian interconnected system (www.snpower.com). The general characteristics of the project are illustrated in the Table 2.1

Table 2.1 General characteristics of the Project

Location	Rio Huaura, north of Lima, Peru
Installed capacity	168 MW
Type	Run-of-river
Average annual expected output	838 GHh/yr
Design flow	33m3/s
Tunnels	14 km

Main HSE challenges at the Project

The main safety related challenges which the Project is expected to meet at peak of construction processes with 2000 employees and multiple subcontractors are the following (Cheves specific HSE Plan, 2011)

- Contractor HSE management Commitment
- Public Road Safety
- Tunnel Work (Falling rocks and ground support)
- Moving and lifting of materials and equipment
- Drilling and blasting, handling and storage of explosives
- Heavy traffic on site
- Ventilation conditions in tunnels and Power House
- Illumination in tunnels and Power House

2.2 Client's approach to management of HSE risks in construction

The Client employs contractors for execution of all construction works which are required to be carried out at Greenfield project. Apart from it, the Client involves an engineering consultancy company as the Engineer whose role is to develop design and manage the contractors including ensure compliance with quality requirements and in the Cheves case to follow up HSE requirements at the work fronts.

To ensure the effective project execution, the Client has developed a proprietary methodology for executing its project called PROMAS where all processes and procedures related to the Client's value chain are described. PROMAS provides standardised methodology for organisation, planning and control of Company's operations and activities at Business Development, Project Development and Project Construction phases (See figure 2.3). Management of HSE risks in construction projects is integrated in PROMAS. PROMAS contains the Specification "Health, Safety, Environmental and Social (HSES) management" developed for contractors and which is one of the main documents used for evaluation of HSE activities in this research.

Apart from that, the Procedure “Management of HSE and CSR in Construction” directed at HSE related personnel of the Client can be found in PROMAS (Kjellen et al., 2011).

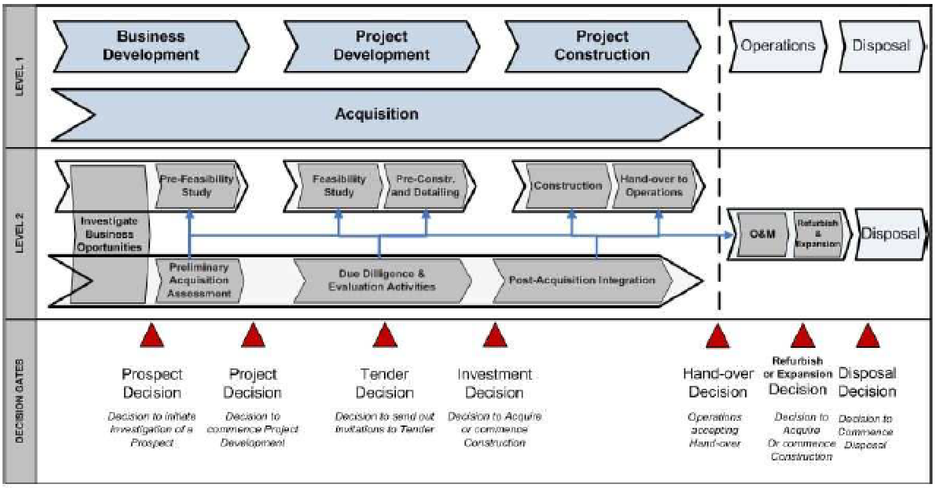


Figure 2.3 Client’s value chain in PROMAS

Activities performed by the Client to manage construction related HSE risks during all stages of the project are shown in Table 2.2

Table 2.2 HSE activities performed by the Client at different project phases

Phase	HSE activities
Business development	Coarse analysis of HSE issues
Project development	• HSE risk assessment, • Site investigation of HSE issues (checklist) • HSE input to Contract strategy (HSE qualifications among local contractors, HSE consequences of chosen contract philosophy) • Constructability analysis of design • Prequalification of tenderes on HSE • Invitation to tender, tender evaluation ,negotiations and award • Technical evaluation of tender – HSE evaluation of tenderer’s qualifications and resources and proposed methods and HSE management of construction

	• Bid clarification meetings
Project construction	Kick-off activities • Verification of HSE management program • Training and team building seminars • Follow up of HSE milestones during establishment Follow up during construction: • Safety induction • HSE inspections • Meetings • Monitoring of HSE performance • Follow-up of EMAP • Audits Emergency response planning

2.2.1 HSE management by the Client before construction

Contractors are selected through a tender procedure (Figure 2.4). A tender is an offer to do or perform an act which the party offering, is bound to perform to the party to whom the offer is made (http://www.lectlaw.com/def2/t076.htm).

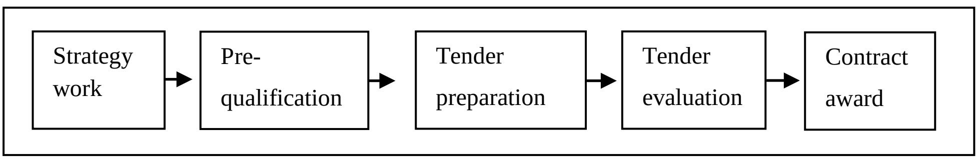


Figure 2.4 Contractual process (Kjellén, 2011b)

The Client has a strong focus on safety and this is reflected in the contracting process. The sequence of actions aimed at management of HSE issues during the tender process is showed in Figure 2.5

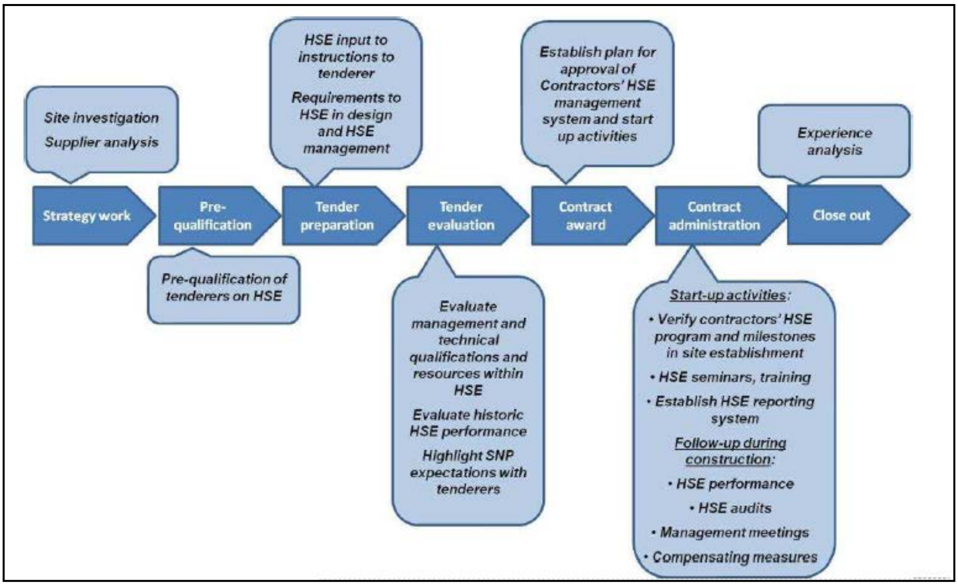


Figure 2.5 HSE part of a tender process in the Client (Kjellen, 2011b)

As a result of the tender, the selected contractor receives HSE requirements and accordant responsibilities as a part of the contract. Principle Contractor is appointed by the Client out of all involved contractors and receives the major responsibility for safety and health at the project. As a part of the contract, Principle contractor gets the Specification on "Health, Safety, Environmental and Social (HSES) management" which contains (A) description of responsibilities of Principle Contractor and the Client's personnel, (B) requirements to HSE management system of Principle Contractor. The Specification does not provide detailed requirements, but general requirements to elements of Contractors HSE Management System such as planning of work, risk assessment, HSES program, authority permits, management of subcontractors, reporting etc.

2.1.2 HSE management during construction

As a result of the selected contracting method, it is a responsibility of the Engineer to follow-up the compliance of Contractor to Client's HSE requirements which are provided in the HSE Specification as a part of the contract to Contractor. Contractor is responsible for follow up of its subcontractors and reports on HSE statistics to the Engineer on monthly basis. The Engineer combines reports from all contractors in one and provides it to the Client.

3. Literature review

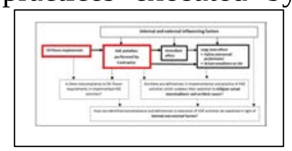
This chapter presents theory relevant to the task and is based on a literature review. The chapter is used later as the basis for the methodology, analysis, discussion and conclusion of the evaluation of HSE activities taken by Contractor in the developing country.

The first section describes best practices for safety management at a construction project. First, procedures for the management of safety of a construction project in contractual environment are described. Then, the information from earlier research on safety management systems and HSE activities is provided.

The second section describes the factors influencing safety in construction project in developing countries.

Last section describes evaluative research. The section deals with development of criteria, how an evaluation should be designed and how to conduct research and evaluate the effects of measures to be implemented.

The theory is summarized and synthesized to provide a basis for discussion. In addition, the theory of evaluative research is used to develop a method for the evaluation of HSE practices executed by Contractor in a developing country.



3.1 Safety management in construction

3.1.1 Construction safety management in contractual environment

As it was mentioned in Section 2.2, the Client employs contractors for construction works and focuses on HSE issues from the beginning of a tender process. Therefore it is important to review the best practices to manage safety in contractual environment. The most structured and well defined approach to safety management in case of working with contractors among all available to the author literature sources is illustrated in OGP report “HSE management – guidelines for working together in a contract environment”(Table 3.1).

Table 3.1Overview of phases in construction process (OGP, 2010)

Stage	Client	Contractor
1.Planning	Scope of work/context, risk assessment	
	Define contracting method/ HSE responsibilities	
2.HSE capability assessment	Establish HSE evaluation criteria and capability assessment protocol	Contractor responds to HSE capability assessment questionnaire and if requested HSE audits
	HSE capability assessment of contractors	
	Establish bidders list	
3.Tender and award	Bid documentation preparation and development of bid	Contractor prepares bid, including HSE plan
	Bid documents evaluation and clarification	HSE plan including remedial actions as agreed
	HSE management strategy	
	Contract award	
4.Pre-mobilisation	Pre-mobilisation verification audit	Preparation, selection of subcontractors
5.Mobilisation	HSE field review or audit	Mobilisation including subcontractors
	Site specific training – progress meetings	
6.Execution	Monitoring, audits and inspection	Execution, supervision and reporting

		Monitoring, audits and reporting on subcontractors' activities
7.De-mobilisation	Acceptance of work and restored site	Demobilisation
8.Final evaluation and close-out	Review	
	Final evaluation	Final evaluation and close-out report

In addition to OGP guidelines, the research of Fidgerald shows that improvement in *contracting processes* such as measurement of performance, provision of clear expectations and goals, inclusion of safety incentives in the contract and strengthening of management of contractors has a distinctive positive effect on safety performance at construction projects. Moreover, performance criteria should be provided in the contract together with incentives and penalties for on-the-job performance. However, Hinze and Gambateze (2003) showed in their study that incentives do not have direct influence on safety performance. The Client has implemented the basic steps of OGP guidelines in execution of tendering processes and coordination of Contractors throughout the whole project in PROMAS (See section 2.2).

Data collection for this research was performed during Execution phase of The Project. During this phase it is crucial that roles and responsibilities according to the contract are clear defined, understood and complied by the Client, the Engineer and Contractor. The responsibility to monitor compliance to contract requirements can be assigned to representatives with permanent presence at site (OGP, 2010). This role is assigned to the Engineer at the Project. Joseph Fitzgerald (1995) also pointed out at the need for better accountability in safety management of contractors in tunnelling and the need for better implementation of HSE practices to avoid accidents.

In order to achieve and maintain a high safety standard at the project, it is necessary that contractors implement and continuously improve safety management system (OGP, 2010; Hughes and Ferrett, 2008). In the HSE

Specifications provided in the contract, the Client requires from Contractor to have health and safety management system and provides guidelines based on OHSAS 18001. The different health and safety management systems and their elements are reviewed in the next section.

3.1.2 Safety management systems

Experience of many companies around the world shows that in order to avoid accidents and material damage with adequate use of resources it is necessary to implement an occupational health and safety management system (Teo and Ling, 2005; Hinze and Gambatese,2003; B. Fernández-Muñiz et al, 2007; Hughes and Ferrett, 2008). There are three most recognised health and safety management systems which are used around the world: HSG 65, OHSAS 18001 and ILO-OSH 2001. All three systems have the similar phases in their application (planning phase, performance phase, performance assessment phase and performance improvement phase), which correspond to Plan-Do-Check-Act circle. The figure 3.1 shows the common approach behind all three systems. The Client recommends Contractor in the Specification on “Health, Safety, Environmental and Social (HSES) management” provided in the contract to have OHSAS 18001 implemented (Kjellen et al, 2011).

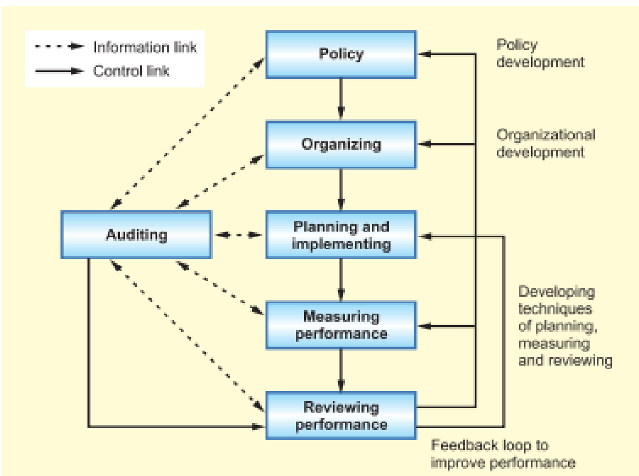


Figure 3.1 Phases of safety management systems (Hughes and Ferrett, 2008)

It is worth mentioning that HSG 65, OHSAS 18001 and ILO-OSH 2001 health and safety management system have some advantages and disadvantages. Positive outcomes of implementation of H&S management system is that it (A) easier to demonstrate compliance to H&S regulations, (B) ensure that safety is given high priorities, (C) safety risk are identified and eliminated, (D) ensure that the organisation is prepared for emergency. However, as a result of inadequate implementation of H&S management system, some problems can occur. They are related to excessive documentation, reduction of resources and lack of understanding by supervisors (Hughes and Ferrett, 2008; Zohar, 2007). Moreover, some studies showed that a company with a certified safety management system might have poor safety records on accidents and lack of safety culture (Teo and Ling, 2005; Kjellén, 2011). Teo and Ling (2005) show that the cause of this situation is a lack of regulatory tools to govern the development of policies for safety management systems. It is worth mentioning that there is a deficient follow up of implementation of safety management systems by authorities in Peru (European Commission, 2007). The situation when H&S management system proves to be inefficient can be avoided through proper resource allocation for performance assessment (Mearns et al., 2003., Zohar, 2000) Many researches argued about the content of H&S management system (Grote & Künzler, 2000; Hurst, 1997; McDonald et al., 2000; Mitchison & Papadakis,1999; Santos-Reyes & Beard, 2002 in Fernández-Muñiz et al, 2007; Hale et. al,1997; Teo and Ling, 2005). Teo and Ling (2005) describe main safety management elements as follows:

- safety policy,
- safe work practices,
- safety training,
- group meetings,
- incident investigation and analysis,
- in-house safety rules and regulations,
- safety promotion,
- evaluation, selection and control of sub-contractors,
- safety inspections,

- maintenance regime for all machinery and equipment,
- hazard analysis,
- movement control and use of hazardous substances and chemicals,
- emergency preparedness,
- occupational health programmes.

All of these elements are vital for an effective safety management system and detailed information about them can be found in many sources (for example, see Hughes and Ferrett, 2008; Holt, 2008; Hale et al, 1997, Levitt and Samelson, 1993, Fernández-Muñiz et al, 2007), The focus of this research is only on safety inspections, Job Safety analysis and RUO reporting which can be considered as sources of information about hazards and causal factors which provoke occurrence of unwanted events. These elements are selected for further analysis because many researches indicated that the most significant weakness at construction sites is the way of identification of potential hazards and their mitigation. The tendency is to rely on experience rather than plan activities adequately and execute risk assessment (Fitzgerald, 1995). In addition, it is worth mentioning that implementation of OHSAS 18001 safety management system is recommended by the Client, whereas implementation and execution of safety inspections, JSA and RUO reporting is a requirement described in the contract Specification. The brief review of safety inspections, JSA and RUO reporting is provided further.

3.1.2.1 Safety inspections

According to Kjellén (2000), safety inspections are related to diagnostic processes of HSE practices, though they are not focused directly on hazard identification.

Aims of safety inspections

Safety inspection involve identification of deviations at working places, analysis of their origin, development of proper control measures and control of results (Kjellén, 2010). During inspections deviations from regulatory requirements and company standards are identified and corrected, therefore conditions are improved and risks are reduced (Kjellén, 2000). Safety inspections are usually associated with faultfindings and in order to avoid it they should be focused on fact-finding and cooperation between inspectors and all parties involved such as workers, supervisors and management (Holt, 2001).

Basic information about safety inspections

There are many types of inspections which are used in industry (Holt, 2001; Kjellén, 2000). This thesis concentrates on traditional workplace inspections performed by Contractor. They are usually executed by safety representatives, supervisors and HSE staff. The information found through review of the literature on the best practices in construction regarding workplace safety inspections (Holt, 2001; Hughes and Ferrett; 2008, Kjellen, 2000; Oloke and McAleenan, 2010; Hill, 2005; Parry, 2003; Lingard and Rowlinson; 2005) is summarised into a check-list. The check-list contains requirements to safety inspections which should be fulfilled to ensure effectiveness of inspections. This check-list is used as criteria for evaluation of safety inspections performed by Contractor.

- Adequate expected standards (criteria) are provided to inspectors
- Inspectors have the plan for inspection
- Themes for inspections are defined
- There is limited number of themes to be checked during one inspection (it should be not more than 9)
- Checklist items are possible to observe or assess
- Inspectors follow the plan and know what to look for
- Inspectors keep an open mind during inspections
- All site areas are covered during inspection
- Findings from inspections are registered in inspection protocols in an adequate reliable manner
- Actions are proposed based on the findings
- Actions are adequate, feasible and comprehensive
- Remedial actions are planned and initiated with the deadlines specified for each action
- Responsible people are assigned for taking remedial actions
- Responsible people are informed about their responsibility
- Implementation of remedial actions is followed-up

A company should have a procedure for inspections with clear aims, scope, responsibilities and description of routines (Holt, 2001; Hughes and Ferrett; 2008, Kjellen, 2000). The themes of inspection should be planned in advance; otherwise focus of inspectors will be limited to a few types of deviations (Kjellén, 2000). Checklist should be developed by a company and based on the regulatory requirements, company norms, results from accident investigations and previous inspections. With regards to frequency of inspections, the optimum for construction site with high risk of accidents is weekly held inspections (Kjellén, 2000). The inspections and remedial actions proposed to findings should be documented and responsibility for remedial actions should be assigned. The follow-up of inspections is necessary for correcting the deviations and learning from them (Holt, 2001; Hughes and Ferrett; 2008, Kjellen, 2000).

Limitation of safety inspections

Inspections are not aimed at identification and correction of human errors or unsafe working methods. In addition, contributing factors to accidents related to organisational and human factors cannot be traced and mitigated with safety inspections (Kjellén and Hovden, 1993). The human ability to concentrate attention on many items simultaneously is limited, that in turn limits the coverage and reliability of inspections (Reason, 1998; Kjellén, 2000).

3.1.2.2 Job Safety Analysis

Job Safety Analysis is a type of inductive risk analysis which should be applied when the job has already been identified as hazardous or for new jobs where the consequences for safety are uncertain (Kjellén, 2000).

Aims of JSA

JSA is focused on identification and elimination of hazards present in the particular job (Kjellén, 2000).

Basic information on JSA

JSA is applied usually for new jobs and for jobs which involve activities different from routine operations (OLF, 2010). Before the execution of jobs which have a potential to cause harm, JSA is also required. In order to perform JSA it is necessary to collect all information which is required for JSA: detailed job description, drawing of machinery, work instructions, training schedule, description of past incidents related to this job. JSA should be performed by the group consisting of experience workers and a supervisor. During the execution of JSA the analyzed job should be broken into tasks in order to analyze risks specific to each task of the job. This step of JSA is crucial and in case of analyzing the job as one task JSA is not efficient. After identification of hazards present in the task, analysis of causes and evaluation of risk should be performed. Based on the level of identified risk, the remedial actions should be developed (Kjellén, 2000; Holt, 2001; Hughes and Ferrett; 2008). The process of execution of JSA follows the flow reflected in Figure 3.4 (OLF, 2010)

Based on the literature on best practice of JSA in contraction (Holt, 2001; Hughes and Ferrett; 2008, Kjellen, 2000; Oloke and McAleenan, 2010; OLF, 2010) a check-list with requirements to JSA has been developed by the author. This check-list is used for evaluation of JSA performed by Contractor (See Chapter5):

- Contractors have a written procedure for JSA
- Contractors have criteria to decide whether JSA is required or not for the particular operation
- Contractors have a plan for JSA with establishment of analysis teams
- Contractors have a proper method including check list of hazards
- Contractors perform JSA before each new operation and for new equipment
- All steps of the job are considered in details in each JSA
- The review of hazards is adequate. All are hazards covered. All types, causes, consequences and risks of each hazard are identified
- Risk reducing measures are identified
- The quality of the measures is adequate.
- JSA is conducted
- Contractors hold group meetings for execution of JSA

- All hazards are identified and documented. The description is adequately detailed to reflect the actual hazards in the job. As opposed to "generic hazards"!
- Causes are analysed
- Risk is assessed
- Analysts propose risk reducing measures based on JSA
- There are deadlines for execution of risk reducing measures
- Risk reducing measures are adequate, feasible and comprehensive
- Responsible people are assigned for taking risk reducing measures
- Responsible people are informed about that
- Implementation of measures are follow-up

Detailed description of JSA can be found in OLF Recommended Guidelines "Common model for Safe Job Analysis (SJA)" (2010) and many books related to safety management (Kjellén, 2000; Holt, 2001; Hughes and Ferrett; 2008; Levitt and Samelson, 1993)

Limitations of JSA

Proper JSA requires participation of experienced job executers and their supervisors. They should have enough knowledge to identify risks related to the job, and proper understanding of the whole range of measures which should be taken to mitigate intolerable risks (Holt, 2001). In some cases it might be tedious therefore analysts tend to skip some steps or just copy the information from JSA performed for other tasks. If a checklist is used for hazard identification, it should not be just a list of random hazards. The checklist should be developed based on identified causes of accidents occurred in the company or other companies using the same job (Harms-Ringdahl, 2001).

3.1.2.3 RUO reporting

The term reported unwanted occurrence (RUO) was introduced and taken into operation by the Client in 2008 by Urban Kjellén. RUO is defined as "any near accident, unsafe act or hazardous condition reported by own or contractor employees". It is important to notice that RUO reports do not include reports from regular inspections and reports by HSE personnel. The Client included RUO reporting in safety policies in 2008 and has it in the requirements to Contractors with the goal of RUO-rate equal to 1. The literature on reporting of unwanted occurrences was not found by the author, while research on near miss reporting is limited.

Aims of RUO reporting

One of the aims of RUO reporting as well as near miss reporting according to Jones et al.(1999), Schaaft et al. (1991) and Cambraia et al.(2010) is to collect the information in order to utilize it for accident prevention. Another central aim of RUO reporting is to involve not related to safety employees in safety issues so that reporters' risk awareness and feeling of ownership in safety increase.

Basic information on RUO reporting

RUO reporting which includes near miss reporting is a proper source of information only in case of atmosphere of trust (Schaaft et al., 1991). A potential reporter should have a clear criterion regarding what should be reported. Holt provides examples of unsafe acts and unsafe conditions which should be reported and eliminated (See table 3.2).

