OCCUPATIONAL SAFETY IN A CONSTRUCTION ALLIANCE PROJECT: FINDINGS FROM A LARGE-SCALE FINNISH LIGHT-RAIL PROJECT

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Abstract: Alliancing is a relatively new procurement method in large infrastructure and other construction projects. Occupational safety (OS) in alliances is an area towards which very little research interest has been directed thus far. This is surprising giving the common understanding of accidents, injuries, and occupational illnesses and the burden they represent for individuals, companies, and communities. This study focuses on OS inside the major Raide-Jokeri Light-Rail Alliance project in Finland. OS is approached through a survey directed at all the participants of the alliance, including subcontractors. A total of 360 responses were collected, representing roughly half of the personnel at that time. The survey shows how OS is experienced rather uniformly inside the alliance and amid the stakeholders; however, certain differences were also detected among the personnel, providing the possibility of focusing on development actions inside the alliance. The survey results can be interpreted as revealing certain signs of a mature safety culture inside the alliance project; yet, future studies with more sophisticated research approaches are needed.

Keywords: alliancing, construction, project alliance, occupational safety, safety management, safety culture

1. INTRODUCTION

Despite years of continuous, painstaking work and research in the field of occupational safety (OS), the numbers of occupational accidents, illnesses, and injuries have remained high in the construction industry. Construction is a remarkable branch of industry, creating employment and income for different layers of societies at the national and regional levels (Lehtola et al., 2008; Lingard, 2013). The construction industry is thus a significant contributor to the economy but also has a dark side due to its highly hazardous nature, which represents a remarkable burden at the national, regional, organizational, and individual levels (Jaafar et al., 2018; Janackovic et al., 2013; Lehtola et al., 2008; Schulte, 2006). Even though the correlation between the high quality of OS performance and productivity, effectiveness, and quality in construction is recognized (Alkaissy et al., 2020; Shirali et al., 2018), OS is still considered an auxiliary function to comply with OS laws and not a core part of the business (Law, 2020), and adverse issues, like an immature safety culture, a lack of information and communication technologies, problematic employee behavior, and inadequate risk management processes, are still commonly associated with construction, making accidents, injuries, and illnesses possible (Jin et al., 2019).

Most commonly, construction projects are executed in a shared workplace, where several companies, often subcontractors or suppliers, work in cooperation and under the supervision of the general contractor during different stages of a project and for different lengths of time. (Flanagan et al., 2007; Mok et al., 2015; Rahman & Adnana, 2020). This may lead to a situation where information sharing in general and that concerning OS and interactions between the stakeholders are limited (Manu et al., 2019; Trinh & Feng, 2020). In addition, within this multiemployer complexity, responsibilities concerning OS might be unclear, and problems may manifest themselves in several ways. In general, stakeholder management in construction is a topical point for scientific and practical discussion (Moradi et al., 2020a; Xia et al., 2018), and a need to develop construction project governance and contract procedures between the stakeholders has been deemed evident, also when examined from the OS perspective (Adaku et al., 2021; Hanioglu & Menches, 2017; Nabi et al., 2020).

This study focuses on OS in an alliance-type construction project. Alliances differ from traditional types of project delivery models, like “construct only” or “design and construct,” with regard to their collaborative nature. In a project alliance, contractual stakeholders (i.e., the partners of the alliance) collaborate with mutual pain-share/gain-share agreements to achieve the best outcome for the entire project. An alliance is a project delivery method where the contractual parties agree to share joint responsibility for the

design and construction of the project and form a joint organization to manage the project. In alliances, the parties share both the risks and the rewards and share information in close cooperation with each other (Lahdenperä, 2017; Lehto & Aaltonen, 2021; Love et al., 2010).

A project alliance consists of parties from both the owner and non-owner sides working together to achieve mutual benefits. Different authors have revealed the benefits of this collaborative project delivery arrangement (Lahdenperä, 2017; Love et al., 2010; Rahman & Adnana, 2020; Young et al., 2018). Yet, not all alliances are successful (Day, 1995; Lahdenperä, 2017).