Table 3.2 Examples of unsafe acts and conditions (Holt, 2001)

Unsafe acts	Unsafe conditions
• Working without authority • Failure to warn others of danger • Leaving equipment in a dangerous condition • Using equipment at the wrong speed • Disconnecting safety devices such as guards • Using defective equipment • Using equipment the wrong way or for the wrong tasks • Failure to use or wear personal protective equipment • Bad loading of vehicles • Failure to lift loads correctly • Being in an unauthorised place • Unauthorised servicing and maintaining	• Inadequate or missing guards to moving machine parts • Missing platform guardrails • Defective tools and equipment • Inadequate fire warning systems • Fire hazards • Inappropriate housekeeping • Hazardous atmospheric conditions • Excessive noise • Not enough light to see

of moving equipment • Horseplay • Smoking in areas where this is not allowed • Drinking alcohol or taking drugs	to do the work

Based on the limited information on near-miss reporting (Jones et al, 1999; Cambraia et al., 2010; Schaaf et al., 1995; Schaaf et.al, 1991) and consultation with HSE expert, the following check-list with requirements necessary to achieve effective RUO reporting was developed:

- Contractors have a procedure for RUO incl near accident reporting
- Responsibility for RUO reporting is clear for all personnel at site
- Criteria for RUO reporting are clear
- Reporting routine is understandable and simple
- Contractor takes initiatives to promote a positive reporting culture
- Employees know to whom reports should be submitted
- There are incentives for reporting
- Reports are followed up

Limitations of RUO reporting

RUO reporting usually provides information only on technical deviations and contributing factors. Employees tend not to report on unsafe acts and human errors because of possibility of disciplinary action (Kjellén and Hovden, 1993). The quality of reports depends significantly on knowledge of potential reporters on which actions and conditions can be considered safe and which unsafe. It also depends on feedback and might be deteriorating in case of resource shortage to provide a proper feedback (Kjellén, 2000).

3.1.2.4 Summary of best practices of safety management in construction

To summarise the literature review on following conclusions can be drawn and will be used further in analysis of results of this research and Discussion chapter:

- clear HSE targets, incentives and penalties should be included in the contract as well as HSE requirements should be reflected in the contract Specification (OGP,2010; Fidgerald, 1995)
- all involved actors such as the Client, the Engineer and Contractor should understand their HSE responsibilities (OGP, 2010)
- the Client should focus on follow up the Contractor's and the Engineer's accountability for their responsibilities according to the contract (OGP, 2010)
- the Client should keep under control that the interface between the Engineer and Contractor is functioning effectively (OGP, 2010)
- in order to achieve and maintain a high safety standard at the project, it is necessary that contractors implement and continuously improve safety management system (Teo and Ling, 2005; Hinze and Gambatese,2003; B. Fernández-Muñiz et al, 2007; Hughes and Ferrett, 2008)
- safety inspections and JSA are diagnostic processes in HSE management and important elements of safety management system (Kjellén, 2010)
- safety inspections are focused mostly on identification and elimination of technical deviations at workplaces (Kjellén and Hovden, 1993).
- JSA is primary used for identification of risk reducing measures for new manual jobs and for jobs with intolerable level of risk. JSA requires time for execution and exhaustive knowledge of job nature. If JSA applied on daily basis for the same jobs it might lose its worth (Kjellén, 2000; Holt, 2001)
- RUO reporting is used for collection of information regarding near accidents and deviations at workplaces as well as for involvement of non HSE personnel in safety issues. Routines, criteria and incentives for reporting should be properly developed and communicated to all employees. Moreover, feedbacks to reports and follow up are vital for effectiveness of RUO reporting (Kjellén, 2011b).

The success of implementation of safety inspections, JSA and RUO reporting as well as effectiveness of safety management system on the whole depends on different factors (Kjellén, 2011). Thus, these factors should be taken into account during evaluation of HSE activities and require further scrutiny. Moreover, implementation and effectiveness of the whole health and safety management system requires management support and commitment at all phases (Zohar, 1980; Rundmo & Hale, 2003; B. Fernández-Muñiz et al, 2007).

3.2 Factors influencing safety at construction sites

The research on factors influencing implementation of HSE practices is limited, although the influence of HSE practices on safety performance has been examined by many researchers (Hallowell and Calhoun, 2011; Abudayyeh et.al, 2006). One of a few papers on this topic (Aksorn and. Hadikusumo, 2008) identified 16 success factors influencing the implementation of safety programs in construction projects in Thailand which researchers grouped into 4 categories using Factor Analysis technique (See table 3.3). According to their results, management support and appropriate safety education and training are the most influential factors for implementation of HSE practices.

Table 3.3 Factors affecting safety program implementation (Aksorn and. Hadikusumo, 2008)

Success Factors	Sub-factors
Worker involvement	Positive group norms
	Personal attitude
	Personal motivation
	Continuing participation of employees
Safety Prevention and Control System	Effective enforcement scheme
	Appropriate supervision
	Equipment acquisition and maintenance

	Appropriate safety education and training
	Personal competency
	Program evaluation
Safety arrangement	Good communication
	Delegation of authority and responsibility
	Sufficient resource allocation
Management Commitment	Management support
	Teamwork
	Clear and realistic goals

With regard to factors influencing overall safety performance, not only results of HSE practices, different studies showed different results. Kheni et al (2010) based on literature review identified factors influence safety performance at construction sites in developing countries (See Table 3.4), while Kartan et al (2000) indicated the following factors influencing safety in developing countries: competitive tendering, lack of safety regulations, extensive use of subcontractors, lack of relevant accident data, extensive use of foreign labour, high labour turnover and low priority of safety.

Table 3.4 Factors influencing safety in developing countries (Kheni et al., 2010)

Variability of approaches to OH&S	Client/financiers concern for OH&S Differences in measures adopted to mitigate OH&S risks OH&S roles within the company
External environment	Influence of economy on business operations including OH&S of the company Inadequate support to the company from the

	government Standards of living reflected in workers' poor demand for OH&S
Culture	Religiosity of OH&S Workers' relationships with one another Extended family system Extended family environment of the company Existence of close relationships within the company Collectivistic style of life
Internal and external environments of the company	Benefits deriving from good OH&S are not immediate Government commitment to improving performance of the construction sector Resources available to the company State of the economy as an enabler of OH&S management within the company

The paper by Kjellén (2011) describes the factors identified during previous research (Hofsetede, 2004; Kjellén et al, 1997; Manu et al, 2010; Mearns and Yule, 2009) and his experience which he systemised and split into two groups: (A) external, which specific to the nation or have their influence internationally, and internal (B), which are specific to the particular project (See figure 3.2).

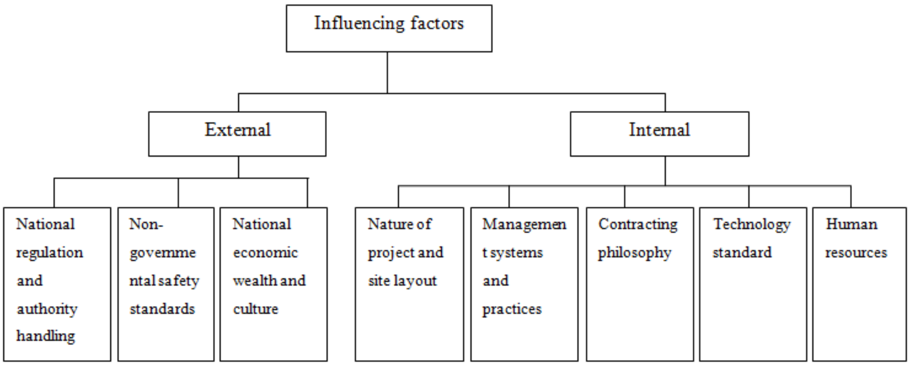


Figure 3.2 Factors influencing safety (Kjellén, 2011a)

This approach of grouping factors will be taken for further detailed review of some these factors which is will be used for analysis of results of HSE activities evaluation.

3.2.1 External factors

3.2.1.1 National regulation and authority handling

Construction industry is one of the industries which have high accident statistics. The significant number of international standards has been developed to improve safety at workplaces in construction.

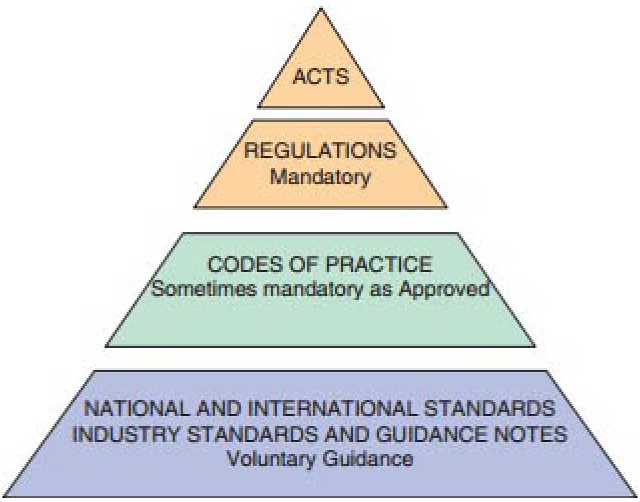


Figure 3.3 Framework used in construction industry according to Hughes and Ferrett (2008)

Peruvian requirements

Peruvian Directive (2007) "Labor Inspection Guideline on Security and Occupational Health in Construction Sector" (Supreme Decree No. 007-2007-TR) was developed because the construction sites constitute a business sector where skilled workers are exposed to particularly high levels of risk. The Directive obliges the companies involved in construction to establish a culture of risk prevention. More detailed this requirement is described in Regulations on safety and health at work (2005), THE SUPREME ACT N º 009-2005-TR.

The Standard G.050 (2009) on Safety during construction specifies the minimum necessary safety considerations to be taken into account in civil construction activities. It states minimum requirements to workplace safety, health and safety plan, mechanism of supervision and control, accident reporting, qualification of contractors and accident prevention.

Ministerial Resolution No. 148-2007-TR and Supreme Decree No. 009-2005-TR provide a general description of requirements to main elements of occupational health and safety system which are necessary to ensure social protection and development of decent work.

Industry guidelines

Some international standards for occupational safety and health are specified in the contract requirements by the Client. One of them is OHSAS 18001(2007) which constitutes the main requirements to occupational health and management system to control occupational and safety risks. It is worth noting that that this standard is recommended not required from Contractor in Client's Specification. Based on these requirements it is possible to develop proper safety policies and build and improve occupational health and safety system to avoid accidents. (http://www.ohsas-18001-occupational-health-and-safety.com/procedure.htm)

The guidelines on Safe working in tunnelling (2008) have been developed for tunnel workers and line management to help recognize and reduce risks in tunnel construction processes. The guidelines provide essentials for prevention of accidents in tunnels; however, they do not cover design issues such as rock support.

The standard used in industry is Code of Practice for Safety in Tunnelling in the Construction Industry. It was developed in 1982 to provide "comprehensive guidance on health and safety issues arising from tunnel and shaft construction and tunnel maintenance, renovation and repair". The standard deals with planning, organization, emergencies, working environment, communications and safety aspects of access, transport, electrical and mechanical plant and equipment, compressed air working and atmospheric hazards. Contractor and the Engineer at The Project use the standard frequently.

Another guide for evaluation and control of workplace exposures to chemical substances and physical agents is used by Contractor to satisfy Client's requirements. It is called "Threshold Limit Value (TLV®) and Biological Exposure Indices (BEIs)". The guide is useful when there is a need to determine safe levels of exposure to various physical and chemical agents in the workplace.

Reporting to authorities

Reporting gives necessary knowledge for preventive work to the responsible authority. Another purpose is to provide information for the supervision of compliance with safety laws in the workplace (Kjellén, 2000). Peruvian requirements for reporting to authorities are given in Table 3.5

Table 3.5 Reporting to authorities in Peru

Authority	Event	When	By whom
Police	Death	Immediate notification	The Client The employer
Ministry of Labor and Employment promotion	-Death - High potential near miss, or high potential risk (an event that can cause death or affect a community)	Within 24 hours	The Client The employer
Ministry of Labor and Employment promotion	LTI, personal injuries	The last one working day of the next month	Clinic, hospital, etc.
Ministry of Labor and Employment promotion	Occupational disease- illness	Within 5 days after the diagnosis	Clinic, hospital, etc.

To summarise the section it is important to stress that Peruvian regulations are a subject of a continuous change, but they still provide only general description on requirements to safety in construction. Therefore, international industry standards can be used in addition by Contractors in implementation and follow up of safety activities of HSE department and at all levels of the organisations.

3.2.1.2 National economic wealth

Influence of economic situation in the country on safety in the organisation is inevitable and discussed in different studies (Gun, 1993; Kjellen, 2011, Hughes and Ferrett, 2008; Levitt and Samelson, 1993, Kheni et al, 2010; Kartam et al., 2000). Economy affects the size of HSE budget of companies, standards of living reflected in poor demand by employees for workplace safety, risk taking behaviour, quality of professional and safety education etc.

Due to macroeconomic stability, Peru's economy is considered an 'Emerging Market'. The trend of increasing investment, and improved terms of trade contribute to development of Peruvian economy. Purchasing Power Parity in Peru is 10 times lower than in Norway, however real GDP grew 8.9% in 2007, 9.8% in 2008, 0.9% in 2009, and 8.8% in 2010 (Peru Economy Profile, 2012). Growing wealth of Peru is unevenly distributed and 34.8% (2009) of the population lives below the poverty line. European Commission in Country Strategy Paper (2007) states that The Peruvian economy is characterised by a wide disparity among regions as regards the degree of economic development.

Profuse mineral resources are found in the mountainous areas in Andes and government is launching programs to support the poor (Van den Berge, 2009). Corrupted local administrations in poor areas do not distribute money to locals who are supposed to get them according to the programs. Poor infrastructure hinders the spread of growth to Peru's non-coastal areas; therefore in some places the budget of a family is estimated to be 2 US dollars per day per a person. The regions with the highest rates of poverty and extreme poverty are in the Central mountain range (Huancavelica, Huánuco, Apurimac and Ayacucho). The rates are also high in Cajamarca, Cusco and Puno and in the forest regions (Amazonas, Loreto and Ucayali). The current economic situation in the country led to high turnover of employees, low level of education, long working sifts and logistical problems (European Commission, 2007).

3.2.1.3 Nongovernmental safety standard

The Project is financed through loans from the International Finance Corporation (IFC), which has Policy and Performance standards on Social and Environmental Sustainability (IFC, 2007). Guidelines provided by IFC are not detailed. Compliance of Contractors to the Policy and Standard is monitored with project reporting and regular independent reviews. In addition, IFC conducts audits of the project using IFC's as a reference. Nonconformities to these standards are considered as violations of the lending agreement (Kjellen, 2011a).The other nongovernmental standards which are used at the project are reviewed in Section 3.1.

3.2.1.4 National culture

National culture is shown to be a strong shaping force for workplace relations and personal and group attitude to safety (Kheni et al., 2010). In developing countries many values have their origin in religion which plays a colossal role in people's everyday life.

Geert Hofstede is one of the researchers who is most often referred to within the theme of national cultural differences and has published several books on the subject. He has introduced several dimensions of culture (See table 3.6). Some of the dimensions which are relevant to safety according to studies by other researchers (Mohamed, 2002; Schubert and Dijkstra, 2009) are illustrated in the table. On the other hand, it is common to criticize Hofstede for assuming that individuals are static phenomenon. Moreover, the differences within countries can be bigger than across borders (Lamvik and Raven, 2006).

Table 3.6 Cultural dimensions according to Hofstede (2001)

Cultural dimension	Definition	Value for Peru	Value for Chile	Value for Norway
Power Distance (inequality in society)	The extent to which the less powerful members of institutions and organisations within a country expect and accept that power is distributed unequally	64 (from the range of 11-104)	63	31
Individualism	Individualism pertains to societies in which the ties between individuals are loose. Collectivism pertains to societies in which people from birth	16 (6-91)	20	69

	onward are integrated into strong, cohesive in-groups, which throughout people's lifetime continue to protect them in exchange for unquestioning loyalty			
Masculinity	A society is called masculine when emotional gender roles are clearly distinct: men are supposed to be assertive, tough, and focused on material success, whereas women are supposed to be more modest, tender, and concern with quality of life.	42 (5-110),	28	8
Uncertainty avoidance	The extent to which members of a society feel threatened by, and try to avoid, future uncertainty or ambiguous situation	87 (8-112)	86	49

In a workplace context Power Distance is highly relevant for the interpretation of hierarchical positions: In high power distant cultures, authority of the boss is acknowledged as a result of natural inequality whereas in low power distant countries hierarchy is interpreted as a set of rules created for convenience among equals (Schubert and Dijkstra, 2009). Therefore different styles of leadership are effective in different cultures to motivate people to behave safe. It is worth mentioning that people highly prefer working with a foreman of the same nationality. (Schubert and Dijkstra, 2009)

In high Power Distance cultures like Peru flow of communication goes only from up to bottom direction. For example, workers execute orders of supervisors without questioning them in terms of safety. In countries with high uncertainty avoidance there are a significant number of rules and procedures at workplaces but the research shows that people tend not to follow them because they 'prepared to engage in risky behaviour in order to reduce ambiguities' (Hofstede, 2001, pp. 116). High collectivism and feminism demonstrate that people are willing to take care for each other and feelings inside of the group the group is more important that the achievement of the target (Hofstede, 2001). All these factors influence safety in different ways.

It is worth mentioning that there are researches that showed that people from cultures with similar indexes in all dimensions defined by Hofstede can demonstrate different attitude to safety and have a difference in injury statistics (Spangenberg et al, 2003). For example, the lower LTI-rate was achieved by Swedish construction workers in comparison with Danish construction workers participating in the same project. This success in safety was attributed to Swedish national education programs and monetary incentives introduces for Swedish workers. Apart from that in different studies it was found that the attitude of management to safety is an important shaping factor for employees' attitude to safety, and it has more influence than national differences (Fernández-Muñiz et al,2007; Mearns and Yule, 2009; Mohamed et al, 2009).

3.2.2 Project specific influencing factors

3.2.2.1 Management systems and practices

Management support for safety is demonstrated being the main influencing factor in many studies (Fernández-Muñiz et al,2007; Hale et al 1997, Zohar,1980; Rundmo & Hale, 2003; Tinmannsvik and Hovden, 2003, Mohamed 2002). While implementing safety management system, the management commitment should be the first step to improve safety outcomes (Fernández-Muñiz et al, 2007; Hale et al 1997). In addition, many studies showed that majority of accidents are caused by failure in **management control** rather than careless of workers. Inattention to safety issues during planning of work and resource allocation will contribute to a culture of noncompliance

Fernández-Muñiz et al (2007) found it their study strong positive statistically significant influence of managers' commitment on employees' involvement and success of safety management system (Figure 3.4). It can be interpreted in light of this research that commitment of management determines the workers participation in HSE practices. Moreover, it affects the results of HSE practices.

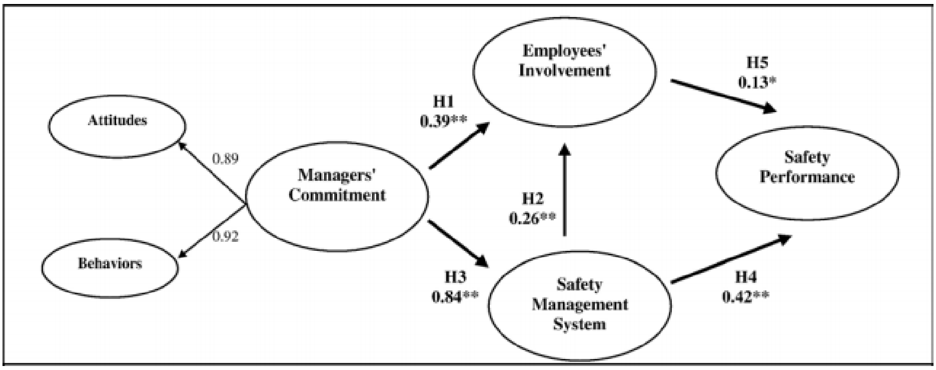


Figure 3.4 Correlation analysis for management commitment (Fernández-Muñiz et al, 2007)

When scrutinising influence of management on safety, it is important to note that Tinmannsvik and Hovden (2003) separated *general* management factors from *safety specific* management factors (See table 3.7). They concluded that general management factors play more important role in improvement of overall safety performance in comparison with safety specific management factors.

Table 3.7 General management factors and HSE management factors (Tinmannsvik and Hovden, 2003)

General management factors	Safety specific management factors
Education and training Machines and technical equipment Maintenance Transportation and storage Housekeeping Procedures and activities Communication Leadership and work administration	Safety attitude Safety equipment and protective equipment Emergency preparedness Safety experience exchange Safety programme activities (safety objectives, safety organisation, safety representatives, inspections, safety meetings, accident investigation and safety action plan)

In addition, they found that employees evaluate safety in the company as high when they are satisfied with safety specific management activities. The important conclusion of Tinmannsvik and Hovden that “Safety specific management factors may affect the injury frequency rate mainly through the general management factors, and may be a necessary precondition for the influence of general management factors, on safety performance in an organisation” (Tinmannsvik and Hovden, 2003, pp.588).

Moreover, management commitment and participation in safety is a vital element in safety climate (Zohar,1980; Rundmo & Hale, 2003; B. Fernández-Muñiz et al, 2007). In addition, communication of management about its commitment to safety and employees’ feedback are necessary for promotion of reporting in the company (Mohamed, 2002).

At the Project responsibility for HSE is in practice delegated to Contractor’s HSE department. Representatives of Contractor’s general management participate in weekly HSE meetings, but responsibility to execute the decisions taken at these meetings is allocated mainly on HSE department. Moreover, Contractor’s general management does not ensure that supervisors and foremen take the HSE responsibility during their work.

3.2.2.3 Human resources

Loss of control which leads to accidents occurs at a sharp end of an organisation (Reason, 1997, Kjellén, 2000). Humans affect safety directly and indirectly and the level of influence is impossible to overestimate. As it was showed in section 3.2.1 external factors influence also human resources which are involved in the project. The existence of a cheap source of labour in Peru, combined with the low socioeconomic status of workers are main obstacles to improving safety because this limits workers' capacity to refuse working under poor working conditions at the project (Kheni et al, 2010)

Marten van den Berge in his paper „Rural Child Labor in Peru"(2009) indicates that 29% of children in the age category 6-14 were working in 2001.The child labour in Peru tripled during the time period from 1993 to 2007. The majority of working children are from rural areas where the economic situation and infrastructure are worse than in cities (Van Den Berge, 2009). Van Den Berge found out that children work in Peru due to (A) a strong necessity to earn money for basic needs, (B) to learn crafts from parents and (C) schools are too remote and transport system is not developed. As a result, working children are behind in their studies from 1 to 3 years (95%) and some fail to get General Basic Education. Olivos and Talavera (2006) reported that 22% of Peruvian aged older than 40 years are illiterate (Mariella Olivos and Jorge Talavera, 2006). Therefore, the level of professional and safety education of workers is low. This in turn affects their capability to execute HSE activities.

The situation in the country also affected workers at the Project, who have a low level of professional and safety education and provide resumes with false information about their experience to Contractor.

3.2.2.4 Contracting philosophy

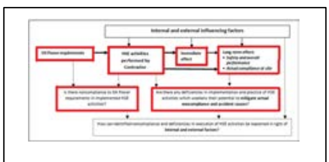
The way the Client organises construction works in the Project is described in Section 2.1.2. According to Kjellen (2011a), the contracting philosophy affects safety performance. A number of small contractors and subcontractors make safety management more complicated and challenging for the Client due to more interfaces and presumably lower qualifications, therefore it is difficult to achieve and maintain a high level of safety in such environment (Manu et al., 2010). The Project employs one Principle Contractor which is responsible for its subcontractors and coordination of safety issues with three other contractors involved into the project.