However, as experiences of this mode of project delivery have increased, it has proven a successful method (Love et al., 2010). For an alliance to succeed, it is essential that collaboration with stakeholders, both owner and non-owner participants, is established and maintained and recognized as playing a significant role (Lahdenperä, 2017) and that the project managers have the required competencies to lead the project (Moradi et al., 2020b). Formal contracts, such as gain-share/pain-share ones are important success factors in alliances, but equally important are relationship-based elements, such as commitment, trust, communication, and cooperation, which all represent elements of a good organizational culture (Yeung et al., 2007). When examined from the OS perspective, the concept of safety culture comes close to the premises of organizational culture. Discussions concerning the definition of safety culture and its connections to organizational culture have been vibrant, yet have not resulted in any definite agreement (Edwards et al., 2013; Guldenmund, 2000). As discussed, for instance, by Choudhry et al. (2007b) and Edwards et al. (2013), safety culture can be seen as a result of the overarching organizational culture.

This study focuses on OS inside an ongoing major construction project conducted as an alliance project. In addition to highlighting how OS is perceived among the stakeholders, this survey portrays a view of the safety culture within the project. The project, *Raide-Jokeri*, is a large Finnish light-rail construction alliance project in the metropolitan area of Helsinki. In this study, OS is approached through a questionnaire aimed at all personnel working on the project at the end of 2020. This study aims to answer the following research questions:

1. How is OS perceived inside the alliance project by the different stakeholders involved?
2. How do the perceptions manifest themselves when considered from the different stakeholders' perspectives?

1.1 Safety Culture

Managers' OS attitudes and behaviors are reflected in employees' OS performance. Safety perceptions can be interpreted from the safety culture perspective (Clarke, 1999). This chapter provides insights into existing knowledge on safety culture in general, as well as in construction, to facilitate discussion on the safety culture in the alliance project. The origins of the concept of safety culture date back to the Chernobyl Nuclear Power Plant accident in 1986 and the subsequent reports. Accordingly, "Safety culture is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management" (International Atomic Energy Agency, 1986). Thus far, the discussion around the concept has strongly emphasized the importance of safety culture in accident analysis and investigations (Kjellen & Albrechtsen, 2017). The many definitions of safety culture commonly refer to the values, attitudes, norms, beliefs, practices, policies, and behaviors of personnel (Provonost & Sexton, 2005), and the basic assumption is that there is a connection between an organization's cultural traits and the level of safety (Antonsen, 2009).

Safety culture is commonly measured through questionnaires in practice, yet the utilization and analysis of these have also been criticized (Guldenmund, 2007; Provonost & Sexton, 2005). Questionnaires provide an analytical approach to a complex phenomenon, especially when aiming to describe current cultural manifestations, like various types of behavior and how these are perceived by existing groups (Guldenmund, 2010). Even though questionnaires can be considered a quick option for this purpose, they are also "dirty" in that they provide sets of factors and scores but not the underlying reasons for them. Thus, safety culture questionnaires and their result interpretations should be considered carefully with the organizational context in mind (Guldenmund, 2007). Further, the predictive value of surveys should be critically considered, and emphasis should be placed on asking the right questions in the right way (Antonsen, 2009).

Safety culture has been a topic of scientific discussion in many industries (e.g., Biggs et al., 2013; Morrow et al., 2014; Nævestad et al., 2018; Singer & Vogus, 2013; van Nunen et al., 2018), including construction (Choudhry et al., 2007a; Fang & Wu, 2013; Trinh & Feng, 2020). Common organizational characteristics, like good communication, organizational learning ability, senior management's commitment to safety, and a working environment that rewards the identification of safety issues, have been identified as essential elements of a good safety culture (Lopez de Castro et al., 2013). In construction, a good safety culture has been seen as an important element when developing OS performance (Fang & Wu, 2013; Minh et al., 2018), but challenges are also recognized. Zou (2011) describes the path towards a good safety culture as a long and painstaking road, where the journey is more important than the end destination.

2. METHODOLOGY

2.1 Study Context

This study focuses on a large-scale alliance project in Finland. The project is called *Raide-Jokeri* and is Finland's largest light-rail construction project. The project extends for 25 kilometers through the Helsinki Metropolitan area, and it will replace the old, ineffective, and less environmentally sustainable trunk bus line that serves 40 000 passengers daily. The total cost of the *Raide-Jokeri* project were estimated to be €386M at the beginning of the project, but now the estimations have grown to €550M due to the increase in the size of the project, with a light-rail maintenance depot, a new bus depot, and numerous smaller adjoining projects. The construction work started in 2019 and will last until 2024.The *Raide-Jokeri* project owners are the cities of Helsinki and Espoo. Based on a tender phase, the key stakeholders of the alliance consortium were chosen. The alliance consortium includes three large-scale engineering companies as the designers, while the contractor work is completed by a consortium between two international construction companies. In addition, the rail operator belongs to the key stakeholders of the alliance consortium, and various subcontractors are included as part of the project. In 2021, when this study was conducted, over 200 subcontractor companies had already participated in the project.

The *Raide-Jokeri* project is divided into six sectors, of which five are devoted to track sectors and the sixth one is the light-rail depot construction site. The project personnel are divided into these six track sectors, all working under their own sector management. In addition, three units for special work tasks (electricity, special constructs, and track builders) and a Big Room for the alliance coordination and management have been established.

A light-rail track is being built in densely built-up areas, which means that constant vigilance needs to be upheld due to the large amount of both pedestrian and vehicle traffic as well as previously built infrastructure. A persistent challenge is to ensure the uninterrupted flow of water, gas, electricity, and heat, with the latter being especially important in wintertime. In addition, the line is in direct contact with over 100 nursing homes and 100 schools. *Raide-Jokeri* operates in the jurisdiction of two police and two fire and rescue precincts. Considering the multi-stakeholder environment with different organizational layers and various subcontractors and the total size of the construction site that spreads across the metropolitan area, this project can be considered as having large-scale complexity. As raised in the literature (e.g., Bosh-Rekveldt et al., 2011; Minh et al., 2018), such a complex construction project induces significant challenges not only for the project management but also for OS. To deepen the understanding of the complexity of OS management and its continuously developing nature in the *Raide-Jokeri* alliance project, the OS actions and measures introduced and utilized in the project are summarized in Table 1.

TABLE 1. OS MANAGEMENT ACTIONS DURING THE RAIDE-JOKERI PROJECT

Year	OS management action introduced
2019	Weekly toolbox talks on every production block for all field workers
	Training for all supervisors who give the toolbox talks
	Weekly safety info in an alliance internal newsletter
	Monthly safety walks by the OS manager and block managers (including special technical managers for electric, rail, and engineering structure construction)
	Implementation of safety observation software for basic OS reports
	Organization of weekly on-site safety inspections (MVR) for all blocks
	Training for all personnel who carry out MVR inspections
	Top management safety walks
2020	Coordinated work groups for government cooperation between alliance members; police, fire, and rescue services; and the military
	Implementation of systematic accident and near miss investigation protocol
	Training for all personnel who carry out MVR inspections
	Safety training for supervisors who are responsible for accident investigations
	Work team isolation program against Covid-19

When considered from the accident statistics perspective, the OS performance in the *Raide-Jokeri* project can be interpreted as being good. For instance, the accident frequency (occupational accidents/million working hours [AFR]) was 11.0 in 2020, whereas, as a comparison, in the construction industry, the AFR was 17.8. (Confederation of Finnish Construction Industries, 2021). Despite a rather good OS performance in terms of its AFR when compared to others, there are indicators, like the number of safety observations per employee, that can be interpreted as signs of an immature safety culture inside the project. For instance, approximately 90% of all near miss reports are completed by 20% of the personnel. This indicates that not all the personnel at all organizational levels are committed to the common cultural values of the project.

2.2 Data Collection

This study was executed through a survey using a structured safety culture questionnaire. Surveys, like the one used in this study, can be considered as a systematic way to collect information from a sample of a target population to construct quantitative descriptors of the group's different attributes (Groves et al., 2011). The questionnaire, originally designed by experienced OS professionals, was introduced for commercial use in 2019, and since then it has been used in 12 countries with over 25 500 individual respondents. The questionnaire has reached its current form through a continuous development process, where customers have provided feedback and constructive development ideas. Now, the questionnaire can only be modified with minor customer-specific changes, and consequently, the results are somewhat comparable between companies.