3.2.2.5 Nature of the project and site layout

The layout of the project affects safety significantly (Kjellen, 2011a). The Project is located in mountainous area and nature of the project involves activities associated with a high risk such as tunnelling and transportation on narrow roads with unstable slopes and risks of driving off the road and falling into the valley. Tunnelling in this project represents a set of hazards due to high rock tension and portions with very loose rocks. The roads were cut out of mountains and there is a tendency of road erosion and landslides. Apart from that, there are risks of falling boulders especially during the rain (Kjellén, 2011a)

3.2.2.6 Technology standard

The level of technology standard affects safety considerably (Kjellén, 2011a). The use of new technologies can help avoid the direct contact between hazard and a potential victim (Manu et al., 2010). However, it is crucial that workers are trained properly on how to use new equipment (Fidgerald, 1995). The Project has a high technology standard in international comparison. Equipment is maintained properly and available at proper safety standard, but some workers do not use it and prefer manual tools to automated ones.



3.3 Evaluation research

According to Gertler (2011) "Evaluations are periodic, objective assessments of a planned, ongoing, or completed project, program, or policy"(pp.8). The most effective way to use evaluations is to use them for answering particular questions related to design, implementation, and results of a program. Evaluations are closely related to social scientific research, but have a different purpose that is provision of useful feedback about the object of evaluation. Research though adds to the body of knowledge (Alkin, 2010).

Periodic evaluation of the current work can help shape the course of future work. Evaluations provide information which can be used to take decisions leading to improvement of the program (Alkin, 2010). Evaluations can be formative and summative. Formative evaluations (A) are used during early stage of program implementation, (B) carried out to provide information for improvement of the program, (C) used to scrutinise if the program activities are being carried out and carried out in a proper manner. Summative evaluations assess the outcomes of the program, determining its overall impact (Alkin, 2010). In order to resolve the task of this thesis, the formative evaluation is used. Therefore, literature review is further focused on formative type of evaluations.

The main element of Evaluation are showed in the figure 3.5

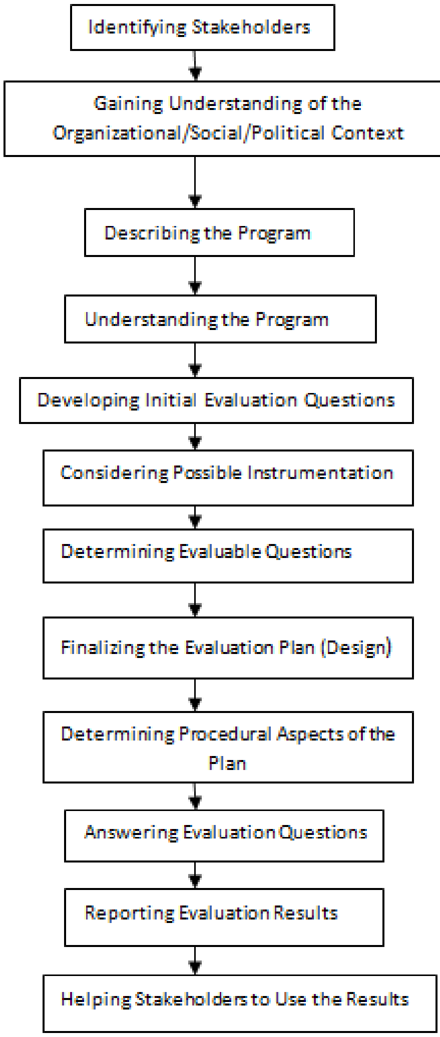


Figure 3.5 Stages of evaluation (Alkin, 2010)

Before the commencement of evaluation it is important to reach a comprehensive understanding of the object of evaluation (Alkin, 2010). For example, in case of evaluation of a safety program it is necessary to understand:

- Intended results
- Stakeholders
- The content of the program under evaluation

- Related to program documents such as contracts, regulations and so on.

During the evaluation of the program it is important to consider elements of the program such as activities and short-term effects of these activities (Kjellén, 1983). Shannon et al. (1999) claims that "...judgment on the appropriateness of outcome measures will depend on the clear identification of program objectives" (pp.164). Figure 3.6 illustrates the relationship between program objectives and outcomes.

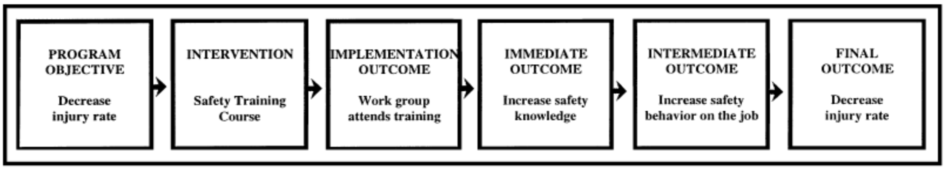


Figure 3.6 Relationship between program objectives and outcomes (Shannon et al., 1999)

Having a logic model of the program (Figure 3.7), evaluator would know what to look for in evaluation and select relevant measurement instruments (Alkin, 2010).

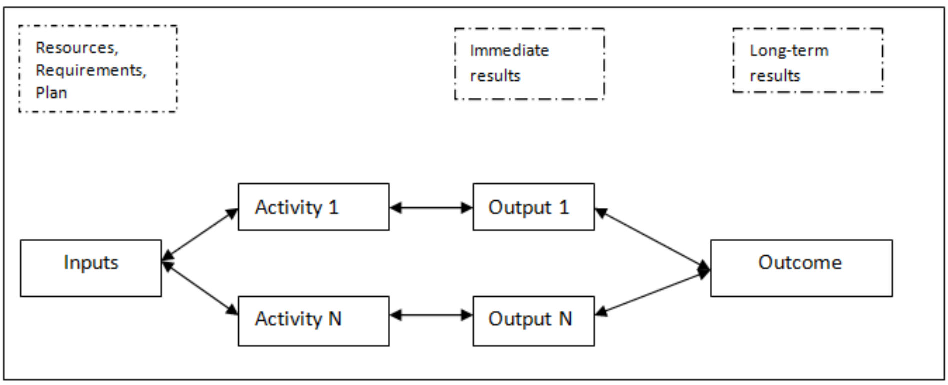


Figure 3.7 Model of the program under evaluation (Alkin, 2010).

The design of evaluation plays a critical role in development and execution of evaluation. Inadequate design leads to wrong results and waste of resources (Clarke, 1999). The following questions should be addressed during design of evaluation (Alkin, 2010):

- What should be evaluated?
- What is the purpose of evaluation?

- What data is need?
- Whom will the data be obtained from?
- When will data be acquired?
- How will these data be analysed?

When proper design of evaluation and resources for execution are ensured, the data collection can be planned and executed involving the following methods:

1. Group discussion and meetings
2. One-to-one discussion
3. Written questions and answers
4. Participant observation
5. Documents review
6. Interviews
7. Self-reports
8. Questionnaire

The different method of data collection should be applied depending on the type of information and subsequent analysis is required (Shannon et al., 1999). The collected data can qualitative or quantitative. For collection of quantitative data it is recommended to use tests, questionnaire, and observation protocols and self-reports. Qualitative data proved to be easier to understand and analyse (Alkin, 2010). Quantitative data can be based on different scales. Data is usually encoded with the purpose to reduce the complexity and use in statistical analyses (Kjellén, 2000).

The advantage of qualitative data is the opportunity to be responsive to the particular context and obtain the perspectives of those within it (Alkin, 2010). Group and individual interviews, observations and questionnaires with open-ended questions are used for collection of qualitative information. Such information can be used for interpretation of quantitative data and cross-validation (triangulation) for better understanding of the results (Shannon et al., 1999). This provides greater validity when results of analysis are based on consistent patterns across multiple data sources. In addition, qualitative data are used to explain other factors that may influence the effects achieved.

Summary for evaluation research

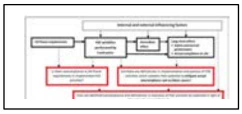
Evaluation is a useful source of the information for effective decision making on possible improvements of the program (Alkin, 2010; Kjellén, 1983). In order to evaluate a program, it is important to measure the level of implementation, immediate effect and final outcome (Shannon et al., 1999). The final outcome is the long-term effects that make the goal of the program. The long-term effects should be taken into account in analysis of implementation of the program in order to understand if the program needs adjustments to current conditions to reach the desired result (Shannon et al., 1999). The implementation should be monitored to see if factors in implementation which can lead to not achieving the desired result (Alkin, 2010). This gives theoretical grounds for developing of the analytical model for this research (See figure 1.1) which is used to measure implementation, immediate effect and final outcome of the evaluated HSE activities.

The criteria for *effective evaluation* are the following (Alkin, 2010):

- Evaluation is conducted in a systematic way
- Data collection and assessment is performed in a planned and methodical way
- Procedures employed for evaluations are objective and sequence of their execution is clear
- Findings and conclusions have credibility
- Errors in reasoning, data collection and analysis are eliminated or analysed regarding possible influence on the findings.

Performing the evaluation of the results of the program and the adequacy of implementation it is important to keep in mind that there might be independent factors apart from program activities which might also affected the outcome of the program (Kjellén, 2011a). Summary of evaluation research is used further in the development of criteria and methodology. It is also addressed in the discussion to confer the method used and to assess the impact of the HSE activities taken by Contractor.

4. Method



The purpose of the methodology chapter is to clarify the choice of method and the way of their execution.

4.1 Task selection and resolution

SN Power as a Client company is interested in maintaining a high level of safety with “zero injures” (HSE policy, 2008) at all its operating plants and projects under construction. In order to follow up safety at Cheves project and take effective decisions in the future, SN Power is interested in evaluation of HSE activities performed by Contractor at the project. This task aligns with the interests of the author of this research which are safety management in contractual environment at construction projects. The location of the project in a developing country brings additional perspectives to the research such as country specific factors influencing safety (Kjellén, 2011).

To resolve the task, the formative evaluation research is selected since it is usually used to provide information for improvement of the program and to scrutinise if the program activities are being carried out and carried out in a proper manner (Alkin, 2010).

Research questions are developed to steer literature review and evaluation in the right direction to the task resolution. Literature review is conducted for research questions No.1-2 to provide the theoretical basis for evaluation method and criteria. The results from literature review conducted for research question No.3 are used to increase the validity of evaluation. Evaluation of HSE practices is performed to resolve research question No.4. Analysis of factors influencing implementation and outcomes of HSE practices is performed to increase the validity of performed evaluation and answer research question No.5. Results of evaluation are used to provide recommendations to SN Power regarding improvement of HSE activities within research question No. 6.

4.2 Analytical model

The analytical model used for this research is shown in Figure 4.1. It is based on the model by Kjellén (1983) used for evaluation of measures taken by a company. The analytical model is also used in this report to illustrate parts of the model which are discussed in one chapter or another.

The analytical model was developed based on the literature review on Evaluation research (See section 3.3). Shannon et al. (1999) claimed that in order to evaluate a program, it is important to measure the level of implementation, immediate effect and final outcome. Therefore, the measurement of the level of implementation of the evaluated HSE activities, their immediate and long-term was included in the analytic model. Shannon et al. (1999) also pointed out that outcome of the program should be evaluated comparing with the input that is the initial goal of the program. So SN Power requirements were included in the analytic model as the input to the evaluated HSE activities. Alkin (2010) and Rossi et al. (2004) indicated in their books that consideration of other factors, which might have influence on the implementation and outcome of the program, is necessary to achieve a high validity of the evaluation. Thus, analysis of influence of internal and external factors influencing the evaluated HSE activities was included in the analytical model. The model elements with questions illustrate the criteria used for the evaluation and sequence of the analysis.

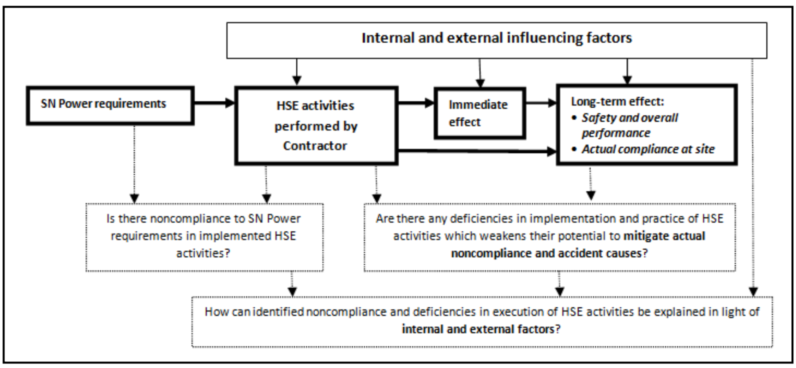


Figure 4.1 Analytical model

4.3 Work flow

The work flow of this research is illustrated in the Figure 4.2.

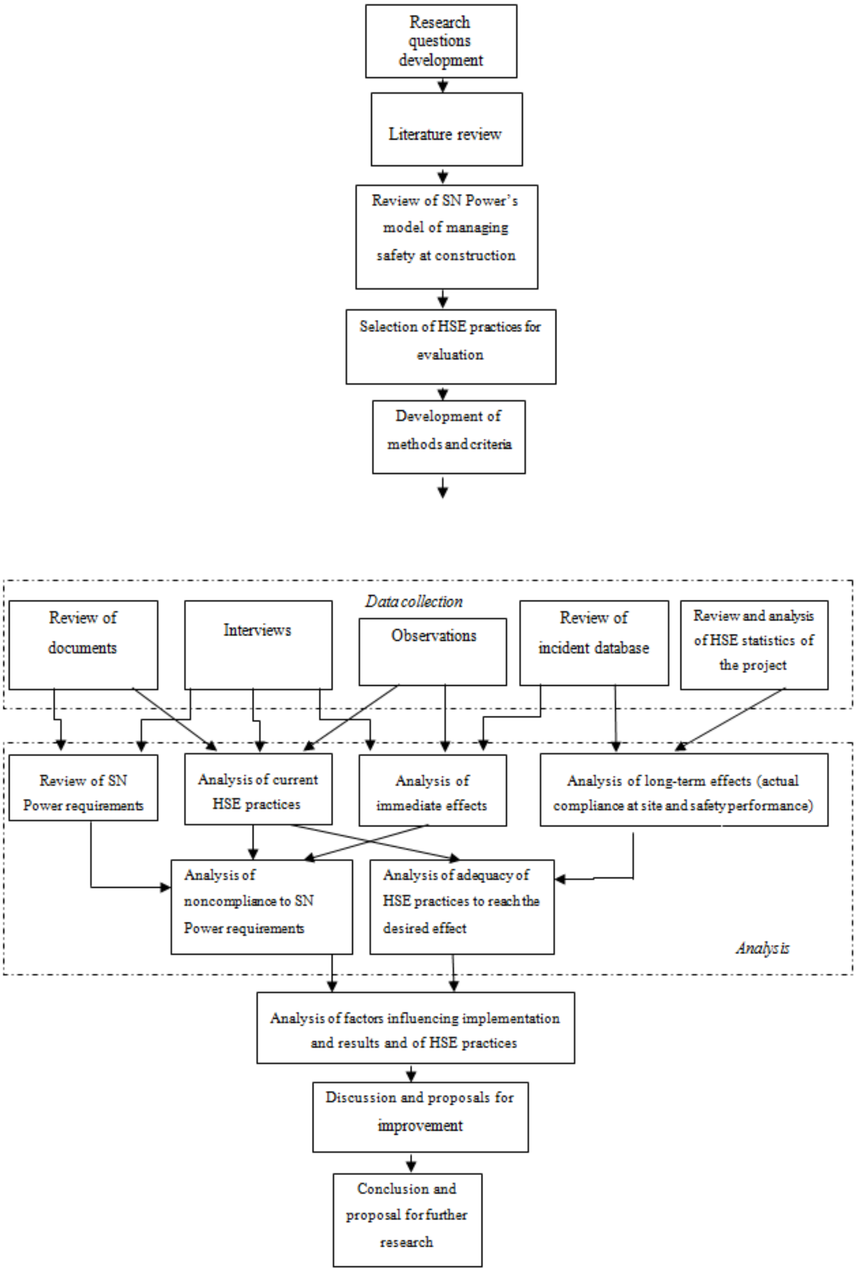


Figure 4.2 Workflow for this thesis

4.4 Evaluation

4.4.1 Evaluation method and criteria

To resolve the task, the formative evaluation research is selected since it is usually used to provide information for improvement of the program and to scrutinise if the program activities are being carried out and carried out in a proper manner (Alkin, 2010).

The object of this evaluation is selected HSE activities performed by Contractor: Safety inspections, JSA and RUO reporting. Each of these activities is evaluated separately. The evaluation of influence of HSE activities is performed through analysis of implementation and outcome (Shannon et al, 1999).

The criterion for *successful implementation* is: HSE activities are implemented according to Client's requirement and best practices in industry reflected in the checklists (See Section 3.2.2) and use their potential to mitigate noncompliance at site and deviations which led to accidents occurred at The Project. The criterion for a *successful outcome (long-term effect)* of HSE activities is taken as: There is actual compliance and adequate safety culture at site and the number of LTI per month is less than 5. The method for evaluation (Figure 4.3) is developed based on these criteria and the model of Kjellén (1983) for evaluation of safety interventions.

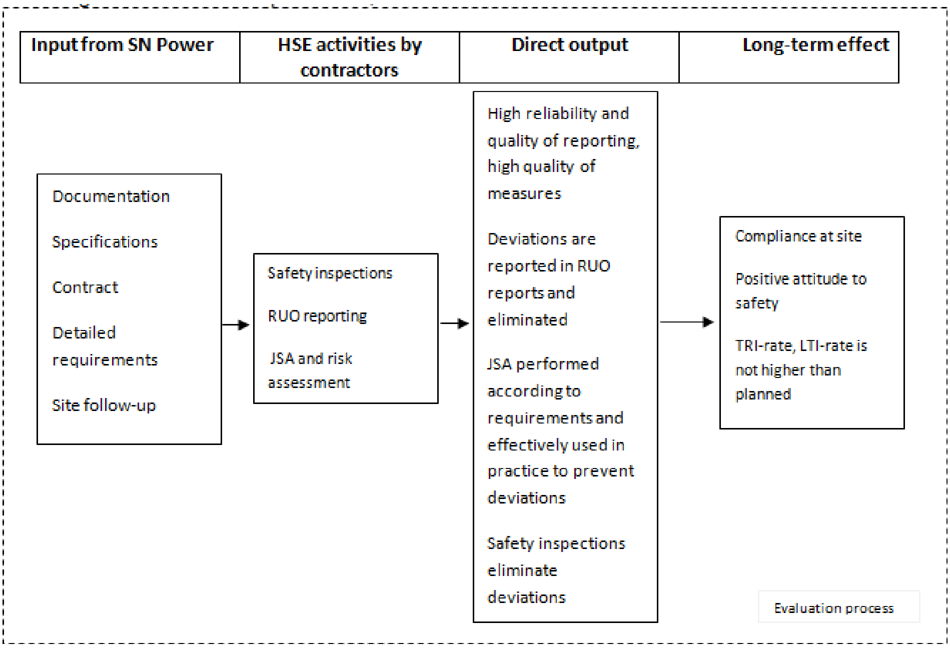


Figure 4.3 Method for evaluation

The input to the activities in this analysis is Client's contract requirements and the checklists. The output is safety performance at site. To understand the effect of other independent factors on the outcome of HSE activities and ensure the validity of evaluation (Wadsworth, 2011), the results of evaluation are scrutinised in light of influencing factors.

4.4.2 Requirements to evaluation

According to Alkin (2010), Wadsworth (2011) and Rossi et al. (2004) the evaluation is valid only if:

- Evaluation is conducted in a systematic way
- Data collection and assessment is performed in a planned and methodical way
- Procedures employed for evaluations are objective and sequence of their execution is clear
- Findings and conclusions have credibility
- Errors in reasoning, data collection and analysis are eliminated or analysed regarding possible influence on the findings.

- The intervention was commenced before the altered state (measured effect) in time
- The evaluation takes into account other relevant factors apart from the program which might affect measured effect independently
- It is taken into account that some long-term effects are not occurred yet
- It is taken into account that the outcome of the program might be reached through a complex network of interdependent effects rather than follow a straight line of simple cause and effect (activity-immediate effect)
- Criteria taken for evaluation are not only objectives, targets and requirements to the program but also the requirement to change and adapt activities of the program in accordance with the actual effect of the program

4.5 Field data

Data collection was performed at The Project in Peru from 3March 2012 to 23 March 2012 as well as in SN Power office in Oslo from 20 January 2012 to 30 April 2012. The data was used for analysis of implementation and immediate and long-term effect of HSE activities.

4.5.1 Review of documents

The review of documentation was conducted to collect mostly qualitative data from Contractor and the Client to perform evaluation of input, implementation, immediate and long-term effect of HSE activities. The list of reviewed documents is presented in the Table 4.1 with the description of the purpose of each review.

Table 4.1 Review of documentation

Documents	Provided by	Purpose of review
Contractor's JSA protocols	Contractor	To analyse the structure of the protocol, comprehensiveness of its checklist, the variety and quality of measures proposed, number of participants.
Contractor's RUO reports	Contractor	To analyse the structure of the protocol, comprehensiveness of its checklist, the variety and criticality of reported issues
Contractor's safety inspection protocols	Contractor	To analyse the structure of the protocol, coverage and quality of findings, the variety and quality of measures proposed, assignment of responsibility
HSE contract requirements prepared by the Client	The Client	To understand the input to HSE activities under evaluation
Contractor's Health and safety plan	Contractor	To find out parties responsible for HSE activities execution and follow up, review plan of HSE activities execution
Contractor's Action follow up document	The Client	To analyse the registered issues reported with RUO reports and daily inspections. To analyse quality and variety of measures proposed, assignment of responsibility and current status of execution of recommended measures.
Contractor's Investigation reports	The Client	To make analysis of accidents to find out the contributing factors and deviations which lead to current safety performance
Client's Audit report	The Client	To cross check findings of this thesis with findings from audits.

The protocols from safety inspections, RUO reports and JSA protocols were received at the last day of the field visit. Therefore it was impossible to use triangulation approach to check reliability and validity of data in these documents. Detailed information for safety inspection protocols, RUO reports and JSA protocols is provided in Table 4.2

Table 4.2 Description of reviewed documents

Document	Date of document registration	Number of documents provided by Contractor	Number of observations	Registration of findings and remedial actions in Action follow up document
Safety inspections	January 2012-February 2012	6	4-7	72
JSA protocols	January 2012	5	20	Not registered
RUO reports	30 January	6	1-2	100

The data obtained from Contractor represents a weak sample for adequate evaluation of quality of implemented HSE activities, but it is representative enough to understand the routines of these activities and quality of used checklists. The weakness of data was partially compensated by information from Action follow up document that contains hundreds of registrations of findings and remedial actions after safety inspections and RUO reporting.

4.5.2 Interviews

The interviews were conducted to collect the qualitative information on implementation of HSE activities and their effect. Semi structured interview type was used to collect the information on the level and quality of implementation of HSE activities. Semi-structured and unstructured interviews were conducted to find out the perception of interviewees of effect of HSE activities and factors influencing this effect. The questions for semi-structure interviews were developed based on the literature review on influencing factors and consultation with HSE expert.

Table 4.3 Interviewees within data collection

Company	Title of employee
Contractor	HSE manager
Contractor	Construction manager
Contractor	HSE inspector
Contractor	Tunnel engineer
Contractor	Surface supervisor
Contractor	Geologist
Contractor	Workers
The Engineer	Project manager
The Engineer	HSE inspector
The Engineer	Deputy project manager
The Client	Project manager
The Client	Project control manger
The Client	HSE manager
The Client	Trainee
The Client	HSE engineer

4.5.3 Observations

Observations were performed to collect the quantitative information for analysis of actual compliance at site. For conducting observation Behavioural Sampling was used which is a technique for observing the deviation from the accepted and safe working conditions. Measurement of behavioural sampling is as follows (Kjellén, 2000).