The questionnaire includes six categories (CAT I–VI), of which I) organizational culture, II) leadership, III) safety systems, IV) personal involvement, and V) opinions and attitudes are targeted at all the respondents, whilst the last one, VI) questions for supervisors, is meant for those with managerial duties. As an example of CAT I: organizational culture, the following definition is given to the respondents: *"Organizational culture – this category focuses on organizational objectives, internal communication, and management's investment in a safety culture. These factors create the basis for safety work and attitudes towards the occupational safety culture."*

Each category includes five questions, and the response options cover a range of different aspects varying from poor (1) to excellent (4). As an example, a question from CAT IV is as follows: *Are you committed to changing your behavior or working habits if there is a safer option available*? For this question, the respondent is given four response options: *1) I work as I please; 2) I can change the way I work if everybody else does so as well and our supervisor makes sure it is done; 3) I can change my working methods to safer ones once I see the benefits. I do not need to be supervised; and 4) I can easily adapt to new ways of working. I can even develop better ways to work whenever I see a hazard. I am willing to share lessons thus learned with others.*

As background questions, the respondents were asked to fill in their age, work experience in the field of construction, the sector they worked in, and their position in terms of the project. In addition, the respondents were asked to fill in their organizational level and whether they were working for an alliance partner or a subcontractor and specify whether they had subordinates in order to define whether they held a foreman's position.

The questionnaire was conducted at the end of 2020. As the workforce was mainly domestic at that time, the questionnaire was only distributed in Finnish. The questionnaire was mostly answered electronically; however, 50 respondents used a printed sheet. This was due to their reluctance to use mobile applications or computers, and the latter method was the supervisors' suggestion for overcoming this. No apparent differences in replies were detected when the handwritten and electronic answers were compared.

Altogether, 360 individuals responded to the questionnaire. This is roughly half of the alliance project personnel at that time. The respondents were divided quite equally between alliance members (192; 53%) and non-alliance participants (i.e., the subcontractors) (168; 47%). This represents the actual personnel situation at the site very well. The age distribution was an equally realistic representation of the whole *Raide-Jokeri* population, with a clear majority (195; 54%) of participants in the 30–50-year-old age category and the rest under 30 (87; 24%) or over 50 years old (77; 21%). Concerning the respondents' positions in the project, two thirds (237; 66%) of the respondents were workers, whilst 80 (22%) held a site supervisor position and 8 (2%) a senior management position. The rest (35; 10%) of the respondents were in support staff, planning, and middle management positions (later labeled as "designers"). Work experience in the construction field was divided rather equally between five categories, with 46 (12%) having worked for less than one year, 92 (26%) with 1–5 years of experience, 65 (18%) with 6–10 years of experience, 87 (24%) with 11–20 years of experience, and 70 (19%) with over 20 years of experience in the field of construction.

2.3 Data Analysis

Average values were calculated for the six categories (CAT I–VI, Table 2). To examine OS perceptions among the personnel, these results were descriptively analyzed concerning the respondents' 1) position, 2) age, 3) experience, and 4) their employers' role in the alliance project. For the between-groups comparisons, the Kruskal-Wallis (K-W) test was used due to its suitability for both the right-skewed data of the values for the categories and for the ordinal nature of the individual questions. The test results are reported in the following format: [K-W, number of respondents per group, H(degrees of freedom), p-value]. As the survey did not force the respondents to answer every question, the number of respondents varied very slightly between the analyses due to single missing responses. To highlight different levels of statistical significance, *, **, and *** are used to denote significance levels of $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively. CAT VI was excluded from the between-groups analysis as the respondents in that CAT were mostly senior staff from the alliance consortium, rendering the comparisons meaningless. Altogether, 110 respondents answered the questions in CAT VI. However, only 84 of those formally worked in a position where they had supervision duties. This was because the items were open for all the participants to answer, regardless of their answers to the question on whether they had subordinates. For this reason, all the answers in this category from workers were discarded from the analysis.