1. Identification of critical behaviour by analyzing the damage reports, safety instructions, inspection reports, etc.

2. Selection of behaviours to be included in the indicator and establish checklists of operational definitions for each item. Selected item should be readily observable, and the difference between safe and unsafe behaviour must be clear

3. Inspections in the workplace to randomly selected intervals to observe the items and if they performed correctly or not

4. Plot of the indicator in a control chart. The indicator is defined as the percentage of observed elements that are correct

The Behavioural observations were conducted with HSE inspector from the Engineer in four places at the Project: Adit1 tunnel, Headrace tunnel, Power house and Transfer tunnel. Checklist for Behavioural Sampling was developed by the author with support by Engineer's HSE inspector. The elements for observations are taken from the guidelines "Safe work in tunnelling" which provides clear examples of safe behaviour and safe conditions. In addition, signs illustrating the required PPE in each particular area of the project were used to adjust Observation checklist to area specific requirements (See picture 4.4). The selection was also based on the clause that the element is easy to observe.

Picture 4.4 Requirements to PPE in Access tunnel of the Project

The checklist contains three sections: safe behaviour, housekeeping, use of personal protective equipment. Each element in the checklist was rated on a scale of 1 to 5, where 1 indicates differences that must be repaired and 5 indicate no discrepancies are found. Each measurement was carried out as an overall assessment of the participants in a team. The checklist can be found in Appendix 1. The results of observations were checked by HSE inspector of the Engineer and compared with findings from daily safety inspections performed by Contractor HSE inspectors to ensure validity of assessment.

4.5.4 Review of incident database

The Client provided the author with the incident database with reported incidents from November 2010 till March 2012 by Contractors. Incident database is composed from monthly reports and accident investigation reports which Client's HSE manager gets on monthly basis.
The database was used to find out and analyse all recordable injures occurred at The Project. The columns of the database which were used to obtain the information are the following: Sequence of event, data, place, remedial actions, type of event, and type of incident. The obtained information was used for analysis of the current safety performance of the project.

4.5.5. Questionnaire

Survey is the most common method to measure safety climate in a company (Hale and Hovden, 1998). This is used to provide an indicator that not only is based on retrospective data. The survey was used as an element in triangulation in relation to measurements of the effect from implementation of HSE practices. The safety culture and safety climate are used to explain how members of an organization think about safety. The difference is that safety culture exists on a higher level which includes policies and objectives, while the safety climate is often used to describe the more specific effects (The Aberdeen University, 1994). Safety climate can be described as a condition of a given point in time and aspects of an organization that have an influence on people's behaviour, how they think and what they feel about safety (The Aberdeen University, 1994). With the help of effective HSE activities, good safety culture can be embedded in organization because it can encourage mutual cooperation between management and workers in the operations of the programs and decisions that affect their safety and health (Aksorn and. Hadikusumo, 2008). Therefore, the safety culture should be considered as long-term effect of HSE activities and questionnaires measuring safety culture can be used to evaluate the effect of HSE activities.

The main part of the questionnaire used for this research is based on the Nordic Safety Climate Questionnaire (NOSACQ-50) developed to measure safety climate in a company. Likert scale is used, where respondents are asked to indicate the amount of agreement or disagreement with statements about different dimensions of safety climate defined by Kines et al (2011). Likert's five-point rating scale is anchored at one end by *completely agree* to *completely disagree* at the other. Intermediate points would be "agree," "do not know," and "disagree." One of the authors of NOSACQ-50, Pete Kines from National Research Centre for the Working Environment in Denmark, kindly provided to the author a copy of NOSACQ-50 in Spanish language. Initially the questionnaire had a capacity to sufficiently capture the shared perceptions of employees of management, workgroup safety related policies, procedures and practices. It contained 50 questions with tested reasonably high validity and reliability (Kines et al, 2011). After consultations with HSE manager of Contractor, NOSACQ-50 was reduced from 50 to 16 questions by excluding questions which measure perception of management safety priority, commitment and competence and management safety justice (See Appendix 2). This affected internal consistency (Cronbach's alpha) of used safety climate scales and consequently validity and reliability of the questionnaire. The scales which have been included into the final questionnaire after the consultation are 1) management safety empowerment; 2) workers' safety commitment; 3) workers' safety priority and risk non-acceptance; 4) safety communication, learning, and trust in co-workers' safety competence; and 5) workers' trust in the efficacy of safety systems. The questionnaire was totally anonymous.

Distribution of the questionnaire took place on 12, 13 and 15 March 2012 with support in organisation and translation during distribution by Omar

Parragga (HSE inspector of Engineer). Potential respondents were informed that the data collection was performed within author's mater thesis and the data was not supposed to be used elsewhere. The questionnaire was handed out to workers during toolbox meetings at the beginning of night shifts in underground works in Access tunnel, Tailrace tunnel and Adit1 tunnel via supervisors. Seventy five questionnaires have been distributed. The number of obtained respondents (N=56) constituted a response rate of 74.6%.

In order to evaluate organizational safety climate and a variation of perceptions of different dimensions of safety climate, T-test was performed. Frequency analysis was executed to find out the distribution of perceptions within each dimension of safety climate.

4.6 Literature review

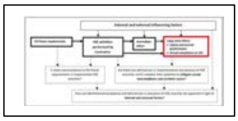
The research process began with the collection and study of relevant research. Some suggestions for articles and books were given by the supervisors. Furthermore, the literature found using search on Google Scholar and BIBSYS, which are respectively a search engine that searches for scientific literature and library system for libraries of all universities in Norway. Searches were mainly done on the articles and books were referred to in the literature that had already been acquired, while the rest were found by using relevant keywords.

5. Results

The aim of this chapter is to review the results of execution of the selected method and provide basis for resolution of tasks. At first, HSE performance at the project is analysed to evaluate the long-term effect of HSE activities performed by Contractor. In order to understand the contributing factors to obtained results regarding current HSE performance, some of reported high potential unwanted events are scrutinised.

Onwards, implementation and immediate effects of HSE activities by Contractor are evaluated to find out if they (A) fulfil Client's requirements and requirements from checklists based on best industry practices (B) ensure diagnoses of deviations and (C) initiate persistent feedback control. In addition, the coverage and adequacy of HSE activities to prevent reoccurrence of accidents occurred earlier at project is analysed.

The results of this chapter are summed up for review in light of different influencing factors in the next chapter.



5.1 Analysis of HSE performance at site

The long-term effects of HSE initiatives which are required by the Client and implemented by Contractor can be evaluated through analysis of HSE performance at the project. In order to ensure a comprehensive evaluation of long-term effects, triangulation is used for analysis of HSE performance: loss-based indicators (LTI, TRI-rate) are used to measure injury statistics; process-based indicator (Behavioural Sampling) is used to measure actual compliance at site; and causal factor-based indicator (Attitude survey) is used to measure attitudes to safety at organisational level (For more information on HSE performance indicators see Kjellén, 2000).

5.1.1 Actual compliance at site

The actual compliance to internal and external safety requirements is significantly affected by HSE activities performed by Contractor. Therefore, the level of compliance at the project is considered as a result of HSE inspections, trainings, reporting, accident investigations, risk assessment and other initiatives of HSE department of Contractor. However, there are other factors such as experience, personal and cultural values and so on which also affect compliance at site (See chapter 6).

Observation of use of PPE, safe behaviour and a level of housekeeping facilitated qualitative analysis of HSE compliance at Cheves. The observations were made during 10 visits to tunnels at day shifts at four places: Power House, Adit1 tunnel, Access tunnel and Headrace tunnel. ITA Guidelines on “Safe works in tunnelling”, signs of speed limit and signs showing the required PPE are used as criteria for evaluation. The important issue as a quality of rock support is not evaluated due to lack of expert knowledge and difficulty to observe and evaluate it properly without required expertise.

Actual compliance at the project is measured with the help of Behavioural sampling. The results are presented as percentage of safe behaviour where 100% is safe behaviour of all personnel. The results of analysis is shown in the Figure 5.1

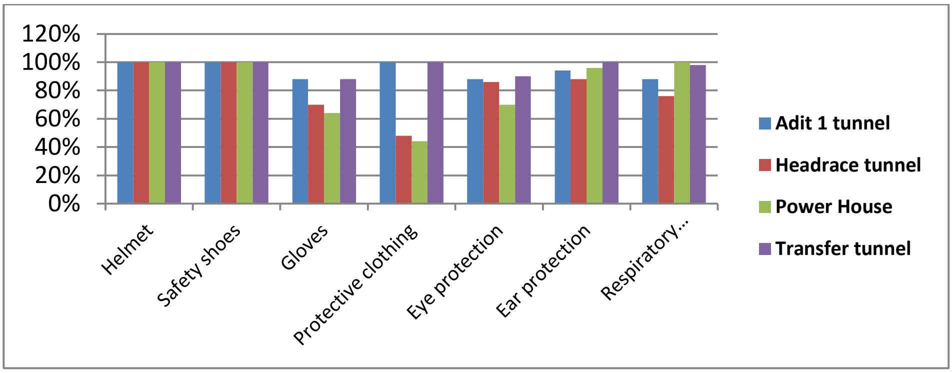


Figure 5.1 Results of behavioural sampling for PPE compliance

Figure 5.1 illustrates that actual compliance at the project regarding PPE is not satisfactory when it comes to wearing gloves and eye protection. Workers reported in RUO reports and informed during interviews that goggles keep fogging up with the high level of humidity and temperature in Power House and Headrace tunnel. The highest registered by the Engineer temperature in Power House is 32C. The protective clothing gets wet and heavy rather quick in such environment. Contractor provides several uniforms to change it during one shift. This does not function as intended and more than 50 % of workers work in Power House and Headrace tunnel short-sleeved.

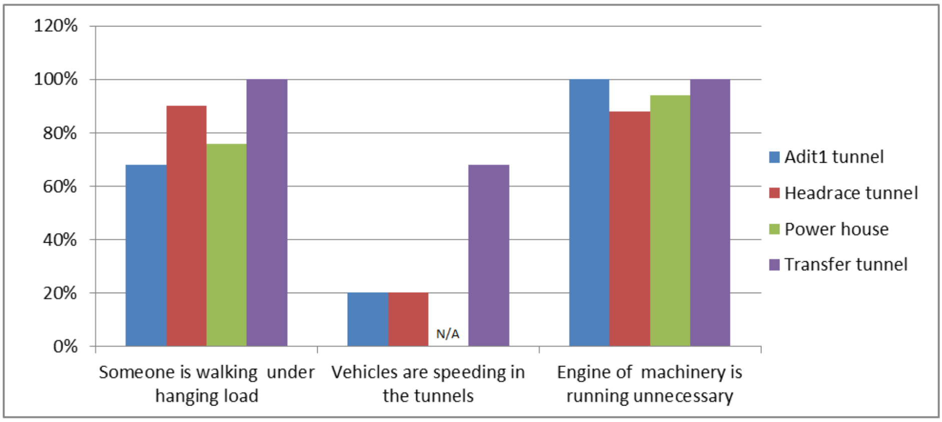


Figure 5.2Results of behavioural sampling for safe behaviour

Figure 5.2 shows that truck drivers demonstrated unsafe behaviour in all tunnels where behavioural sampling was performed. There are no moving trucks in Power House. The information regarding speeding was confirmed with finding from daily safety inspections performed by Contractor. The speeding was measured with speedometers of Contractor. The risk of accidents increases in this case due to absence of a fenced way for walking in tunnels. Another unsafe behaviour such as walking under hanging load was observed and registered mainly in Adit1 tunnel and Power house. Neither barriers nor signs were used to fence danger zone, therefore people were allowed to walk under hanging load.

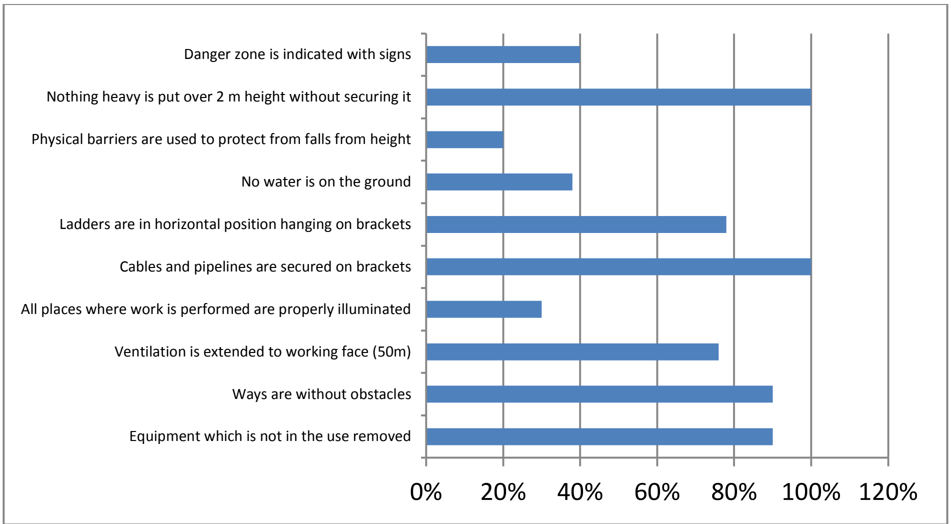


Figure 5.3 Results from behavioural sampling for housekeeping in Adit 1 tunnel

As it can be seen in Figure 5.3, the most significant noncomplience in housekeeping was observed in illumination, ventilation, water on the ground and lack of barriers and signs.

The summary of the results of Behavioural Observations is the following
Identified nonconformity in use of PPE:

- Goggles are not used where it is required by 30% of personnel in Power House
- Gloves are not used where it is required by 50% of personnel in Power House and Headrace tunnel
- Long-sleeved uniform is not used where it is required by 50% of personnel in Power House

Identified nonconformity in safe behaviour

- 80 % vehicles are speeding in tunnels
- Walking under hanging load mainly in Adit1 tunnel and Power House

Identified nonconformities in housekeeping

- Improper illumination of working face

- Distance between working face and ventilation duct is more than 50m
- Water on the ground
- Danger zone is not fenced

HSE statistics as another aspect of HSE performance is investigated in the next section.

5.1.2 Questionnaire

The safety culture and safety climate are used to explain what members of an organization think about safety. Safety climate can be described as a condition of a given point in time and describe what aspects of an organization that has an influence on people's behavior, how they think and what they feel about safety (The Aberdeen University, 1994). Safety culture directly and indirectly affected by HSE activities and evaluation of safety climate can provide valuable information on long term-effects of executed HSE activities. Reliability analysis of the questionnaire showed that 49 out 56 copies are valid. The results were separated according to dimensions of safety climate introduced by the authors of the questionnaire (Kines et al., 2011) 1) management safety empowerment; 2) workers' safety commitment; 3) workers' safety priority and risk non-acceptance; 4) safety communication, learning, and trust in co-workers' safety competence; and 5) workers' trust in the efficacy of safety systems.

Workers safety commitment

The results of questions on perception of commitment to safety by respondents and their colleagues showed that the workers valued highly joint efforts towards safety at workplaces.

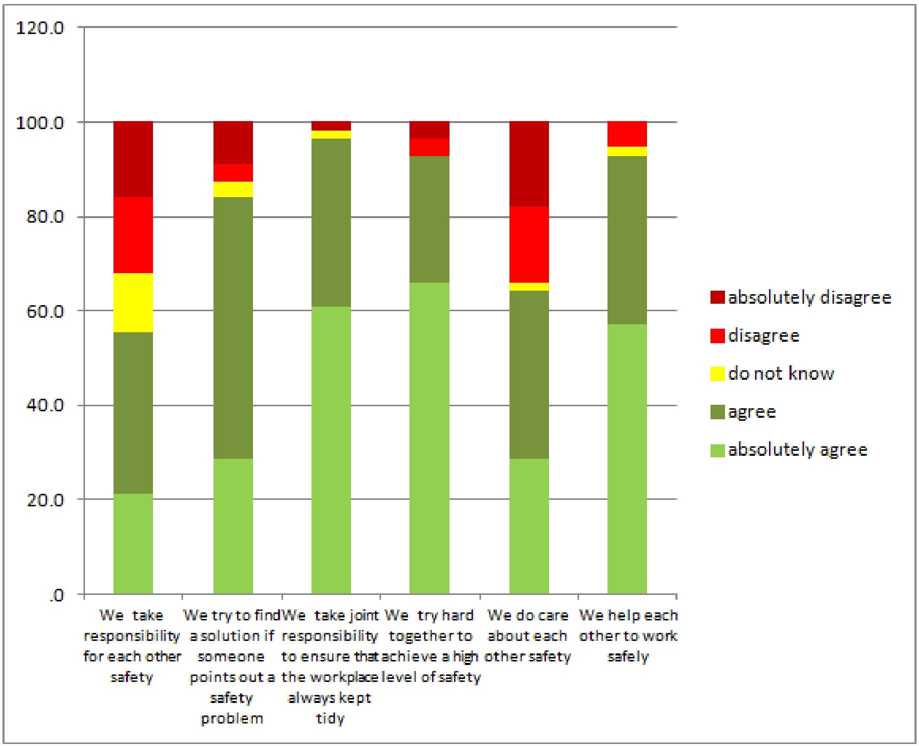


Figure 5.4 Workers' perception of their commitment to safety

Management safety empowerment

The results regarding workers' perception on their empowerment by management is rather high. About 90% workers indicated that they can influence safety and can talk openly and freely about safety. However, it is important to stress that 40% of workers accept risk taking when the work schedule is tight.

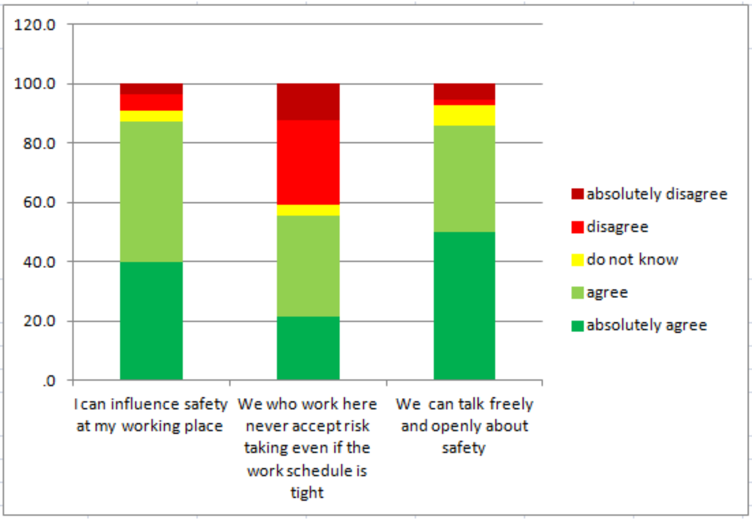


Figure 5.6 Workers perception of management safety empowerment

Workers' trust in the efficacy of safety systems

The majority of workers perceive safety inspections as a safety tool to find serious hazards, but 38% of workers do not believe that it has any effect on safety. Probably, it can be explained by that fact that 35% workers indicated that identified problems are not corrected

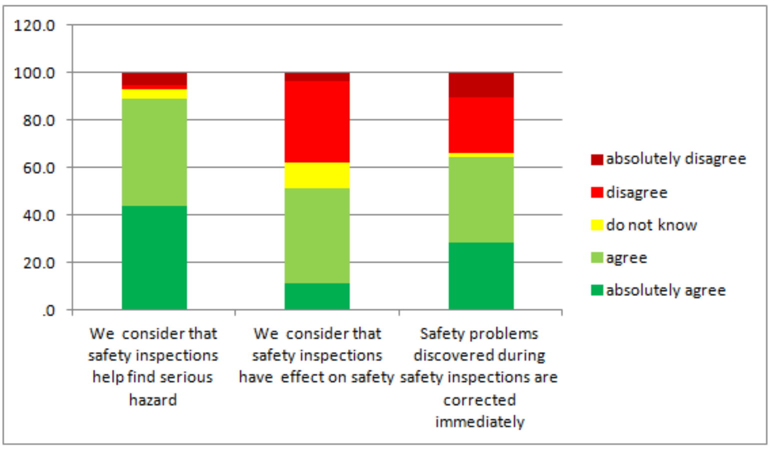


Figure 5.7 Worker's trust in efficacy of safety systems

Safety communication, learning, and trust in co-workers' safety competence

Results on competence and learning showed that almost all workers are learning from their experience and 80% workers indicated their perception of high safety competence of colleagues. The results on safety training are not congruent because 90% workers find safety training useful in accident prevention, while 30% workers perceived safety trainings as meaningless. This can be explained by wrong interpretation of questions. Workers found it difficult to fill in the questionnaire because they were not used to executing any type of paper work.

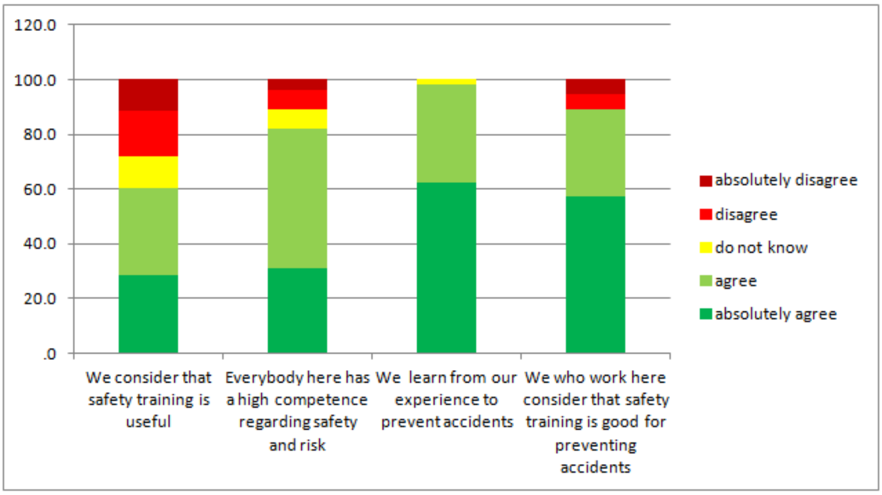


Figure 5.8 Safety communication, learning, and trust in co-workers' safety competence

To **summarise** the results of the questionnaire, it can be stated that workers demonstrated overall positive attitude to safety and cooperation in safety issues with colleagues and management. Most of workers perceive that that they have influence on safety and half of workers accept risk-taking in case of a tight production schedule.

5.1.3 HSE statistics

The review of HSE statistics provides the information on long-term effect of HSE practices executed by Contractor. Hovewer, it is worth mentioning that Tinmannsvik and Hovden (2003) found that HSE practices do not affect the injury rate directly. Injury rate according to them is directly affected by general management efforts. Management factors are studied in chapter 6, whereas in this chapter the focus of the analysis is set on overall safety performance and contribution to it from HSE activities.

It can be seen in Table 5.1 and Table 5.2 that HSE performance of Contractor is below the goal which is yearly set by The Client. Table 5.1 demonstrates that the number of LTIs per six month is growing while MTI and RWC were not reported in January-March 2012.

Table 5.1 Number of LTI, MTI and RWC reported at the project during Jan2011-March 2012

Type of event	Jan-June 2011	July-Dec 2011	Jan-March 2012
LTI	0	10	10
MTI	1	1	0
RWC	3	6	0

Table 5.2 LTI and TRI rate for 2011 and Client's goals

Indicator	Goal	Contractors	Client's personnel	Total
LTI-rate	N/A	6	0	7
TRI-rate	5	12	0	11

Figure 5.9 illustrates the increase in number of LTIs while the RUO-rate is low in comparison with the goal value. The highest LTI-rate was registered in January 2012. Despite the fact that the LTI-rate is fluctuating from July 2011 to February 2012, the increase in number of LTI can be seen. However, it cannot be fully attributed to the deficiencies of the evaluated HSE practices due to a significant role of other factors influencing safety such as inadequate planning of work by Production department, omitting safety critical procedures during execution of underground works and so on. In addition, it is important to mention that

the accidents due to falling rocks were concentrated in a period shortly before conduction of the data collection for this research. These accidents were identified by Contractor's accident investigation team as a result of skipping of rock support execution and improper transmission of safety critical information. These accidents explain a certain part of the increase in TRI-rate reflected in Figure 5.9.

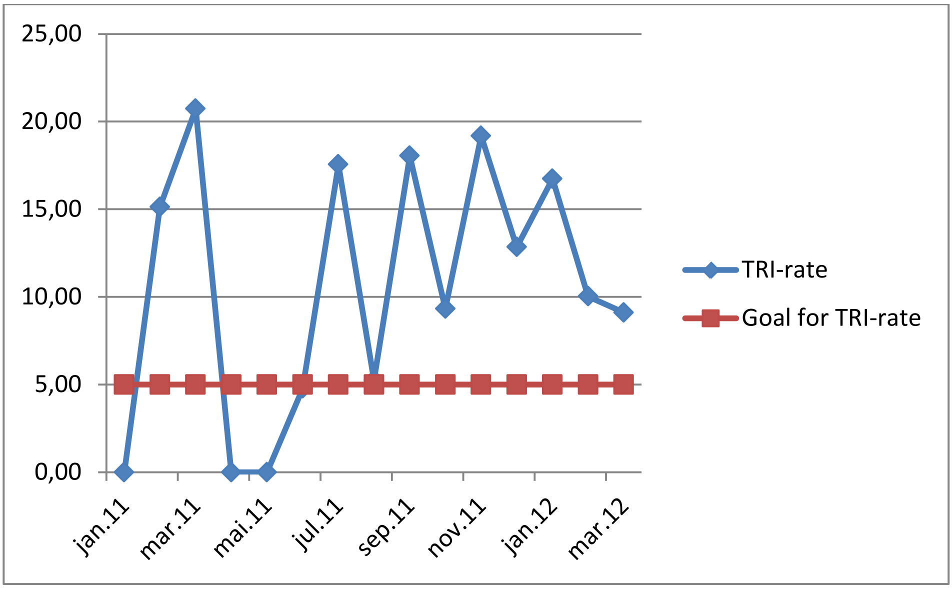


Figure 5.9 Accumulated TRI-rate

It is important to notice that some project specific challenges (See section 2.1) specific to the Project such as public road safety, moving and lifting materials and equipment and handling and storage of explosives are managed successfully by Contractor's HSE department up to the moment of data collection for this research. Therefore, it can be concluded that long-term effect of HSE activities conducted by Contractor is satisfactory, though there is a vast potential for improvement.

The summary of the analysis of HSE statistics is the following

- The long-term effect of HSE activities conducted by Contractor is satisfactory
- There is a trend of increase in TRI from July 2011 to March 2012

- LTI-rate is higher than the goal provided by the Client
- MTI and RWC have not been reported during January-March 2012

With the aim to identify contributing factors to current HSE performance, the analysis of reported incidents is performed in the next section.

5.1.4 Accident analysis

In the previous section it was identified that long-term effect of HSE activities, which is safety performance and actual compliance at site, is unsatisfactory. Therefore, it is important to understand what contributes to the growing number of accidents. Understanding of contributing factors and deviations which led to accidents facilitates identification of issues which should be mitigated with HSE activities to prevent accident reoccurrence and improve safety performance.

In order to understand nature of accidents, the analysis of distribution of incidents according to "Type of event" classification is performed. Incidents reported from January 2011 to March 2012 are analysed (Table 5.3). High potential incidents are also indicated in the table 5.11 to give an overview of their type and quantity.

Table 5.3 Distribution of incidents reported during Jan2011-March 2012

Type of incident	LTI	MTI	RWC
	Number of incidents (number of HiPo)	Number of incidents (number of HiPo)	Number of incidents (number of HiPo)
Person stepping on, striking against or struck by objects excluding falling objects	4 (2)	1	5
Person caught in or between objects	2 (1)	0	2 (1)
Person struck by falling objects	6 (3)	1	1
Falls of persons from heights	3 (1)	0	0
Falls of persons on the same level	3	0	1

Type of incident	LTI	MTI	RWC
	Number of incidents (number of HiPo)	Number of incidents (number of HiPo)	Number of incidents (number of HiPo)
Motor vehicle accident	1 (1)	0	0
Person exposed to harmful substances or radiations	1 (1)	0	0
Total	**20(9)**	**2**	**9(1)**

It can be seen in the table 5.3 that "Person struck by falling object" is the most frequent type of accidents with lost time injury. All of them happened due to fall of rock on the victim. Fifty pro cents of LTIs in this category are classified as high potential incidents, which can be interpreted in this case as it could have been a fatality. Therefore, accidents classified as person struck by falling object are analysed further to find out contributing factors and deviations. Overall, 20 reported LTI accidents are analysed.

Accident analysis is performed in order to identify contributing factors and deviations which led to loss of control and accidents subsequently. The accident model OARU (Kjellén, 2000) is used for analysis. The sequence of event and description of injury for each accident are taken from investigation reports provided by the Client.

Figure 5.10 shows the example of analysis which is performed for the accident occurred on 22 March, 2012. The sequence of event of the accident was the following: *"Mr. John Collantes wore his safety harness and climbed up the ladder by the exterior side of the inclined tile roof, he place himself on the top of the roof where there were cracks and holes. In this work conditions, he was observed by the chief of the campsite, Mr. Romel Rivera who called Mr. Collantes' attention to take the preventive measures, but Mr. Collantes continued with his work.After a few minutes of Mr. Rivera's attention call, and when Mr. Collantes was moving on the inclined roof, he step on the cracked tile, losing his balance. He tried to* *hold himself on the wooden beams of the roof, but he could not and fell over the left side of his elbow"*

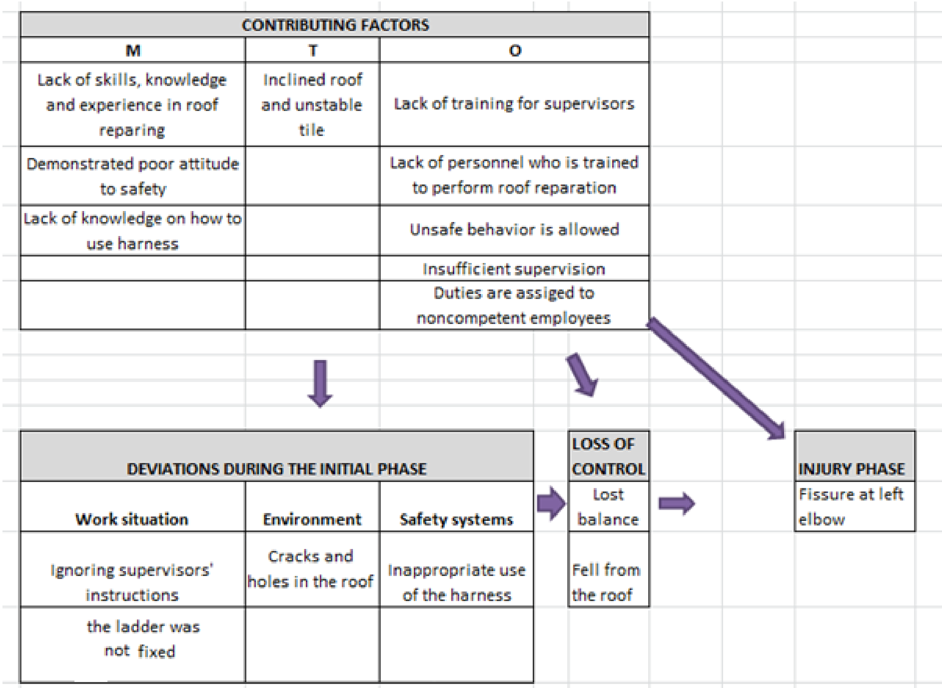


Figure 5.10 Analysis of an accident based on OARU model

It is found that some contributing factors and deviations are the same in all accidents (Figure 5.11). With regard to contributing factors it might demonstrate that the same organisational and technical factors contributed to accidents. Most of the identified contributing factors can be referred to the organisational factors and, therefore require also effort of general management of Contractor to improve the current situation. Concerning the identified deviations, they are mostly related to unsafe working methods and lack of knowledge followed by improper supervision. However, it is worth noting that analysis is based on the investigation reports and depends on quality of investigations and subsequent reporting. Furthermore, the focus of investigations can be directed on the issues which are important from investigator's point of view and consequently other issues are not reflected in the reports.

Table 5.4 **Contributing factors identified in all analysed accidents**

CONTRIBUTING FACTORS		
M	**T**	**O**
Responsibility to perform risk assessment is not taken	Signalisation of danger zone is not used	Tacit acceptance of unsafe behaviour
Responsibility to stop unsafe acts is not taken	Physical barriers are not used	Insufficient supervision
Individuals' attitude to safety is inadequate		Unsafe methods of work
Individuals' norms are		JSA is not used properly
		Information flow is not adequate
		Inadequate activity planning
		Improper training on hazard identification

Table 5.5 **Deviations identified in all analysed accidents**

DEVIATIONS DURING THE INITIAL PHASE		
Work situation	**Environment**	**Safety systems**
Work procedure is not followed	Working conditions are inadequate	PPE is not used in a proper way
Unsafe working method	General rock scaling is not performed	Danger zone is not signalized
Improper communication with supervisor/colleagues		

As it is mentioned earlier, 6 out of 20 LTIs are classified as "person struck by falling object". The identified deviations specific to accidents due *to a falling rock* are lack of the rock scaling, location of a victim in danger zone, improper use of equipment, improper illumination, and improper communication with a previous shift regarding the status of rock support.

Analysis of *motor vehicle incidents* resulted in material losses shows that contribution factors are different from other type of incidents due to different nature of working processes. The driving activities are executed by drivers being alone and therefore individual attitude to safety is even more critical due to limited possibility to control and supervise the drivers. The influence of working environment such as falling rocks, the narrow and unstable (prone to slide towards the river) road, the river crossing the road and uncontrolled local transport is determining the situation when loss of control is difficult to prevent. Therefore the control of deviations is crucial and should be executed through relevant HSE activities with support from Contractor's general management.

The summary of analysis of incidents reported from Jule 2011 to March 2012 is the following

- Most of contributing factors are related to organisational factors such as (A) inadequate planning, (B) tacit acceptance of unsafe methods of work, (C) insufficient supervision and (D) inappropriate application of risk assessment in tunnelling and surface works.
- Some of contributing factors can be eliminated only by general management and production department of Contractor especially at The Project. Therefore focus of this research will be placed on deviations and contribution factors which can be controlled and eliminated by HSE activities by HSE department of Contractor.
- The identified deviations can be generalised as following:
  - Unsafe working method
  - Inappropriate use of working equipment
  - Inappropriate use of PPE
  - Improper housekeeping

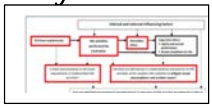
5.1.5 Summary of long-term effect of HSE activities

During analysis of HSE performance, the satisfactory long-term effect of the evaluated HSE activities was found. However, the trend of increase in TRI-rate was identified. The number of unwanted event increased during July 2011- March 2012. In addition, actual compliance at site was satisfactory but there were the cases of noncompliance which might be corrected with HSE activities and general management support in assigning HSE responsibility to supervisors and foremen and demonstrating real commitment to HSE at the Project. The questionnaire showed a positive attitude of workers to safety but 40% workers are ready to risk taking in case of a tight production schedule. Therefore, it can be concluded that long-term effect of HSE activities performed by Contractors has a potential for improvement. Table 5.6 reflects a summary of section 5.1. The information in the table is used in the section 5.1 to understand if a functional potential of HSE activities is used fully to eliminate the deviations illustrated in the table

Table 5.6 Summary of analysis of long-term effects

Actual compliance at site		
Use of PPE	**Safe behaviour**	**Housekeeping**
Goggles are not used where it is required	Long-sleeved uniform is not used where it is required	Improper illumination of working face
Gloves are not used where it is required	Walking under hanging load	Distance between working face and ventilation duct is more than 50m
Long-sleeved uniform is not used where it is required		Water on the ground
		Danger zone is not fenced
Deviations		
Safety system	**Work situation**	**Environment**
PPE is not used	Low hazard awareness	Insufficient lighting, ventilation
Danger zone is not signalised	Usafe working method	Unstable environment (ground, rock massif)
	Inattention to hazards	

5.2 Evaluation of HSE activities performed by Contractor



In order to resolve tasks and execute selected method, the evaluation of HSE activities is performed in this section. The activities selected for analysis is safety inspections, Job Safety Analysis and RUO reporting. The analysis is conducted to understand, internal and external HSE requirements and compliance of performed activities to them. The feedback control taken after execution of HSE activities is analysed in order to evaluate immediate effect. The use of full potential of activities to eliminate deviations and contributing factors identified in section 5.1 is reviewed to evaluate the quality of activities and their immediate effect.

5.2.1 Safety inspections and follow-up

Client's requirements

The Client has a requirement in the contract specification stating that Contractor has to conduct weekly HSE inspections and follow up. Safety inspections constitute one of diagnostic processes in HSE management what is also reflected in OHSAS 18001:2007. Three types of inspections are hold at The Project: daily inspections, weekly inspections and inspections which are performed once per half of a year.

Implementation of safety inspections

The resources which are currently used by Contractor to conduct HSE inspections are reviewed based on MTO model (Table 5.7).

Table 5.7 Review of resources used for daily safety inspections by Principle Contractor

MTO category	Daily inspections	Weekly inspections	Inspections held once per 6 months
Personnel	Performed by Contractor HSE inspectors. They are trained to identify hazards and implement proper remedial actions.	Performed by the group of representatives of management from Contractor, the Engineer and The Client. Trained on inspection routines HSE manager of Contractor is always present. Other participants are not	Performed by SHE inspectors of Contractor. Contractor's inspectors are trained to identify hazards and implement proper remedial actions.

		trained to perform HSE inspections but they have many years of experience in different construction related fields.	
Instruments and tools	HSE inspectors are facilitated with equipment required for inspections. HSE inspectors do not use a checklist for this type of inspections. The protocol form is filled during each inspection. All protocols include: • Information on place, date, responsible employees, day/night shift and phase of work • Description of deviations and deficiencies found during inspection • Corrective actions with information on urgency, responsible people and status • Observations of nonconformities	Neither checklist no protocols are used during weekly inspections. Identified deviations are corrected immediately or discussed later on, during weekly HSE meetings. No tools are used.	A detailed checklist with 123 items is used during this type of inspection. The themes which are covered during the inspection are the following: • Organization of accident prevention • General conditions of work • Fencing and signalization • Electrical installations and temporary works • Auxiliary resources • Moving machinery • Workshop, plants and laboratory
Organization and procedures	The information from the protocols is transferred to HSE information system run by Contractor. In addition, this information is registered in *Action follow up* document used to control execution of corrective actions. HSE department of the Client receives the Action follow up document monthly from Contractor. This allows the Client to follow up the results of HSE	There is no written procedure at the project on how weekly inspections should be executed. Place of the inspection is decided one hour before an inspection is supposed to be performed.	Contractor has a written procedure on how this type of inspections should be performed. The inspections are planned by HSE department in Contractor. The inspection takes several days for execution.

	inspections hold by Contractor. HSE department of Contractor has an HSE plan for daily inspections. Responsible HSE inspectors and a place of the inspection are indicated in the plan.		

The results of the evaluation of HSE practice - weekly safety inspection - are presented in the Table 5.8. The first column shows Client's requirements which are provided to Contractor in the contract specification. The second column demonstrates the practices which should be taken by contractors in order to satisfy Client's requirements. These practices are used as criteria for evaluation of *daily* HSE inspections performed by Contractor. Results of the evaluation are presented in the third column. The fourth column reflects the information on immediate explicit effect of analysed HSE inspections. In order to ensure a comprehensive analysis through triangulation process, the information was collected from three different sources: (A) interviews with Contractor's employees, (B) review of the inspection protocols and (C) analysis of "Action follow up" document.

Table 5.8 Evaluation of daily inspections conducted by Principle Contractor

Client's requirements	Actions to satisfy Client's's requirements	HSE practices performed by Contractor	Immediate effect
HSE inspection plan with • *Frequency* of regular inspections (should be weekly) • *Participants* (should be scheduled for line management and workers representative)	Adequate expected standards (criteria) are provided to inspectors Inspectors have the plan for inspection Themes for inspections are defined	No deviation HSE inspectors do not use checklists	Observed safety related problems eliminated immediately or registered. Not all remedial actions have been implemented
Theme-specific checklists for inspections and focus	There is limited number of themes to be checked	Themes for inspections are not defined	Implemented remedial actions do not have

Follow-up according to OHSAS 18001:2007	during one inspection (it should be not more than 9)		adequate coverage and quality. The majority of remedial actions are corrective.
	Checklist items are possible to observe or assess		
	Inspectors follow the plan and know what to look for		
	Inspectors keep an open mind during inspections	No deviation	
	All site areas are covered	Not all site areas are covered	
	Findings from inspections are registered in inspection protocols in an adequate reliable manner	No deviation	
	Actions are proposed based on the findings	No deviation	
	Actions are adequate, feasible and comprehensive	Actions are only corrective, no preventive actions are proposed	
	Remedial actions are planned and initiated with the deadlines specified for each action	No deviation	
	Responsible people are assigned for taking remedial actions	Responsibility is not assigned to a particular person. Sometimes responsibility is assigned to production or quality management department	
	Responsible people are informed about their responsibility		

As stated by HSE manager of Contractor, HSE department has a plan for HSE inspections. Contractor fulfils the requirements of the Client regarding planning and regular execution of inspections. With regards to participants, Contractor does not involve workers into any type of inspections hold by Contractor. The theme specific checklist is used only once per 6 month. It contains 123 items so that it takes several days to cover all of them. Both available to the author inspection protocols and Action follow up documents are lacking the assignment of responsibility for remedial actions to a particular person.

Immediate effect of safety inspections

More than 35% of remedial actions are aimed at the correction of identified deviations such as “perform housekeeping” in case of identification of solid waste in the tunnels (Figure 5.9). Analysing the expected effect from the remedial actions, it can be found that a significant number of proposed changes assume altering of working methods at the department level and higher. This is correspondent to 1st and 2nd level of the hierarchy of Van Court Hare (Figure 5.12). It means that in case of successful implementation, a positive long-lasting effect from these remedial actions can be expected (Van Court Hare in Kjellén, 2000). According to Action follow up document, 40 deviations have been found during daily inspections during January 2012. Twenty two of them were related to housekeeping. As it can be seen in the Figure 5.13, the responsibility to correct 45% of all findings was assigned to HSE department. Taking into account that 55% of findings are related to housekeeping, it is not adequate to assign the major responsibility to HSE department. In this case Contractor’s personnel will get the message that HSE issues are under control of only HSE department, and cannot be influenced by Production department in general and by workers in particular.

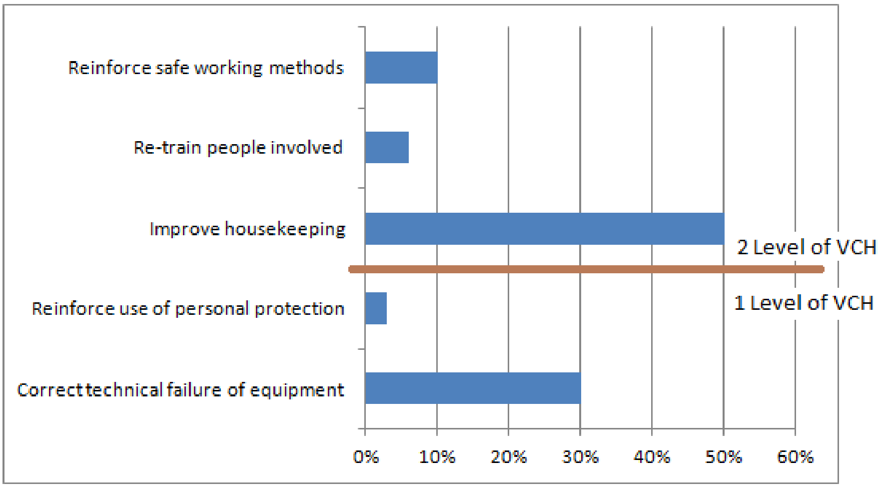


Figure 5.11 Classification of remedial actions taken to correct issues identified during daily inspections during February 2012

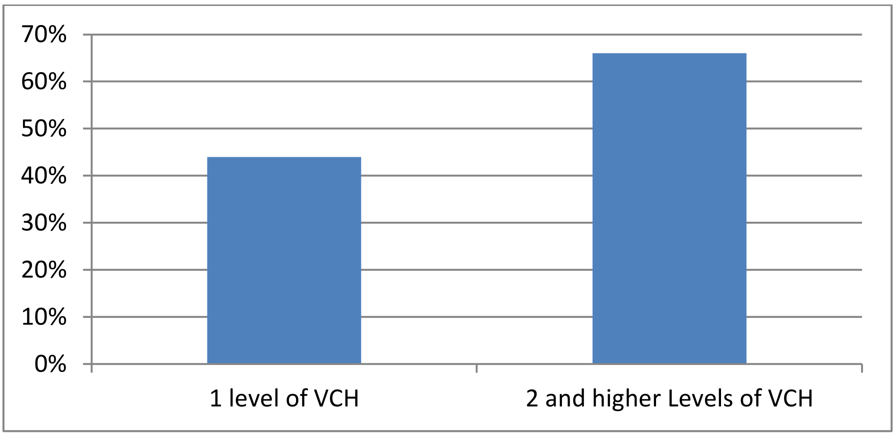


Figure 5.12 Classification of remedial actions according to Van Court Hare theory

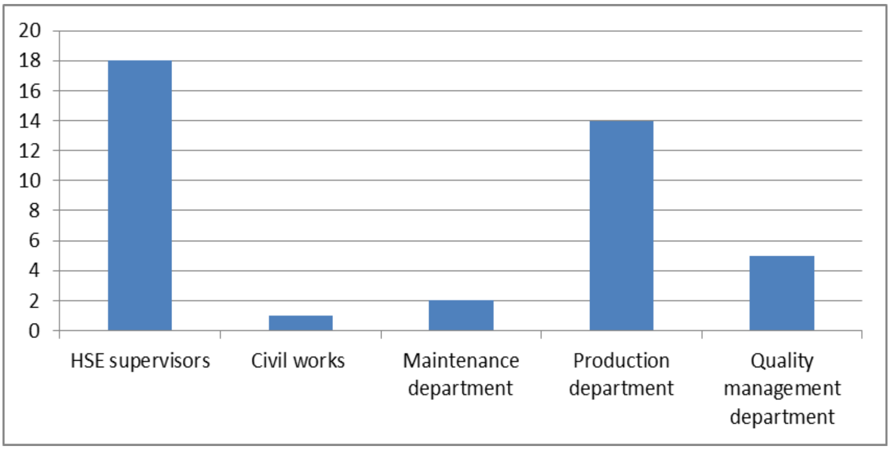


Figure 5.13 Distribution of responsibility for remedial actions recommended after daily safety inspections during February 2012

Table 5.9 Example of Action follow up document for daily safety inspections

ITEM	N°	OBSERVATION	CORRECTIVE MEASURE	RISK LEVEL	DATE	RESPONSIBLE	FULFILLMENT
30.01.2012 CHECRAS TRANSFER TUNNEL	13	Existence of areas with slope inside the tunnel	Perform maintenance access tunnel due to slopes	LOW	05.02.2012	Production Department	DONE
		Solid waste in the tunnel	Perform housekeeping before commencement of work	LOW	01.02.2012	Production Department	DONE
		Lighting inside the tunnel, poor	Coordinate with production tentative schedule	MEDIUM	05.02.2012	Production Department	ON GOING
31.01.2012 CHECRAS PLATAFORMA 1	14	Accumulation of solid waste in the back of the bathroom	perform housekeepingof the area	LOW	02.02.2012	Production Department	ON GOING
		Fire extinguishers have not been inspected since October	inspect fire extinguishers	LOW	03.02.2012	HSE Supervisor	DONE
		Steel cutting equipment is lacking maintenance	servicing the equipment fabricated steel	MEDIUM	05.02.2012	Maintenance Department	ON GOING
		Wood stored with open nails	move the timber to a good, free movement of people	LOW	05.02.201	Civil works	ON GOING
		cylinders with residual oil without support or trays	implement waterproof base	LOW	02.02.2012	Maintenance Department	ON GOING
31.01.2012 CHECRAS HEADRACE TUNNEL	15	Misuse of emergency station	provide a suitable place for staff to leave any personal item	LOW	02.02.2012	HSE Supervisor	ON GOING
		PPE's hanging on the lift inside the tunnel	verbal warning to workers who need to stop committing PPEs, and feedback in hse	LOW	02.02.2012	HSE Supervisor	ON GOING
31.01.2012 CHECRAS TRANSFER TUNNEL	16	the emergency telephone is not signalized in the tunnel	Indicate the telephone	LOW	02.02.2012	HSE Supervisor	DONE
01.02.2012 ACCESS TUNNEL	17	The staff re-entered the tunnel after the explosion in the truck chassis when the tunnel was 50 ppm in full co ventilation	Meet waiting time programmed to ventilate the tunnel after the uneven, fulfilling the procedure	HIGH	02.02.2012	Production Department	PENDING
		c9r-840 the truck entered the tunnel in times of evacuation and the transit of equipment	Do not enter the tunnel at the time of disposal and whether the parking is unavoidable, do so in the niches	HIGH	02.02.2012	Production Department	PENDING

The use of full potential of activities to eliminate deviations and contributing factors identified in section 5.1 is reviewed to evaluate the quality of activities and their immediate effect.