3. RESULTS

This study showed signs of fairly good OS inside the alliance project, with an average score of around 3 or more for each of the 6 categories (Table 2). From the alliance management point of view, these findings could be interpreted as encouraging, as they showed that the leadership seemed to be somewhat consistent among the project personnel, from the core alliance members to the subcontractors, and that the safety systems utilized in the project were mutually understood and accepted, although there was room for improvement at all levels of the organization. Some interesting differences were identified among the respondents, as can be seen from Table 2, where the means for the different categories are shown concerning different variables from the respondent group.

TABLE 2. AVERAGE SURVEY VALUES FOR THE SIX CATEGORIES AND FOUR DIFFERENT VARIABLES

	CAT I: Organizational culture	CAT II: Leadership	CAT III: Safety systems	CAT IV: Personal involvement	CAT V: Opinions and attitudes	CAT VI: Questions for supervisors*
Position						
Workers	3.24	3.18	2.99	2.99	3.15	3.09
Supervisors	3.34	3.21	3.06	3.12	3.29	3.29
Designers	3.25	3.15	3.00	3.27	3.55	3.51
Senior management	3.60	3.30	3.15	3.43	3.53	3.48
Age (years)						
< 30	3.19	3.09	2.92	2.81	3.11	3.15
30–50	3.27	3.20	3.01	3.07	3.23	3.25
> 50	3.34	3.27	3.12	3.28	3.36	3.60
Experience (years)						
< 1	3.37	3.21	3.00	2.94	3.25	3.32
1–5	3.15	3.12	2.93	3.01	3.16	3.21
6–10	3.25	3.26	2.99	2.93	3.21	3.19
11–20	3.22	3.09	2.94	3.03	3.16	3.17
> 20	3.44	3.33	3.24	3.33	3.41	3.50
Role in the alliance						
Alliance member	3.26	3.14	2.99	3.11	3.28	3.30
Subcontractor	3.28	3.25	3.03	2.99	3.17	3.19

* The questions in CAT VI were only aimed at those in supervisor positions (n = 84) as opposed to the total number of respondents (n = 360).

In regard to the respondents' positions, the highest agreement across all the categories was found for CAT II (leadership), where the averages varied only slightly from 3.15 (designers) to 3.30 (senior management). Similarly, concerning CAT III (safety systems), the variation in the average values was modest, ranging from 2.99 (workers) to 3.15 (senior management). In the organizational culture category (CAT I), the averages were in general quite high, but the high average value for senior management (3.60) stands out from the others. Statistical comparisons between the different personnel groups indicated significant differences [K-W, n(workers) = 237, n(supervisors) = 80, n(designers) = 35, n(senior management) = 8, H(3) = 13.49, p = 0.004***] for question (Q) 16 "Are you committed to safety reporting?" [H(3) = 13.50, p = 0.004***]; Q19 "Are you committed to changing your behavior or work methods if there is a safer option?" [H(3) = 7.8, p = 0.05*]; and Q20 "Have you changed your personal safety habits at home?" [H(3) = 14.41, p = 0.002***]. All these questions belonged to CAT IV (personal involvement), with the workers' responses having the lowest values.

Statistical differences between the personnel groups were also detected concerning CAT V (opinions and atmosphere) [K-W, n(workers) = 236, n(supervisors) = 80, n(designers) = 35, n(senior management) = 8, H(3) = 18.98, p < 0.001***]. The differences related to Q21 "Do you believe in the concept of zero harm?" [H(3) = 23.28, p < 0.001***]; Q22 "Would you ever hide safety incidents?" [H(3) = 16.04, p = 0.001***]; and Q25 "Are you committed to safety or forced to consider it?" [H(3) = 15.81, p = 0.001***]. In all these questions, the workers' responses were lower than the others. For Q21 and Q22, senior management provided the highest averages; however, for Q25, the highest averages were given by the designers and the supervisors.

Concerning respondents' age as a variable, the variation within the categories was rather modest, with the respondents aged below 30 years old found to be, in general, the most critical. Multiple statistically significant differences were identified when the respondents' age was used as a variable. For CAT III (safety systems), the difference was rather small [K-W, n(< 30) = 87, n(30–50) = 196, n(> 50) = 77, H(2) = 4.9, p = 0.086*] and can be pinpointed to differences in responses to Q11 "Are you receiving frequent and interesting safety training?" [K-W, H(2) = 5.97, p = 0.051*] and Q12 "Is there a clear plan for your team's development of a safe work environment?" [K-W, H(2) = 6.66, p = 0.036**].