It can be seen that safety inspection are aimed only at housekeeping and use of PPE. This limitation of focus can be partially explained by the limitations of safety inspections. The important deviation which might be identified with safety inspections is deficient rock support. However, it requires expert knowledge on technologies in tunnelling.

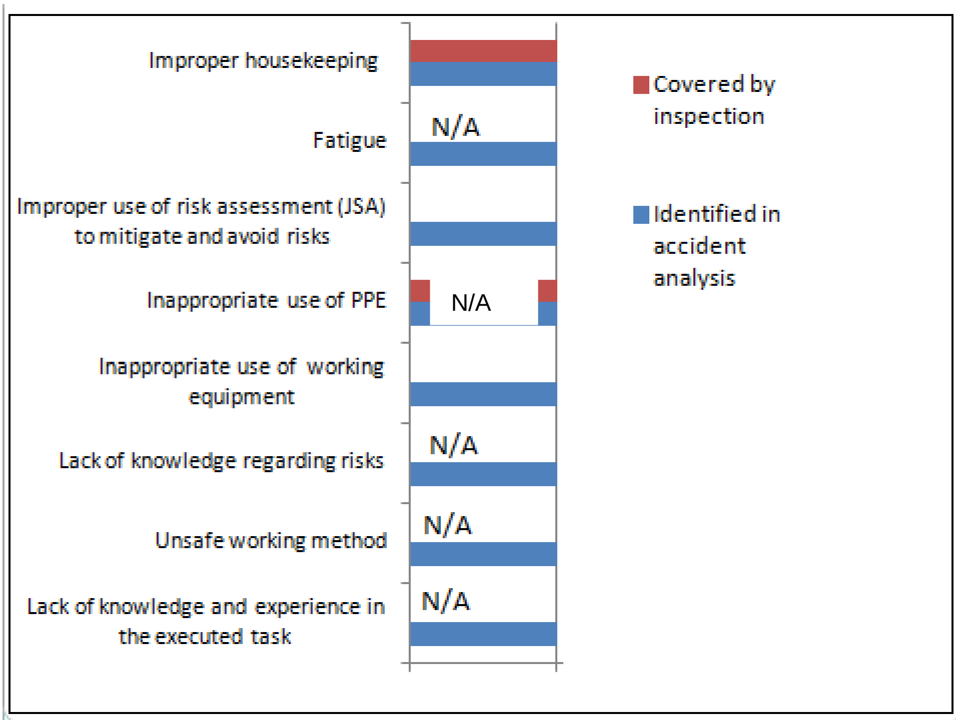


Figure 5.14 Adequacy of implementation of safety inspections regarding accident prevention

Summary of results for Safety inspections

Developed and implemented by Contractor safety inspections fulfil all requirements of the Client to HSE inspections excluding use of a theme-specific check list. The inspections diagnose technical deviations at workplaces related mainly to housekeeping and use of PPE, while the quality of rock support is not inspected. The control measures proposed during inspections are of high quality and a positive long-lasting effect on safety can be expected but it requires support of Contractor's general management. Therefore, it can be concluded that safety inspections achieve some positive effects, but the full potential are not realised yet.

5.2.2 Job Safety Analysis (JSA)

Client's requirements

The Client has a requirement to contractors to perform regular risk assessment and follow up of identified risks. Risk assessment constitutes one of diagnostic processes in HSE management. Job Safety Analysis is mentioned as a tool to perform risk assessment in the contract specification.

Implementation of JSA

The description of JSA performed by Contractor's personnel is presented in table 5.10 with the help of MTO model.

Table 5.10 Review of resources used by Contractor for JSA

MTO category	Description
Man	Risk assessment is performed by supervisors during each shift. Supervisors are trained on how to use Risk Assessment form. Workers also receive instructions on how to perform Risk Assessment, but they find the form complicated.
Technology	Contractor has three types of forms which are used to perform risk assessment. The forms have been developed for surface works, maintenance works and works in tunnels. All types of forms contain a risk matrix, fields for date, time, area and sequence of work. Different checklists are provided in the forms depending on the place of work.
Organization	The information about a written procedure for JSA or other types of risk assessment is not available. The instruction on how to fill in the JSA form is announced to workers at toolbox meetings by HSE manager of Contractor. Job Safety Analysis is performed by supervisors daily and the content of JSA is the same from day to day for the same group of workers.

JSA routines conducted by Contractor were evaluated using the same approach which was used for evaluation of safety inspections practiced by Contractor. The results of the evaluation are shown in the table 5.11.

In this case the information was collected from three different sources to ensure triangulation: (A) interviews with Contractor's employees, (B) review of JSA protocols and (C) observation of the process of execution of JSA by Contractor supervisors.

Table 5.11. Evaluation of JSA performed by Contractor's employees

Client's requirement	Actions needed to satisfy Client's requirements	HSE practices performed by Contractor	Immediate effect
Critical operations are identified, analysed, evaluated and documented by using JSA Adequate control measures are taken Results of JSA should be implemented in relevant job procedures	Contractors have a written procedure for JSA ---------------------------- Contractors have criteria to decide whether JSA is required or not for the particular operation -------------------------- Contractors have a plan for JSA with establishment of analysis teams ------------------------- Contractors have a proper method including check list of hazards --------------------------- Contractors perform JSA before each new operation and for new equipment --------------------------- All steps of the job are considered in details in each JSA ------------------------- The review of hazards is adequate. All are hazards covered. All types, causes, consequences and risks of each hazard are identified ---------------------- Risk reducing measures are identified ----------------------- The quality of the measures is adequate. ------------------------ JSA is conducted ------------------------ Contractors hold group meetings for execution of JSA --------------------------- All hazards are identified and documented. The description is adequately detailed to reflect the actual hazards in the job. As	No information --------------------------- CONTRACTOR does not have a criteria for execution of JSA CONTRACTOR does not have a plan for execution of JSA ----------------------------- CONTRACTOR has a protocol for JSA containing a check list of hazards ----------------------------- The supervisors perform JSA during each shift ----------------------------- All works which are executed during one shift are considered in one protocol of JSA -------------------------- Hazards in the checklist are general. Causes and consequences are not identified ---------------------------- No deviation ---------------------------- The quality of measures is not always adequate -------------------------- No deviation ---------------------------- JSA is done by a shift supervisor -------------------------- Only items of the checklist are used, no extra hazards are	Most of control measures are implemented Implemented risk reducing measures do not have adequate coverage and quality Workers and supervisors adhered to some measures in practice, especially in the presence of HSE representativ es

	opposed to "generic hazards"! ---------------------------- Causes are analysed ------------------------ Risk is assessed ---------------------- Analysts propose risk reducing measures based on JSA ------------------------------- There are deadlines for execution of risk reducing measures ------------------------------ Risk reducing measures are adequate, feasible and comprehensive ----------------------------- Responsible people are assigned for taking risk reducing measures ---------------------------- Responsible people are informed about that	identified -------------------------- Causes are not analysed --------------------------- No deviation --------------------------- No deviation ---------------------------- There are no deadlines for execution of risk reducing measures ---------------------------- Risk reducing measures are not comprehensive ------------------------------- People are not assigned for taking risk reducing measures ------------------------------ People are not assigned	

The evaluation of JSA routines conducted by Contractor's personnel demonstrates that Client's requirements to risk assessment are not fulfilled by Contractor. Instead of identification of critical operations and splitting jobs into tasks, Contractor's supervisors perform risk assessment for all works they execute during following JSA 12 hours. The form for JSA is drawn up in the way that it has one field for the description of all works and a checklist of general hazards. Therefore, risk assessment is limited to examination of hazards provided in the checklist. The hazards are general such as "lack of cleanliness", "inadequate use of PPE", "work at height", "inadequate signalling" and so on. This does not facilitate an analyst with possibilities to review all hazards specific to each particular task which is planned.

Immediate effect of JSA

The absence of a proper procedure for risk assessment leads to the fact that not all relevant risks are documented and analysed. This affects the quality and variety of risk reducing measures what is important for accident prevention. Therefore, Client's requirement to control measures taken after risk assessment is not fulfilled. All control measures which were proposed in the available documentation of JSA are aimed at protection of a victim with PPE and improvement in housekeeping. Moreover, the identified hazards and risk reducing measures are the same in all available to the author JSA protocols. Daily execution of JSA in a combination with insufficient forms and lack of training on hazard identification caused that Contractor's employees perceive JSA as a meaningless but necessary routine. With such approach to JSA it is impossible to fulfil the requirement of stating that "results of JSA should be implemented in relevant job procedures".

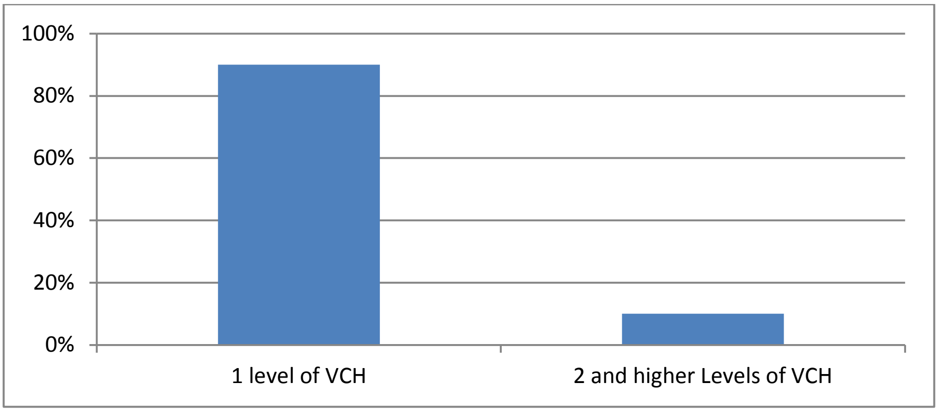


Figure 5.15 Classification of remedial actions recommended after JSA performed during February 2012

Analysis performed to find out if the executed at site JSA has adequate quality to mitigate identified in section 5.1 deviations gave an unsatisfactory result. It was found that the check list in JSA protocols cover most of the deviations which should be eliminated to avoid reoccurrence of accidents, but proposed during JSA remedial actions are not sufficient for the elimination.

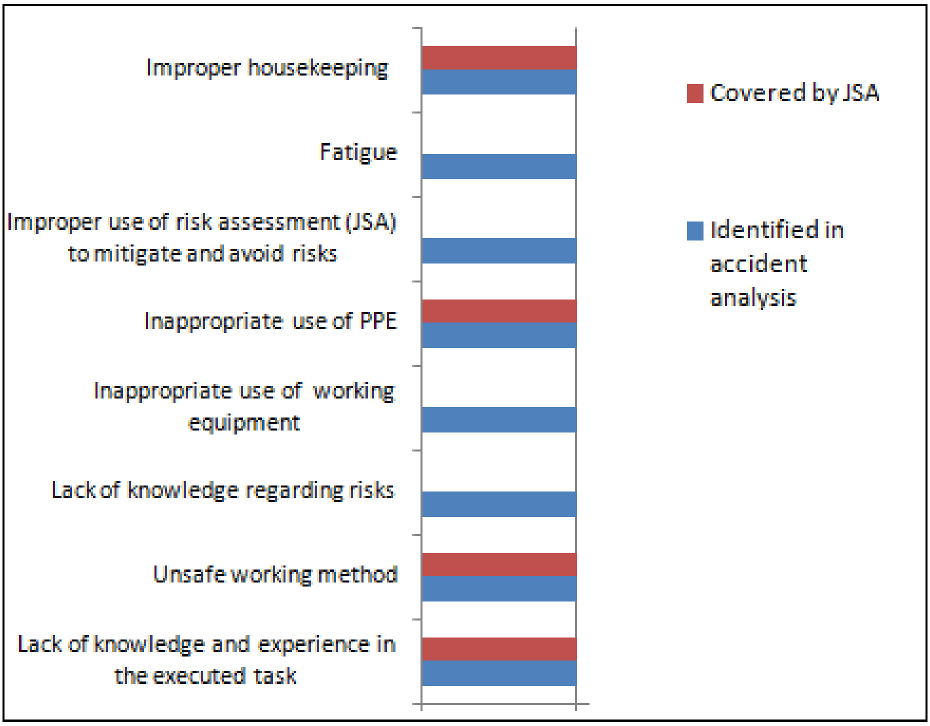


Figure 5.16 Adequacy of implementation of JSA to prevent reoccurrence of accidents

Summary of results for JSA

It can be concluded that requirements of the Client to risk assessment are not fulfilled. In additions, JSA routines are implemented in the way that workers do not participate in risk assessment and perceive JSA as a bureaucratic procedure developed just to satisfy requirements of management. Control measures proposed during JSA are aimed at protection of the workers instead of eliminating sources of risks and using proper barriers. The checklist used in JSA covers most of deviations identified in section 5.1 but improper implementation and practice of JSA hinders realisation of its full potential.

5.2.3 RUO reporting

Client's requirements

RUO reporting is used by the Client to involve all personnel at the project in HSE processes and to obtain HSE related information from the sharp end of the construction process. According to the contract specification Contractor is expected to facilitate and promote RUO reporting at The Project.

Implementation of RUO reporting

The resources used by Contractor to achieve it are reviewed in table 5.12

Table 5.12 Review of resources used by Contractor for RUO reporting

MTO category	Description
Man	HSE manager of Contractor participates in toolbox meetings weekly and provides oral instructions on RUO reporting. All personnel of Contractor and Engineer are trained on use of RUO forms. Not all employees of The Client are instructed regarding RUO reporting routine.
Technology	Contractor developed a form for RUO reporting. The forms are available at the offices of Contractor supervisors and Engineer HSE inspector. The form for RUO reporting contains a checklist with general issues such as excavation, PPE, signalisation, works at height, transportation of people, ventilation, illumination and so on. There are also fields for giving the information about a reporter and nonconformity.
Organization	Contractor implemented the rule which holds that a reporter gets a sticker on his/her helmet every time when he/she reports. The sticker grants the right to participate in a lottery organized by HSE department of Contractor. During the lottery any reporter can win a backpack, a pen or a cap. The lottery is held once per month.

The results of the evaluation of RUO routines practiced by Contractor are shown in the table 5.13. In this case the information was collected from three different sources to ensure triangulation: (A) interviews with Contractor's employees, (B) review of RUO reports and (C) analysis of Action follow up documents.

Table 5.13 Evaluation of RUO reporting practiced by Contractor

Client's requirement	Actions needed to satisfy Client's requirements	HSE practices performed by Contractor	Immediate effect
As a part of monthly progress reporting RUO rate in construction	Contractors have a procedure for RUO incl near accident reporting ---------------------------	No data --------------------------	RUO reporting on site is not reliable. RUO-rate is 0.48 while RUO-rate goal is more than 1

activities last month and since start of the construction works Goal for RUO-rate is provided by Employer	Responsibility for RUO reporting is clear for all personnel at site --------------------------- Criteria for RUO reporting are clear -------------------------- Reporting routine is understandable and simple ------------------------- Contractor takes initiatives to promote a positive reporting culture ---------------------------- Employees know to whom reports should be submitted --------------------------- There are incentives for reporting	No deviation --------------------------- There is no clear criterion --------------------------- No deviation --------------------------- No deviation ---------------------------- No deviation ---------------------------- No deviation	RUO is reported by personnel who are not responsible for HSE Remedial actions are proposed for the most of reported issues There are deadlines for execution of all remedial actions which are registered in Action follow up document Remedial actions are not adequate and comprehensive but feasible People are not assigned for taking remedial actions. Responsibility is assigned to departments. A significant number of remedial actions have not been implemented Implemented remedial actions do not have adequate coverage and quality Important findings communicated to the personnel

			Personnel at site understand the benefits of RUO reporting

Evaluation of RUO reporting routines, monthly HSE reports and interviews with Contractor workers gives evidence that CHH fulfils Client's requirement regarding implementation of RUO reporting routines. However, the goal value for RUO-rate set by the Client has not been reached in 2011 by Contractor.

Immediate effect of RUO reporting

It is important to stress that there is no clear criterion for reporting. Contractor uses RUO reporting as a tool to increase workers' hazard awareness and concentration on possible risks. However, the possibility to use RUO reports as a source of information for the accident control or possibility to create workers' feeling of ownership in safety is not taken. Employees are motivated to report with a help of a lottery which is held among reporters every month. At the same time some Contractor's workers claimed that their reports had not been followed up.

The majority of remedial actions planned to respond to RUO reports involve changes of work methods and reinforcement of safe behaviour. This can lead to a long-lasting positive effect on HSE performance at the Project according to Van Court Hare theory (Van Court Hare in Kjellén, 2000). Figures 5.17 and 5.18 illustrate the level of remedial actions in Van Court Hare hierarchy of measures and the main focus of measures.

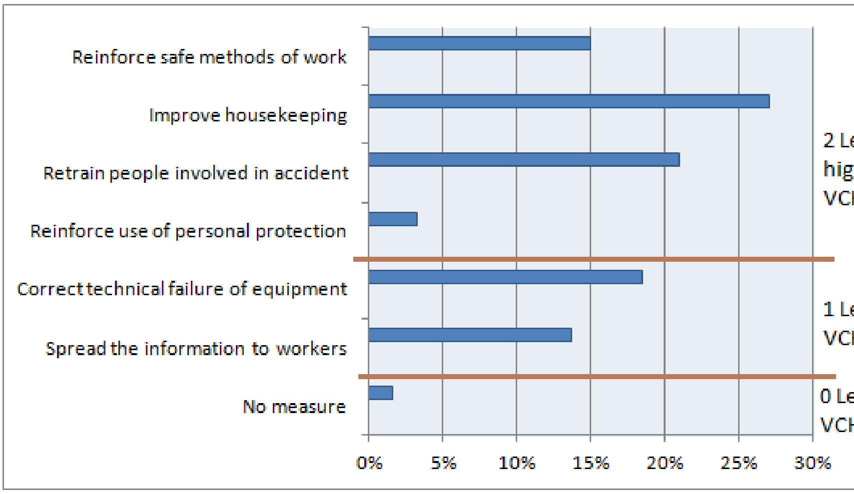


Figure 5.17 Percentage of measures proposed as a response to issues reported in January 2012

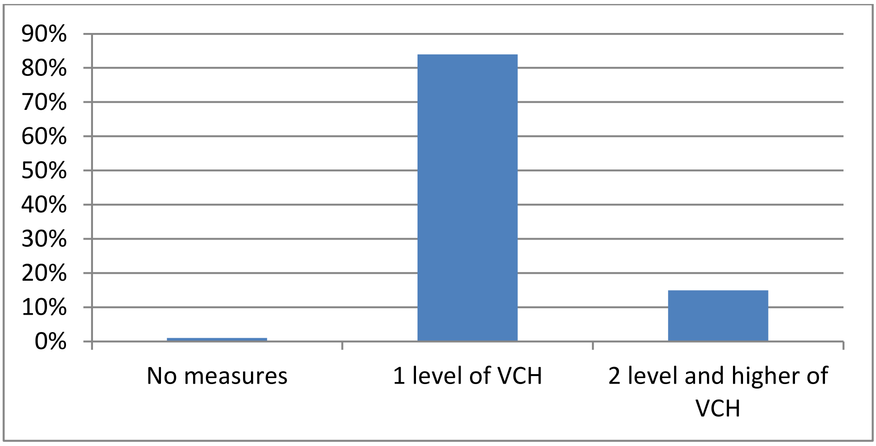


Figure 5.18. Evaluation of measures taken after RUO reporting according to Van Court Hare

The analysis of implementation of measures proposed for reported issues in January 2012 shows that 67% measures have been executed at the same month by Contractor's HSE department. It can be concluded that with regards to RUO reporting, Contractor fulfils Client's requirements but the potential for improvement is still significant and requires involvement of Contractor's Production department in management of HSE issues.

The topics of RUO reports reported from January to March 2012 are analysed to find out if RUO reports provide the information related to deviations identified in section 5.1.

Figure 5.19 shows that RUO reports provide information on unsafe acts and improper use of working equipment which are not covered by safety inspections due to their functional limitations. Therefore this source of information should be used more effectively.

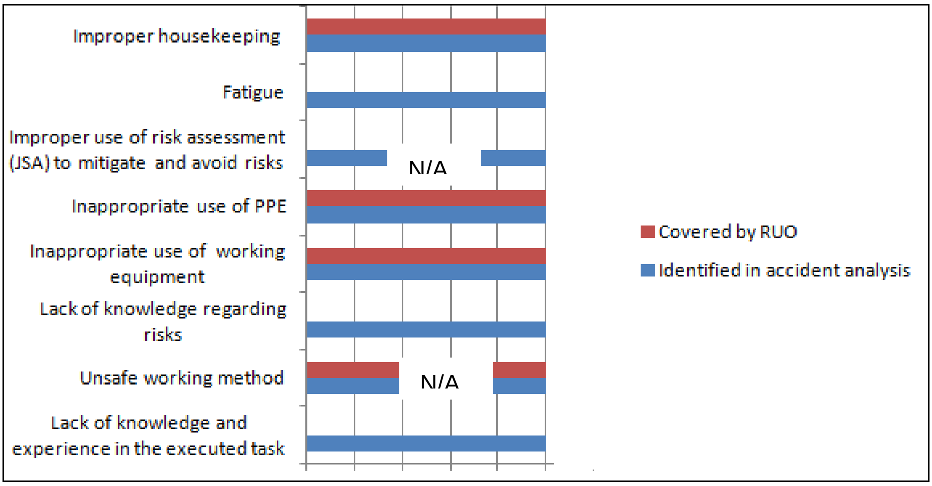


Figure 5.19 Adequacy of implement N/A JSA to prevent reoccurrence of accidents

Summary of results for analysis of RUO reporting

RUO reporting routines are developed and implemented according to Client's requirements. Contractor's employees are motivated by a lottery to report. Reported issues are limited by a checklist provided in a RUO form. Proposed corrective actions can be evaluated as sufficient with a potential for a positive long-term effect but "Pending" status of 33% planned measures decreases the effectiveness of RUO reporting and make reporters feel unappreciated. It is important to mention that RUO reports provide the information on deviations identified in section 5.1 which are difficult to identify during safety inspections due to their limitations and lack of inspectors' knowledge on technology. Inspectors are not required to have that type of knowledge, but HSE department can use the information reported with RUO reports properly in an efficient way but that requires support from Production department.

5.3 *Summary of the evaluation of HSE activities*

Table 5.14 Summary of evaluation of HSE activities performed by Contractor at the Project

HSE activity	**Implementation**	**Immediate effect**	**Long-term effect**
Safety inspections	Client's requirements are met. The majority of requirements based on the best industry practices are met. Focused on technical deviations but have a potential to include a check of quality of rock support.	Control measures are of good quality but some are pending for execution. Potential to prevent reoccurrence is fully used.	Actual compliance at site is satisfactory, but some deviations are identified and require Contractor's general management support for elimination. There is a trend showing the growth in injury rate. Safety culture at the project is good and reflected in positive attitude of workers to safety. However, a significant
JSA	None of SN Power requirements are met. Implementation and execution are not adequate according to the best industry practices.	Control measures are of not high quality. Potential to prevent accident reoccurrence is not used	

RUO reporting	Client's requirements are met. Workers are stimulated properly to report.	Immediate effect is positive since workers are involved in safety issues. Potential to prevent accident reoccurrence is not fully used due to pending of execution of planned remedial actions	proportion of workers showed the readiness to risk taking when a production schedule is tight

Due to limitations of safety inspections, JSA and RUO reporting should be used more effectively because it will ensure the involvement of workers who work at sharp end of the organisation and have more knowledge to identify deviations at working place. However, it is also important to provide proper safety and professional trainings to workers and supervisors.

It can be recommended that information about how to avoid deviations identified in section 5.1 will be included in safety inductions. Especially important to inform new workers about rock support issues and transportation related problems. In-house safety rules should also reflect the identified deviations and incentives scheme should support the enforcement of compliance. All these HSE activities would complement evaluated in this research safety inspections, JSA and RUO reporting to compensate their functional limitations and weaknesses in implementation.

Summary of the evaluation of HSE activities is used further in analysis of factors influencing safety performance and for discussion about how implementation of the activities impacts their overall immediate and long term effect. The identified deviations are used to develop suggestions for improvement of HSE activities, contract requirements and follow up.

6. Factors influencing safety performance

The analysis in Chapter 5 showed that the quality and coverage of JSA's and RUO reports partly, and safety inspections fully, satisfy Client's requirements. It was also found that safety inspections and RUO reporting routines have been implemented according to the best industry practices in construction safety; however some functional possibilities provided by RUO reporting are not fully used to prevent reoccurrence of accidents at the Project (See Chapter 5). The analysis in Chapter 5 also demonstrated that a functional potential of JSA is not used effectively due to inadequate implementation of JSA routines.

The factors which may have influence on the obtained results are considered in this section. The review is done to understand which influencing factors that have significant effect on studied HSE activities and safety subsequently. The review is performed based on the model which is shown in Picture 6.1. Understanding the influencing factors will facilitate improvement of the current HSE activities and provide vital information for development of new safety related initiatives.

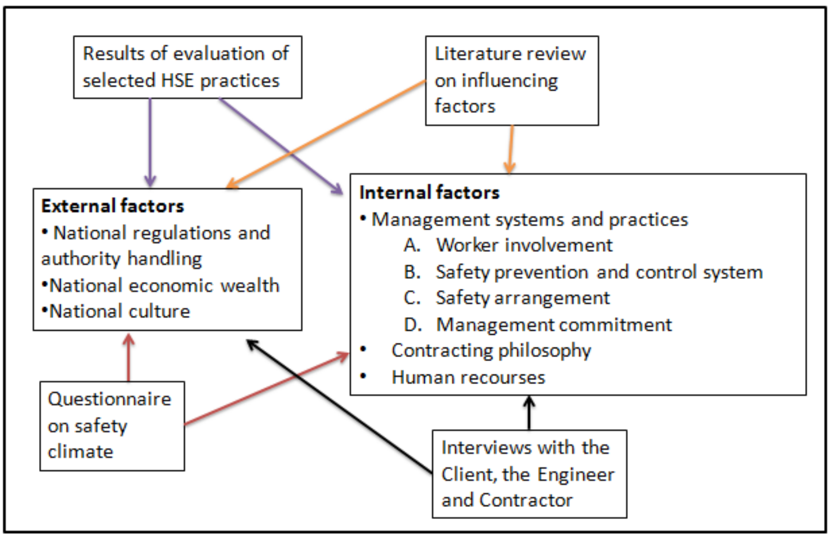


Figure 6.1 Method for analysis of factors influencing safety

6.1 External factors

In this section the analysis is carried out with focus on the factors existing on international and national levels and is affecting safety performance and implementation of HSE practices in projects.

6.1.1 National regulation and authority handling

The contractor's HSE manager claimed that safety related governmental regulations in Peru are as strict and comprehensive as in Spain, but they do not provide any detailed requirements. In addition, Peruvian HSE regulations do not include requirements to fire protection, machine guarding, air quality, personal protective devices, electric hazards, lifting appliances, excavation and tunnelling work, scaffolding, explosives handling and welfare facilities (Supreme Decree No. 007-2007-TR,2007; Standard G.050, 2009; Ministerial Resolution No. 148-2007-TR, 2007; Supreme Decree No. 009-2005-TR, 2005)

Moreover, the proper follow up of the regulations is not arranged by the governmental institutions due to lack of human and financial resources (European committee, 2007). This means that regulations are not enforced well enough to be implemented properly in companies. Labour inspections conducted by government inspectors are infrequent and ineffective (European committee, 2007).

The situation with the compliance to regulatory requirements is satisfactory in the Project because the Contractor is obliged to follow the Performance standard of the project financial lender, the International Finance Corporation (IFC) and the contract requirements from the Client which are stricter than the governmental regulations, as it was found during the interview with the HSE manager of Contractor. Client's HSE manager confirmed that the Project is audited regularly by the Client and IFC to check on compliance to IFC's performance standards and the Client's HSE requirements.

As a conclusion it can be stated that the governmental regulations for occupational health and safety are superficial and their follow-up by the Peruvian authorities is not efficient. The safety in the Project is however not affected by the absence of comprehensive governmental regulations because the Project focuses on the contractual and IFC requirements that are stricter than the national regulations.

6.1.2 National economic wealth

As it was described in the Theory chapter above, the economic situation in Peru is improving with the passage of time, but non-coastal areas are still suffering from extreme poverty. The Project is located in the Andes area and has to interact with local communities. Despite the fact that execution of the Projects is carried out based on loan from IFC and does not involve Peruvian investments, the Project is affected by the economic situation in Peru. For example, according to the results of the interview with the construction manager and the HSE manager of Contractor, they have to cope with a high turnover of employees, low level of their education, long working shifts typical for Peru and logistical problems. Most of workers involved in the Project started their working life when they were children due to financial problems of their families and therefore they did not have an opportunity to obtain professional education (Van den Berge, 2009).

In their paper "Working time around the world" Lee et al. (2007) pointed out that the number of working days in a typical shift rotation in Peru is 20-23 days which is one of the longest working shifts worldwide. The contractor's construction manager claimed that the economic situation in the country and especially in the region is critical in terms of poverty so that people are looking for an opportunity to work 30 days instead of 23 days at a run. For that reason, workers in the Project work 30 days on and 7 days off. It is important to notice that the long working shifts has been identified to be a contributing factor to accidents due to fatigue workers experience after 20 days of working. This was confirmed in interviews with Contractor's personnel.

The number of industrial projects is growing along with investments in Peruvian economy. In this situation a significant amount of contractor's employees have been resigning from the job to get better-paid jobs in other projects even if the difference might be less than 5% (according to the construction manager of Contractor). The high turnover and limited project budget will influence safety in a negative way. Contractor's HSE manager claimed in the interview that the shortage of human resources in his department affected the coverage of safety inspections, the possibility to provide proper feedback to RUO reports and the quality of safety training. Moreover, a high turnover of workers has lead to a continuous need to train workers on hazard identification, RUO reporting, use of JSA and so on. The risk of accidents is highest when people are new to a project (Levitt and Samelson, 1993). It should also be noted that Hinze and Gambateze (2003) found out in their research the trend that the higher turnover is correspondent with the higher injury rate.

Logistic costs in Peru constitute 34 percent of a product value (Gonzalez et al, 2007). In addition, as it was stated by the Engineer's HSE inspecto, the delivery time of the products from other continents is considerably long. This is mainly caused by poor infrastructure, only 2% of GDP is spent on infrastructure development and investments go to prestigious expensive projects instead of satisfying urgent needs for infrastructure in poor regions (European Commission, 2007). What's more, proper regulations to improve efficiency of service logistics providers are missing. The custom clearance procedures are complicated and lengthy (Gonzalez et al, 2007). The poor quality of roads and the long waiting time for materials and equipment affect safety in a negative way. The equipment needed for safety inspections such as a pH meter was not delivered in time which in turn influenced the quality of safety inspections. As a result of undeveloped infrastructure, poverty and inefficient political programs:

- Safety inspections are affected by lack of necessary equipment.
- JSA analysis is affected by workers unwilling to take on any responsibility for risk assessment and risk of losing their job if they make mistakes. High turnover hinders proper implementation of JSA due to a necessity to train all new workers on JSA execution by the limited resources of the contractor's HSE department.
- RUO reporting has limited success, partly due to workers fear of losing their jobs or bonuses in case of reporting of unsafe acts. Quality of reporting is affected by workers' low living standard and subsequent low demands for safe workplaces.

- Overall safety performance of the project is affected by long working shifts, problems with logistics for equipment and materials, people taking short-cuts to get more money in bonus, inadequate attitude to safety as a result of poor living standard and low value of human life.

6.1.3 National culture

According to the study of Hofstede (2001), Peru has a relatively high index of Power Distance while Norway has low Power Distance. Therefore, it is important that the Client, represented mainly by Norwegian employees, has a proper understanding of cultural differences. As described in the theory chapter, a high index for Power Distance indicates that people have greater respect for authority (Hofstede, 2001). They want their boss to be decisive and tell them what to do (Schubert and Dijkstra, 2009). Work management with sufficient expertise is crucial because subordinates trust such and do what they are told. In cultures with high Power Distance subordinates do not question the decision made by the superior because they do not want to show him disrespect (Hofstede, 2001).

Since Peru has a relatively high index of Power Distance it is expected that workers will be following the orders of foremen and supervisors even if orders should mean unsafe behaviour and represent threat to their lives. High Uncertainty Avoidance (87) in Peru leads to an excessive amount of rules and norms in society so that their intentions are lost to the people. This was confirmed during the interviews with Contractor's HSE manager, construction manager and tunnel engineer. For that reason it is widely accepted in Peruvian society not to follow the rules, regardless of their origin. Instead, according to Contractor's construction manager and the Engineer's quality inspector, new individual and not well developed rules are created. The combination of high Uncertainty Avoidance with relatively high Power Distance can explain the results of Behavioural Sampling presented in section 5.1.1, showing noncompliance among workers and foremen to safety rules regarding proper use of PPE and speeding in tunnels. Based on Hofstede theory (2001) it can be concluded that foremen and supervisors seem not to place a high priority to safety because their superiors do not prioritise safety. Due to high Power Distance, foremen and supervisors have high respect for authority of their superiors and do not question their plans, objectives and correspondent orders (Schubert and Dijkstra, 2009). The same happens with workers whose status in organisational hierarchy is even lower. They feel it natural that the superior tell them what to do and thus they are reluctant to execution of JSA which requires equal participation and exchange of opinions among workers and their supervisor (See section 5.2). The authority of the superior is so high in Peruvian society that influence of supervisors and foremen on safety at construction sites is more significant there than in Norway. Thus, the importance of proper accountability, qualification and communication skills of supervisors and foremen must be underestimated. Foremen should have exhaustive professional and safety knowledge and being capable of transmitting it to the workers and being a good role model for workers.

Peru according to Hofstede (2001) is a country with a pronounced collectivism. Therefore it is habitual for all people to take care of each other as it is described in the book “Growing Up in a Culture of Respect: Child Rearing in Highland Peru” (Bolin, 2006). The questionnaire (See section 5.3) of this research shows worker’s high values for cooperation with colleagues in safety issues. During interviews, workers confirmed their willingness to participate in improvement of safety at workplaces and therefore it can be expected that workers would participate actively in RUO reporting but RUO-rate in the Project is lower than the goal. This can take place due to insufficient feedback on reports or due to mistrust of management or to government have been formed during years of instability in Peru (See European Commission, Plan for Development, 2007)

6.2 Internal factors

The analysis in this section is conducted based on the literature review and results of the interviews and the questionnaire conducted by the author at the Project. During the interviews with Contractor’s and Engineer’s personnel it was identified that some of project specific influencing factors reviewed in section 3.2.2 have more influence on HSE performance at the Project than others. These “critical” factors are taken for analysis of evaluation results to increase the validity of the evaluation.

6.2.1 Contractor’s General management

In order to evaluate the influence of Contractor’s general management of safety performance in the Project and understand how support of the general management affects implementation of HSE practices, the analysis is performed based on method of Aksorn and Hadikusumo (2008)

Table 6.1 Analysis of Contractor’s general management commitment to HSE

Critical success factors	Status	Comments of informant
Management support	Poor	Despite the fact that Contractor’s construction management participates in weekly safety inspections and safety meetings, safety is not given the same priority as production. Responsibility for majority of safety issues is assigned to HSE department of Contractors that impedes synergy between safety and production Contractor upper management has no real and visual HSE management commitment. Contractor has no serious focus on HSE training of its management. Contractor management has no focus on supervisor HSE accountability. Contractor management has no real commitment to making sure that changes are implemented.
Clear and realistic goals	Fair	A long term goal is provided to Contractor by the Client but not broken down into regular day-to-day operations. Contract safety requirements are general

		without defined value ranges for safety related parameters (for example, temperature in Power House, and the maxim allowed length of ladders and so on). There are not incentives for safe work in the contract between the Client and Contractor Therefore, the Client's goals are unrealistic to achieve, in case of insufficient resource allocation by Contractor and lack of safety related incentives in the contract.
Personal competency	Poor	Many inexperienced in rock support workers are hired (According to the interviews with Contractor's personnel). Some new workers are lacking knowledge on safety. Lack of experience and false pretence regarding experience in resume are identified as contributing factors to some accidents which have occurred at the project (According to the investigation reports)
Program evaluation	Good	Reactive evaluation of safety at the project is carried on monthly basis by Contractor in the form of HSE monthly reports. The Client performs audits. This paper is a part of proactive evaluation which is arranged by the Client
Appropriate supervision	Poor	Regular safety inspection is conducted on a daily basis by full-time safety inspectors of Contractor. However, it is found that the number of safety inspectors is not sufficient to bear the workload (according to information from the HSE manager of Contractor). Moreover, it is found the supervisors and foremen do not take responsibility to stop unsafe acts and tacitly accept unsafe working methods (according to

		investigation reports and Behavioural observation).
Equipment acquisition and maintenance	Fair	Required safety equipment is used by most workers where working conditions do not hinder it. When a replacement of PPE is required, the procurement process takes long time due to logistic problems (according to the interview with HSE inspector of the Engineer).
Delegation of authority and Responsibility	Fair	Workers are aware of their safety related responsibility, however, in the most cases HSE department takes responsibility for mitigation of majority of issues identified during safety inspections or reported by workers (according to Action follow up document).
Sufficient resource allocation	Poor	The Contractor operates under a limited budget. There is no financial incentive in the contract to perform works in a safe way. This leads to limitation of expenses spend for safety needs (according to the interview with the HSE manager of Contractor).

It is worth mentioning that contributing factors which led to actual project accidents were mainly related to organisational factors. Therefore, it is crucial to ensure Contractor's general management support in order to prevent reoccurrence of accidents.

Analysis of control measures proposed after safety inspections showed that they are of high quality because they involve changes of working methods at the organisational level and therefore proper execution of these measures will bring a positive long lasting effect for safety (Kjellén, 2000). But analysis of documentation on status of execution of these measures showed that execution was pending in the majority of cases. This can be explained by the limitation of human resources of Contractor's HSE department and the lack of Contractor's management support in implementation of these control measures, what is vital for the measures which should be implemented at the organisational level

(Fernández-Muñiz et al, 2007; Hale et al 1997, Zohar,1980; Rundmo & Hale, 2003; Tinmannsvik and Hovden, 2003, Mohamed 2002).

The allocation of responsibility for remedial actions mostly on HSE department (Action follow up document, 2012) demonstrates that general management separates responsibility for safety issues and productions issues. This might cause production department neglect safety issues during planning and execution of works. Subsequently, it provokes the pressure from supervisors to complete work in combination with their tacit acceptance of unsafe practices (Mohamed, 2002).

Therefore, the main problems related to Contractor's general management which have influence of effect from the evaluated HSE activities are:

- Contractor upper management has no real and visual HSE management commitment.
- Contractor has no serious focus on HSE training of its management.
- Contractor management has no focus on supervisor HSE accountability.
- Contractor management has no real commitment to making sure changes are implemented.

6.2.2 HSE management

HSE management has a direct influence of implementation and execution of safety inspections, JSA and RUO reporting. Proper resource allocation, effective working methods and planning can support significantly the implementation of HSE activities. The results of analysis of factors, affecting implementation of HSE activities, related to HSE management is showed in Table 6.2

Table 6.2 Analysis of HSE management commitment to HSE at the Project

Critical success factors	Status	Comments of informant
Effective enforcement scheme	Poor	On-site safety rules were written and enforced and formally communicated to workers during toolbox meetings. Punishment tends to be adopted when

		any violations are reported (according to Contractor’s HSE manager).
Teamwork	Poor	HSE department of the Engineer is reluctant to work as a team with Contractor’s and Client’s HSE department.
Appropriate safety education and training	Poor	Formal safety education and trainings are provided for workers. Special training is periodically given as needed. Training on rock support for workers is lacking (according to Contractor’s HSE manager). Supervisors and Contractor’s general management need more HSE trainings(according to interviews with Client’s employees and Engineer’s HSE inspector)
Good communication	Good	Safety related issues are communicated during toolbox meetings and trainings on regular basis. Signs, notice boards and posters are also used to communicate safety related information.

As it can be seen from analysis, HSE management is important for implementation of HSE activities in a proper way to achieve the desired results (Tinmannsvik and Hovden, 2003). As it was found in the interview with Contractor’s HSE manager, the limitation of financial resources allocated on HSE department leads to the insufficient number of HSE personnel, subsequent overload of HSE department and decrease in quality of work executed by personnel. This directly affects the quality of safety inspections and JSA and even more importantly affects the execution of control measures and remedial actions which requires financial and human resources. As it can be seen from analysis of allocation of responsibility for execution of remedial actions proposed after inspections and RUO reports, more than 60% of them are allocated to HSE department which is already overloaded with everyday issues due to insufficient number of personnel. HSE department has 9 HSE inspectors and 9 work fronts to inspect on daily basis. In addition, a high turnover of workers make it necessary to conduct safety inductions and trainings more often that it could be expected. HSE personnel are often present at toolbox meetings to ensure their quality and communicate recent accidents. According to the interviews with Contractor's personnel, all these factors lead to overload of HSE personnel and affect the implementation of HSE activities and overall safety in a negative way. This problem with the overload of Contractor's HSE department might be explained by the fact that according to Actions follow-up document the responsibility for the majority of HSE issues at the Project is allocated on HSE department and not on Production department. According to the interview with Client's and Engineer's management, general management of Contractor does not demonstrate real and visual commitment to safety at the Project. The literature on the best practices on construction safety states that HSE responsibility should be allocated on general management (Production and Operation department) and HSE department should be of assistance to it. (Tinmannsvik and Hovden, 2003, Mohamed et al, 2009; Fernández-Muñiz et al,2007; Rundmo & Hale, 2003; Hughes and Ferrett, 2008). The present HSE staff is sufficient if only contractor management ensures that the construction manager implements supervisors' HSE responsibility and accountability.

6.2.3 Worker involvement

Involvement of workers in safety issues is showed as a main element of effective safety management system and a crucial element of a safety culture (Hughes and Ferrett, 2008; B. Fernández-Muñiz et al. 2007; Zubaidah et al.,2011, Mohamed, 2002). Therefore, this factor is discussed further to analyse its possible influence on implementation of HSE activities and their long-term effects.

Table 6.3 Analysis of involvement of employees in HSE management at the Project

Critical success factors	Status	Comments of informant
Positive group norms	Poor	Safe working behavior is not a norm in the most of groups of workers. Unsafe behavior is not stopped by colleagues

		(according to Behavioural Sampling and accident investigation reports)
Personal attitude	Fair	Workers commit unsafe acts. Risky working methods are regularly found on jobs (according to Behavioural Sampling and accident investigation reports) Workers showed a positive attitude to safety, but 50% of involved in the questionnaire workers indicated their acceptance of risk-taking in case of tight production schedule (according to the results of the questionnaire)
Personal motivation	Fair	Motivation of workers largely depends on their concern for life, as well as for family well-being, fear for punishment of violation, and loss of employment (according to Contractor's HSE manager)
Continuing participation of employees	Good	Workers are always encouraged to take part in toolbox talks, safety meetings, job safety analysis, safety suggestions, and RUO reporting (according to Contractor's HSE manager). Workers also showed in the questionnaire that they can influence safety at workplace and are allowed to talk openly about safety.

Many studies prove that employees' involvement is a factor determining success of safety management system, because human factors play an important role in safety performance Employees are considered as a final barrier to risk, therefore their behaviour is vital for accident prevention.
Usually involvement of employees leads to strengthening of feeling of ownership in safety (Hughes and Ferrett, 2008; B. Fernández-Muñiz et al. 2007; Zubaidah et al.,2011, Mohamed, 2002). In the Project workers get many possibilities to influence safety. For example, it can be done through RUO reporting and JSA procedure or a feedback at toolbox

meetings. However, as it was mentioned in Section 5.4.1.3 workers have high Power Distance and distrust to management that has developed through years of unfair attitude typical to Peruvian mining projects (European Commission, 2007). This decreases a personal motivation to report unsafe occurrences and participate in Job Safety Analysis. It was also identified during the interview with Contractor's HSE manager and construction manager, that a low level of education and high religiosity of the majority of workers make them feel that accidents are unavoidable. Therefore, workers perceive activities ensuring their safety such as JSA and RUO reporting as meaningless routines which are necessary only for demonstration of compliance to their management. More than 90 % workers filled in the questionnaire indicated that they learned from their experience how to prevent accidents. In Section 5.4.2.1 it is shown that commitment of Contractors general management to safety issues is not high enough to communicate to workers that safety is important at the project. In these conditions tacit acceptance of unsafe acts forming negative group norms is supported. During behavioural observations, noncompliance to wearing proper PPE was demonstrated by foremen. In the culture with high Power Distance the foremen and supervisors have high authority and show an example to follow (Hofstede, 2001). In this case non-conformance by foremen contributes to formation of unsafe group norms. Negative group norms disvalue application of JSA and RUO reporting. A safety inspection cannot improve the current group norms due to its limited functionality (Kjellén and Hovden, 1993).

6.2.4 Human factors

The Project is located in a rural area and Contractor is obliged to employ locals in accordance with Corporate Social Responsibility program of the Client. These workers have a low level of education, mostly only primary education (according to the interviews with all interviewed Contractor's personnel). This affects their capability to learn and analyse. Therefore, workers experience problems in learning about hazards identification and accident prevention. In this context, they prefer to transfer responsibility to execute JSA to supervisors who are better educated. It leads to unawareness of hazards by workers and depreciation of JSA as a useful tool to reduce job related risks. With regards to RUO reporting, the low level of education makes it difficult for workers to apply the criteria for reporting and they tend to focus on housekeeping related issues which are easily observable. This limits the actual thematic coverage of RUO reports. The supervisor shall actively ensure the involvement of workers in the JSA and listen to their ideas and advise.

The level of education in Peru does not always reflect the quality of knowledge the person obtained during studies. Olivos and Talavera (2006) pointed out that "the quality of undergraduates and postgraduates from the vast majority of universities is recognised to be broadly dissatisfactory". They explain it by the absence of the accreditation system for universities in the country. Therefore, safety specialists with local high education might lack necessary knowledge on safety inspections and accident investigations. Moreover, widely accepted culture of exaggerating professional experience specified in resume hinders employment of appropriate specialists. The construction manager of Contractor confirmed in the interview that a solution to this challenge is a mix of local and expatriates employees in one team in order to ensure the transmission of knowledge.

6.3 Summary of analysis of factors influencing safety

According to the analysis conducted in this chapter following factors have the strongest influence on implementation of HSE activities and their effects:

Among external influencing factors

- Economic situation in Peru
- Characteristics of Peruvian culture

Among internal influencing factors

- Contractors' upper and project management visual HSE commitment.
- Safety related incentives provided by the Client to contribute to continuous improvement in HSE at the Project
- Allocation of HSE responsibility to Contractor's HSE department instead of Production department

- Human factors such as a low level of professional and safety education, high influence of religion on workers' attitudes and acceptance of risk-taking when production schedule is tight.