For both CAT IV (personal actions) [K-W, n(< 30) = 87, n(30–50) = 196, n(> 50) = 77, H(2) = 30.76, p < 0.001***] and CAT V (opinions and atmosphere) [K-W, n(< 30) = 87, n(30–50) = 196, n(> 50) = 77, H(2) = 10.44, p = 0.005***], the difference was greater. In CAT IV (personal actions), statistically significant differences were found across all the questions [K-W]: Q16 "Are you committed to safety reporting?" [H(2) = 14.38, p = 0.001***]; Q17 "Are you committed to good housekeeping?" [H(2) = 10.57, p = 0.005***]; Q18 "How would you react if someone were to stop you performing unsafe work?" [H(2) = 11.51, p = 0.003***]; Q19 "Are you committed to changing your behavior or work methods if there is a safer option?" [H(2) = 9.42, p = 0.009***]; and Q20 "Have you changed your personal safety habits at home?" [H(2) = 34.45, p < 0.001***]. For every question, the older the response group, the higher the average response. The same pattern was found in CAT V (opinions and atmosphere) and was statistically significant for all the questions except for Q24 "Do you have a reactive, 'fire-fighting' culture?" [K-W; Q21 "Do you believe in the concept of zero harm?" [H(2) = 8.9, p = 0.012**]; Q22 "Would you ever hide safety incidents?" [H(2) = 5.64, p = 0.060*]; Q23 "How easy is it to talk about safety within your team?" [H(2) = 5.51, p = 0.064*]; and Q25 "Are you committed to safety or forced to consider it?" [H(2) = 8.54, p = 0.014**].

A similar pattern could be observed when comparing groups with different work experience in construction. Statistically significant differences were found across all the categories [CAT I: K-W, n(< 1) = 46, n(1–5) = 92, n(6–10) = 65, n(11–20) = 87, n(> 20) = 70, H(4) = 13.18, p = 0.010**; CAT II: K-W, H(4) = 9.14, p = 0.058*; CAT III: K-W, H(4) = 12.12, p = 0.015**; CAT IV: K-W, H(4) = 25.3, p < 0.001***; CAT V: K-W, H(4) = 12.22, p = 0.016**]. The "over 20 years of work experience" group stands out across all the categories with its higher response means.

When the employer's role (alliance member or subcontractor) was used as a variable, the variation changed between the groups and across the different categories. Interestingly, those participants representing subcontractors answered more positively in CAT I, II, and III. This could be interpreted that they in general feel that the organizational culture inside the alliance seems justified, with formal safety systems and established leadership practices in use. However, the subcontractors might consider themselves as being in a position where they have relatively little power to influence the work through their personal involvement and by expressing their opinions and attitudes. The only statistically significant difference was found for CAT II (leadership) [K-W, n(alliance member) = 192 and n(subcontractors) = 168), H(1) = 4.92, p = 0.026**]. Upon the closer inspection of the individual questions in this category, statistically significant differences were detected for Q6 "Are the leaders active safety role models?" [H(1) = 4.92, p = 0.063*]; Q8 "Do the leaders give positive feedback and constructive criticism related to safety?" [H(1) = 3.89, p = 0.049**]; and Q10 "Are the leaders actively developing the safety culture?" [H(1) = 4.29, p = 0.038**]. In all these three questions, respondents representing subcontractors responded more positively compared to alliance consortium members.

3.1 OS from the Foreman Perspective

The questions in CAT VI were meant for those in foreman positions. Nine out of ten of the supervisors (76; 90%) expressed that they received the necessary support from their own superiors. Most of the supervisors (67; 80%) stated that they would not ignore breaches in safety protocols and would likely take action to improve OS. However, 11 respondents (13%) answered that they would only interfere if it was something serious, and 6 respondents (7%) felt that there was no chance of them interfering in every negative incident. The safety organization was found to be supportive or very supportive by 68 (81%) respondents, whilst 13 (16%) felt that the support concentrated on rules and regulations, and 3 felt that they did not get enough support. Of the respondents, 71 (85%) felt motivated or highly motivated in terms of improving OS in the workplace, whilst 9 (11%) expressed that they felt motivated but found it hard to find time to fulfill all the requirements, and 4 of the respondents experienced that OS was mostly implemented because it had to be and felt that production was their primary duty. A vast majority of the respondents (80; 95%) representing supervisors or management considered that in the OS management context they treat subcontractors in the same way as they treat alliance consortium members. Finally, 71 (85%) respondents found the safety requirements and procedures clear in this alliance project, while only 2 felt they were unclear and reactive.

4. DISCUSSION

This survey study provided new empirical insights into a scarcely studied area on OS inside a large-scale construction project that is executed as an alliance project. In alliance projects, the gains and pains are shared between the consortium stakeholders. Thus, the premises of an alliance project differ significantly from those of traditional project-based construction projects, where different risks are allocated to the stakeholders that are believed to be in the best position to manage them. This study describes an alliance project where OS practices and processes have been developed rather successfully, with good responses in general to the questionnaire, but on the other hand, the survey reveals important aspects to pay attention to when considering development actions.

Despite being based on a survey, the findings of this study can be interpreted from the safety culture perspective. Safety culture is not a stable state, but instead a multidimensional construct. Thus, different cultures can be positioned at various positions, making the evaluation of the safety culture complex (Guldenmund, 2010). This is especially crucial to understanding the construction context as construction sites are naturally and continuously developing working environments, where various actors are involved for longer or shorter periods of time during the project's lifecycle (Flanagan et al., 2007). Although questionnaires should be interpreted with extra caution due to their weaknesses (Guldenmund, 2007), this survey still showed how the respondents representing the subcontractors and personnel from alliance member companies answered in a rather similar fashion, with those representing subcontractors expressing a little more positivity (CAT I–III). Only in CAT III on leadership was the difference statistically significant, emphasizing subcontractors' satisfaction with the leadership in terms of practical OS issues. From the sparsely studied OS in alliances perspective, this is interesting and at least somewhat in contradiction with previous studies as, for instance, Biggs et al. (2013) and Chen and Jin (2015) emphasized the role of subcontractors and their often inadequate management practices and processes as being among the major barriers to safety culture improvement in construction.

Organizational culture, as one of the six categories in the survey, was generally experienced in a positive manner with average values well above 3 on a scale of 1 to 4. The questions within that category focused on management commitment to OS, target setting, OS communication, and a sense of balance between OS and production in this context. The answers were quite evenly distributed when the respondents' position, age, and employer's role in the alliance project were used as variables. Statistically significant differences were detected only when the respondents' work experience was used as a variable. In general, those with only a little experience and those with a long history in the field of construction evaluated the organizational culture more positively than the rest. In addition to their work experience, the respondents' age was a variable that showed statistically significant differences

concerning categories III, IV, and V. In general, when the average values of the categories were compared between different age groups, it was observed that in the sample the average response rises along with age without exception. This parallels well with earlier literature (e.g., Idrees et al., 2017; Sawacha et al., 1999), which has observed that the older a construction employee is, the more aware he/she is of OS requirements.

The survey section for those in a formal supervisor position revealed some important aspects that should be considered from the foreman competencies perspective. Although the supervisors in general seemed satisfied with the OS practices and processes inside the alliance project, there were also some indications of potential obstacles to good OS and stakeholders' commitment to it. Naturally, these obstacles should be dealt with during the project, but they should also be considered as lessons learned to facilitate good management in future alliance projects (Paver & Duffield, 2019). As shown in the previous OS research literature (Biggs et al., 2013; Stajkovic & Luthans, 2003; Zou, 2011), the strongest obstacles to safety culture relate to leadership and management commitment and conflicting messages when their words and actions do not correspond. Some indications of such obstacles could be interpreted from the findings of this study as there were, for instance, some supervisors who considered it challenging to act under the simultaneous pressures resulting from OS and production demands.