7. Discussion

The purpose of the discussion chapter is to provide answers to the research questions that were put in the introduction. This is done by combining theory and results. The method applied for evaluation is discussed in relation to the requirements to evaluations. Then, this provides a basis for discussion of the effects that are achieved as a result of HSE activities and for subsequent suggestions for improvements.

7.1 Discussion of method

As it was described in section 4.4.2, certain requirements should be fulfilled to arrive at a comprehensive evaluation (Alkin, 2010; Wadsworth, 2011; Rossi et al., 2004). The fulfilment of these requirements by the evaluation performed within this research will be discussed further.

According to the first requirement, *evaluation* should be *conducted in a systematic way*. The evaluation of HSE activities was performed through analysis of implementation and effects of these activities (Shannon et al, 1999). The formative evaluation was selected for that purpose and analysis of implementation and outcome of HSE activities was conducted based on the analytical model (Figure 1.1). The use of the analytical model facilitated a systematic way of the process of evaluation. The indication of relevance of different sections of this report to elements of the analytical model supported a reader to follow a systematic flow of the evaluation. Therefore, it can be concluded that the first requirement to a comprehensive evaluation is satisfied.

Shannon et al. (1999) points out that *evaluation of outcome* of safety measures should be *judged based on the program objectives*. However, Alkin (2010) highlights that environment where measures are implemented are not static and therefore not only objectives should be used as criteria for evaluation, but also *needs for adjustment* of activities to the current situation at the project should be *taken into account*. As it was described in section 4.4.1, Client's objectives and requirements to the evaluated HSE activities were taken as criteria for evaluation. Nevertheless, it is important to stress that Contractor can have different objectives than the Client for safety inspections, JSA and RUO reporting. For example, in the interview with HSE manager of Contractor it was found that Contractor's objective for RUO reporting was "to motivate workers to think about safety", while Client's objective for this HSE practice also included learning from unwanted occurrences at the company level. This is an important influencing factor which should be taken into account during evaluation of HSE initiatives. Moreover, the best practices in industry regarding evaluated HSE activities were used to develop another criterion – checklist. Limitation of the time spent by the author for this research, which is 20 weeks, made it impossible to perform exhaustive literature review. This affected the quality of checklist and subsequent validity of the results of the evaluation. However, the requirement to take into account the need for adjustment of activities to the current HSE performance was fulfilled (Alkin, 2010). Analysis of current HSE performance was performed and issues which affected it negatively were used to check if implemented HSE activities are focused on their elimination.

The third requirement to comprehensive evaluation focuses on *data collection and assessment* which should be *performed in a planned and methodical way* (Shannon et al., 1999). A logic model of HSE activities (Figure 4.3) was developed based on the model for evaluation of effects of safety interventions (Kjellén, 1983). The logic model of HSE activities helped plan and perform data collection and analysis in a systematic way using relevant measurement instruments (Alkin, 2010). The figure 4.2 shows the systematic approach to data collection and assessment employed for this research. The third requirement is fulfilled.

During an effective evaluation, *errors in reasoning, data collection and analysis are eliminated or analysed regarding possible influence on the findings*. For that reason, it is important to note several limitations of the performed data collection. As it was mentioned above the literature review was not exhaustive due to limitation of time for the Master thesis that might influence the validity of evaluation through the quality of checklist which is based on the literature review and used as a criterion in the evaluation. Another threat to validity is whether the survey, observations and statistics for reporting and injuries says something about the risk of accidents (Mohamed, 2002; Clarke, 2006).

With regards to the field data, interviews were performed in a language foreign for interviewer and interviewees that affected the accuracy of obtained information, though the author cross checked for correctness of understanding during the interviews. The selection of workers for the interview was random and thus the question is whether they represent the rest of the workers (Shannon et al., 1999). Behavioural Sampling was performed based on industry guidelines with support by HSE inspector of the Engineer who has 10 year experience of safety management in tunnelling. Though the elements for Sampling were selected those which are easy to observe and clearly illustrated in the industry guidelines on safe work in tunnelling (Kjellén, 2000), the type of work conducted in the tunnels during observations was not taken into account. The small number of observations (N=10) affected the representativeness of observations.

Analysis of the documentation provided by Contractor had its limitations. The first limitation is Spanish language in which the protocols for JSA, safety inspections and RUO reports were provided by Contractor. The author does not master written Spanish. In addition, these documents were given in a small quantity (See table) that is improper for adequate evaluation of immediate effect of these activities but representative enough to illustrate the implemented routines and protocols. Immediate effects were analysed with the use of Action follow up document which contained comprehensive information on findings and measures for safety inspections and RUO reports.

The analysis of accidents was performed with the use of the Client’s incident database and Contractor’s accident investigation reports. Therefore, the validity of analysis depends on reliability of reporting by Contractors, quality of reporting and registration in the incident database and quality of accident investigations performed by Contractor. The analysis was focused on accidents with lost time injures which have the highest reporting reliability. On the other hand, it is worth mentioning that risk depends on the frequency and consequences and LTI-rate is not sensitive to the size of injury (Kjellén, 2000). The quality of accident investigations and subsequent reports prepared by Contractor was evaluated as high during the audit performed by the Client on 22-25 August 2011.

The questionnaire was prepared by selecting 16 questions out of 50 questions in NOSACQ-50 (Kines et al, 2011) questionnaire under a strong recommendation of Contractor’s HSE manager. This decreased tested validity and reliability of the initial questionnaire and eliminated a possibility to look into management related elements of safety culture. However, the questionnaire was primarily used by the author to measure workers’ attitude to safety and distribution of different attitudes in each of safety climate dimensions. Used for this purpose, the decreased questionnaire can be considered valid and the results are provided with 95% confidential interval.

Another requirement to a comprehensive questionnaire is that *the finding and conclusions have credibility*. Therefore it is important to stress that the limitation of the selected tools for measurement is that the questionnaire and Behavioral Sampling only measure the state at a certain time (The Aberdeen University, 1994).To strengthen the credibility and validity of evaluation of long-term effect, triangulation is used and supplemented with the qualitative data (Shannon, 1999) from HSE statistics. Implementation and immediate effect of HSE activities is evaluated with the help of the checklist based on the best industry practices and Van Court Hare’s classification of control measures (Kjellén, 2000). Therefore findings from evaluation of immediate effect depend on the quality of the checklist and the quality of registrations of control measures in Action follow up document.

A comprehensive evaluation *takes into account other relevant factors* apart from the program which might affect measured effect independently. The different external and internal factors which can influence HSE performance independently and through implemented HSE activities were analysed. Results of evaluation were scrutinised in light of influencing factors to increase the validity of evaluation.

Evaluation is valid only if *evaluated intervention was commenced before measured effect in time*. In case of this research, safety inspections JSA and RUO reporting was initiated in July 2011 while data collection for this research was conducted in March 2012.

7.2 Discussion of Research questions resolution

7.2.1 Effective HSE practices in construction in developing countries

Safety in construction is a significant issue due to high risks involved in everyday activities. This especially concerns construction activities in developing countries where risks are even higher due to inadequate infrastructure, improper statutory regulations and low standards of corporate systems and living (Mohamed, 2009). The HSE activities which are proved to be effective at construction sites in developing countries are: safety committees, safety inductions, safety trainings, jobsite inspections, accident investigations, first-aid programs, implementation of in-house safety rules, implementation of safety incentives, control of subcontractors, adequate selection of employees, enforcement of personal protection, emergency preparedness planning, safety auditing, safety record keeping and job safety analysis (Hinze and Gambatese, 2003; Aksorn and Hadikusumo, 2008). All these HSE related activities are specified by the Client in the HSE Specification which is a part of the contract requirements. The effectiveness of these HSE activities can be achieved only with proper implementation of a safety management system (Teo and Ling, 2005; Hinze and Gambatese,2003; B. Fernández-Muñiz et al, 2007; Hughes and Ferrett, 2008) such as for example OHSAS 18001 which is recommended by the Client to Contractor in the HSE Specification.

For this research the safety inspections, JSA and RUO reporting were selected for the evaluation due to availability of the data on implementation and immediate effect of these activities that is necessary input to evaluation. It is important to notice that safety inspections, JSA and RUO reporting have functional limitations (Kjellén and Hovden,

1993) which should be taken into account during the evaluation to ensure its validity (Alkin, 2010).

7.2.2 Factors influencing implementation of HSE practices at construction sites in developing countries

Research on the factors influencing implementation of HSE activities in developing countries is limited and results of available studies differ considerably. So Aksorn and. Hadikusumo (2008) identified four main factors that ensure successful implementation of safety programs: Worker involvement, safety prevention and control system, safety arrangement and management commitment. They found in their study that management commitment has the highest influence on success of HSE initiatives. The recent publication of Kjellén (2011a) shows different factors which have influence on implementation of safety practices. There are two groups of factors: external and internal factors. External factors have their influence at the national level while internal factors are project specific (See figure 3.6). These factors were further scrutinized with the help of literature review.

Mandatory governmental regulations, national and international industry standards and guidance compile the framework for establishing a culture of risk prevention (Hughes and Ferrett, 2008). The adequacy of governmental regulations and follow up by authorities influence safety considerably in construction projects worldwide (Mohamed, 2009, Kjellén, 2011a). Compliance with voluntary industry standards facilitates implementation of HSE activities and affects overall safety at the project in a positive way (Hughes and Ferrett, 2008; Holt, 2001; Hill, 2005; Oloke and McAleen, 2010)

Economic situation in the country reflects in the level of safety standard at construction sites (Mohamed 2009, Kheni et al, 2010; Kartam et al., 2000). Success of implementation of HSE activities depends on the size of HSE budget of companies, standards of living reflected in poor demand by employees for workplace safety, risk taking behaviour, quality of professional and safety education and other issues influenced by national wealth (Kheni et al, 2010; Kartam et al., 2000). The poverty of local communities, who tightly interact with project and provide manpower, brings about security concerns, high turnover of employees, demands for long working shifts and employment of workers without adequate professional and safety education(European Commission, 2007).

National culture has a significant effect on implementation of HSE practices and should be taken into account while they are being developed and implemented (Kjellén, 2011a; Schubert and Dijkstra, 2009). The cultural issues influence authority of superiors, socially acceptable behaviour, attitude to rules and safety and flow of communication (Hofstede, 2001). Hovewer, it was also found that management attitude to safety has stronger influence on employees attitudes to safety than culture related matters (Mearns and Yule, 2009; Mohamed et al, 2009).

Management systems and practices were identified as the main influencing factor on implementation of HSE practices and overall safety (Fernández-Muñiz et al,2007; Hale et al 1997, Zohar,1980; Rundmo & Hale, 2003; Tinmannsvik and Hovden, 2003, Mohamed 2002). Without management support and proper resource allocation HSE practices can hardly be implemented. Likewise, general management commitment to safety was shown to have a direct influence on injury rate in the organisation (Tinmannsvik and Hovden, 2003). Management empowerment and worker involvement depend on general management strategies and are necessary for an adequate safety culture and effective implementation of HSE activities (Hughes and Ferrett, 2008; B. Fernández-Muñiz et al. 2007; Zubaidah et al.,2011, Mohamed, 2002).

Human factors play an important role in construction safety (Kjellén, 2011a). A level of safety and professional education, safety related experience obtained during previous employments, appropriateness of knowledge and skills to the executed work, personal attitudes to safety are human factors which affects directly and indirectly the implementation of HSE activities at construction projects in developing countries (Kheni et al, 2010; Kartam et al., 2000).

7.2.3 Method and criteria for evaluation of HSE initiatives taken at the Project

The Client has a “zero injures” safety policy and interested in maintaining the high level of safety at the Project (HSE policy, 2008). In order to take effective decisions regarding safety follow-up of Contractor, information on implementation and effects of HSE activities performed by Contractor is needed. According to the results of literature review, formative evaluation of HSE activities suits the purpose, since it is usually used to provide information for improvement of the program and to scrutinise if the program activities are being carried out and carried out in a proper manner (Alkin, 2010).

The method of evaluation is developed based on the model for evaluation of effects of safety intervention (Kjellén, 1983) which focuses on input to HSE activities, implementation of HSE activities, their immediate effect and long-term effect. The analysis was decided to start from evaluation of long-term effects of conducted HSE activities in order to get better understanding of deficiencies in their implementation. This helped increase validity of evaluation of implementation of HSE activities.

Criteria for evaluation were selected based on literature review on the best practices in construction safety in developing countries and the Client’s relevant requirements to evaluated HSE activities. The requirements to evaluation method and criteria have been satisfied, yet some threats to validity of evaluation during data collection were identified (See section 7.1).

7.2.4 Evaluation of HSE activities performed by Contractor

Long term effect

Evaluation of long-term effect was conducted through analysis of actual compliance at site, safety climate and injury statistics since they represent HSE performance indicators (Kjellén, 2000). The analysis showed noncompliance mostly in use of PPE and speeding in tunnels. Analysis of safety climate demonstrated workers’ positive attitude to safety and feeling of ownership in safety issues, but important to notice that 40%

workers participated in the questionnaire accept risk-taking when the production schedule is tight. Injury statistics at the Project showed increase in TRI-rate with domination of the accidents caused by falling rocks in underground works. On the other hand, other challenges specific to the Project such as safety in transportation on public road, moving and lifting materials and equipment and handling and storage of explosives are managed successfully up to the moment of data collection for this research. Therefore, it can be concluded that long-term effect of HSE activities conducted by Contractor is satisfactory, though there is a significant potential for improvement.

Implementation

Analysis of implementation of HSE activities showed that safety inspections and RUO reporting have been implemented according to SN Power requirements and the best industry practices in construction safety. With regard to JSA, substandard quality of implementation was identified. Protocols for JSA do not facilitate proper sequence and quality of analysis, while daily execution for the same activities decrease perceived usefulness of JSA.

Immediate effect

The immediate effect was measured through analysis of the quality and coverage of reported findings during safety inspections, JSA and RUO reporting in comparison with their potential functionality illustrated in the literature (Holt, 2001; Hughes and Ferrett; 2008, Kjellen, 2000; Oloke and McAleenan, 2010; OLF, 2010). Findings from all activities had a limited coverage with the focus on issues related to housekeeping, though safety inspections also indicated the need for change of working methods and proper control measures were proposed. Control measures planned after JSA were not sufficient for accident prevention because they were mainly focused on use of PPE (Haddon, 1980 in Kjellén, 2000).

Another identified issue related to immediate effects is the implementation of proposed control measures. The analysis showed that despite the fact that the measures planned after safety inspections and RUO reporting should have had a positive long lasting effect on safety (Van Court Hare,1967 in Kjellén,2000), they required involvement of Contractor's general management and had a status "Pending" for several months (Actions follow up document, 2011). In the interviews workers complained about the feedback on RUO reports, whereas in the questionnaire they indicated that findings in safety inspections are not eliminated immediately. The implementation of the control measures planned in JSA was not possible to check due to organisational constraints during data collection.

Therefore it can be concluded that immediate effect from the implementation of safety inspections, JSA and RUO reporting is not satisfactory.

7.2.5 Explanation of immediate and long-term effects of HSE activities in light of influencing factors

External and internal factors influencing safety which were identified during the literature review should be taken into account during analysis of results of the evaluation.

The achieved long-term effect of HSE activities is satisfactory and might be explained from different perspectives. First of all, at the Project Contractor is obliged to comply with the Performance standard of International Finance Corporation (IFC) and the contract requirements from the Client which are stricter than Peruvian governmental regulations, therefore deficiencies in these regulations and weak follow up by authorities does not affect safety at the Project.

Improving but difficult economic situation in Peru, characterised with 37% people living in poverty, does not affect HSE performance at the Project directly due to the absence of Peruvian investments into the Project. However, overall safety at the Project is affected by the consequences of the level of national economy: poor infrastructure, workers' demands for long working shifts, a low level of professional and safety education, workers acceptance of risk-taking to get bonuses. All these factors affect safety climate, compliance and injury rate at the Project.

Cultural dimensions proposed by Hofstede (2001) can be used to explain the results of the evaluation of long-term effect. Nationalities with high uncertainty avoidance tend to break rules due to their excessive number. Thus noncompliance and acceptance of risk-taking behaviour can be attributed to this cultural characteristic. Peruvian Power Distance was evaluated by Hofstede as high and subsequently it can be expected that workers will be following the orders of superiors without questioning (Schubert and Dijkstra, 2009). Therefore in case when safety is not a first priority for superiors it might lead to increase in number of injuries which was identified in this research. The cultural dimensions such as feminism and collectivism play an important role in creating a positive safety climate. Workers indicated in the questionnaire and interview their willingness to help others to work safely and cooperate with the management to improve safety. Therefore, a positive safety climate can be partially explained by national values.

The satisfactory long-term effect has been achieved due to intensive and effective work of Contractor's HSE department, the representatives of which perform daily safety inspections, participate in toolbox meetings, and provide safety inductions and trainings on how to perform JSA and RUO reporting. HSE department performs other activities aimed at accident prevention which are out of the scope of this research but have a significant effect of HSE performance at the Project.

Human factors play an important role in construction safety (Kjellén, 2011a). According to the interviews with Contractor's construction manager and tunnel engineer, workers involved in the project do not have an experience in rock support and they tend to skip this necessary procedure. This leads to fall of rocks in tunnels and subsequent injures. Another human factor is safety attitude which workers developed during previous employments. Workers at the Project have different experience and some of them probably were not obliged to wear PPE by their previous employers. It is also worth noticing that some workers provided false data in their resumes to Contractor which was identified only during accident investigation. This had led to inappropriate task assignment to workers that increased the number of lost time injures.

The achieved immediate effect of HSE activities is not satisfactory due to the delay with execution of control measures. The main identified factor here is the lack of support from Contractor's general management. The majority of control measures assigned to Production department had a status "Pending" in the available to the author documentation.

7.2.6 Recommendations for improvement

Results of the evaluation show the satisfactory long-term effect achieved by Contractors. However, a potential for improvement have been identified and therefore the following can be proposed:

- The Client can add incentives to the contract to ensure continuous improvement of Contractor in safety
- The Client can ensure that the Engineer and Contractor have clear understanding of their HSE related responsibility
- The Client can include more detailed HSE requirements with precise values into the HSE Specification
- The Client can stimulate Contractor to demonstrate real and visual management commitment to safety
- The Client can add a requirements to the HSE Specification that Contractor's management should have frequent HSE training
- The Client can add to the HSE Specification that Contractor should demonstrate that supervisors have received HSE training
- The Client can ensure that Contractor's management takes responsibility for HSE issues

8. Conclusion

The results of evaluation show that a good safety result can be achieved with Client's approach to construction safety management that is to provide contractors with the HSE requirements regarding implementation of certain HSE activities. Moreover, HSE initiatives taken by the Client were evaluated as suitable for achieving good safety results in countries where the frame conditions differ from where they were developed. However, the success of implementation of these HSE initiatives strongly depends on the frame conditions which should be taken into account during follow-up of contractors' HSE performance and development of new contracts. The identified most influential frame conditions in developing countries which affect overall safety at the project and the implementation of HSE initiatives are economic situation in the country, national culture and the sufficiency of safety regulations and standards which contractors have to comply with. The evaluation also showed the significant influence of the project specific factors such as general management support, nature of the project, contracting philosophy, technology standards and human recourses. These factors impose challenges for Client's safety management and weaken a potential of HSE initiatives. Therefore they should be assessed and taken into account in development of HSE requirements for each particular construction project and subsequent follow-up of contractors.

Further evaluation can be proposed to find out the effect of different contracting philosophies on implementation of HSE initiatives and safety performance with focus on the role of the Engineer in HSE management at the project. It can executed through comparison between safety performance and formative evaluation of HSE initiatives taken at Client's project with the Engineer involved into follow-up of contractors' compliance and not involved. It is also worth looking into the long-term effect of Client's contractual approach on development of contractors' safety in case when the same contractor is involved in Client's different projects conducted one after another.

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Appendix 1

Check-list for Behavioural Observations

1 must be improved

2 should be improved

3 should be evaluated

4 small deviation

5 100% safe

Topic for observation	Evaluation
Something heavy is put over 2 m height without securing it	
Someone is walking under hanging load	
Vehicles are speeding in the tunnels	
Danger zone is indicated with signs	
Physical barriers are used to protect from falls from height	
Engine of machinery is running unnecessary	
There is sufficient light for turning area	
Dusty areas are wet	
Equipment which is not in the use removed	
Ways are without obstacles	
Ventilation is extended to working face (50m)	
All places where work is performed are properly eliminated	
Cables and pipelines are secured on brackets	

Ladders are in horizontal position hanging on brackets	
Water on the ground	
Personal Protective Equipment	
Helmet	
Safety shoes	
Gloves	
Protective clothing	
Eye protection	
Ear protection	
Respiratory protection	

Appendix 2

The questionnaire used for this thesis.

Por favor, indique cuál es su parecer respecto a cómo se maneja la seguridad ocupacional en este lugar de trabajo (Ponga solo una X para cada pregunta)					
	Muy de acuerdo *Absolutely agree*	De acuerdo *Agree*	No sabe *Do not know*	En desacuerdo *Disagree*	Muy en desacuerdo *Absolutely disagree*
Los problemas de seguridad detectados durante las inspecciones son corregidos tan pronto como es posible o inmediatamente *Safety problems discovered during safety rounds/evaluations are corrected immediately or as soon as possible*	☐	☐	☐	☐	☐
Yo puedo influir en la seguridad de mi trabajo *I can influence safety at my working place*	☐	☐	☐	☐	☐
Aquí todos tenemos alto nivel de competencia y respeto a la seguridad y los riesgos *Everybody here has high competence concerning safety and risk*	☐	☐	☐	☐	☐
A quienes trabajamos aquí no nos importa la seguridad de los demás *We who work here do not care about each others' safety*	☐	☐	☐	☐	☐
Quienes trabajamos aquí consideramos que las revisiones de seguridad no influyen en la seguridad en absoluto *We who work here consider that safety rounds/evaluations have no effect on Safety*	☐	☐	☐	☐	☐
Quienes trabajamos aquí consideramos que la formación en seguridad es buena para prevenir accidentes *We who work here consider that safety training is good for preventing accidents*	☐	☐	☐	☐	☐
Quienes trabajamos aquí nos esforzamos conjuntamente en alcanzar un alto nivel de seguridad *We who work here try hard together to achieve a*	☐	☐	☐	☐	☐

Quienes trabajamos aquí nos ayudamos mutuamente a trabajar seguros *We who work here help each other to work safely*	☐	☐	☐	☐	☐
Quienes trabajamos aquí nunca aceptamos correr riesgos incluso cuando los tiempos de trabajo son ajustados *We who work here never accept risk taking even if the work schedule is tight*	☐	☐	☐	☐	☐
Quienes trabajamos aquí intentamos encontrar una solución si alguién nos indica un problema en la seguridad *We who work here try to find a solution if someone points out a safety problem*	☐	☐	☐	☐	☐
Quienes trabajamos aquí aprendemos de nuestras experiencias para prevenir los accidentes *We who work here learn from our experiences to prevent accidents*	☐	☐	☐	☐	☐
Quienes trabajamos aquí podemos hablar libre y abiertamente sobre la seguridad *We who work here can talk freely and openly about safety*	☐	☐	☐	☐	☐
Quienes trabajamos aquí no aceptamos ninguna responsabilidad por la seguridad de los demás *We who work here take no responsibility for each others' safety*	☐	☐	☐	☐	☐
Quienes trabajamos aquí consideramos que las revisiones de seguridad ayudan a detectar serios riesgos *We who work here consider that safety rounds/evaluations help find serious hazard*	☐	☐	☐	☐	☐
Quienes trabajamos aquí consideramos que la formación en seguridad no tiene sentido *We who work here consider that safety training is meaningless*	☐	☐	☐	☐	☐