4.1 Future Studies

This study provides important new insight into a sparsely studied area (i.e., OS in an alliance project). In the future, this study could be utilized as a basis for others where the development of a safety culture inside an alliance project is examined. The long span of the project from 2019 to 2024 will enable such study settings. As a topic for future research, we propose focusing on the six construction area sectors and the three other units inside this alliance to examine whether there is any variation in OS and safety culture inside the alliance at the unit/sector level. As emphasized by Provonost and Sexton (2005), such an examination that includes the unit level could provide additional and valuable insights into safety culture.

When unit-level examinations or before-after setups are considered, a mixed-methods study approach (see Shorten & Smith, 2017) with more sophisticated data collection and analysis methods should be considered. A mixed-methods study could include a follow-up survey based on the same questionnaire and the findings (i.e., possible changes in the safety culture could be interpreted through qualitative interviews, field observations, and project document analyses; see Haukelid, 2008). Without explicit context analysis, such a study setting is difficult to arrange in this constantly evolving construction environment involving multiple organizations. This study provides a base for context definition. From the OS perspective, however, the following development actions that have been initiated during 2021 (i.e., after the survey reported in this article) should be acknowledged when the context is analyzed: 1) common OS goals set for all personnel, 2) accident investigation training for supervisors, 3) positive feedback training for supervisors, 4) toolbox talk training for supervisors, 5) safety walks at the site by OS professionals, 6) monthly OS visits to the site by senior management, and 7) the launch of general safety awareness campaigns. In addition, as a major contributor to the Covid-19 situation, the extensive Covid-19-preparedness program launched in 2021 should be acknowledged.

4.2 Limitations

The notions of Guldenmund (2007) on the challenges of using questionnaires in exploring OS and safety culture should be acknowledged when considering the limitations of this study. Indeed, without careful context description, the results may end up being rather vague. For that purpose, a context definition is provided with an adequate description of the project.

This survey was conducted during the Covid-19 epidemic, which also hit the project hard. The survey was planned to be conducted during employees' weekly toolbox talk sessions, but two local outbreaks of the infection in Southern Finland made it impossible as all such sessions were cancelled. This likely affected the number of respondents as answering the questionnaire was left up to the individual employees without supervisor coordination. This might, therefore, have also affected the results, as the respondents did not experience pressure to answer the questionnaire.

The survey utilized in this study was developed for practitioner purposes, and prior to the study, it had been used in 12 countries with 25 500 individual responses in total. In future research, scientific methods could be involved in the further development of the instrument. It is possible that some respondents answered more from the perspective of their actual employer than the alliance project, even though the respondents were given instructions to answer on behalf of the alliance project. In addition, based on the feedback collected from the survey, some individual respondents found some of the questions too long and complicated to understand. This is probably because the average construction worker is not highly educated and does not work with literate affairs daily. Yet, this was not deemed a major problem as the number of longer worded questions was quite modest. However, for future study purposes, some questions should be presented with better and more practice-oriented explanations.

5 CONCLUSIONS

Construction alliance projects provide, based on the idea of pain-share/gain-share, a novel area to study whether such a collaborative arrangement also covers OS at the site. In this study, the focus was a large-scale Finnish construction project, *Raide-Jokeri*, with the idea of examining the OS perceptions at the site from different perspectives. A questionnaire was utilized for this purpose. More specifically, this study sought to observe how OS was perceived within the project and by the different parties in the alliance, namely the alliance members and the subcontractors and different personnel groups. The analyses showed generally good OS in the project but also revealed certain areas for development. Interestingly, the development topics were raised by all project personnel and were not seen as issues only relevant to the two parties of the alliance project: the alliance members and the subcontractors. This could be interpreted as a success factor for the alliance management.

From the alliance OS management perspective, certain signs of a common safety culture could be interpreted from the findings, as the generally good level of OS perceptions has spread to all the project stakeholders, regardless of their formal role in the project. The questionnaire did, however, also reveal certain areas where development actions should be focused. For instance, it was observed that the average responses rose with age without exception. In addition, those with limited work experience and those with a long history in the construction business answered more positively. Hence, when considering development actions, the large population in between (i.e., the middle-aged and those with an average length of experience in the field) should be considered with extra caution.

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OCCUPATIONAL SAFETY IN A CONSTRUCTION ALLIANCE PROJECT: FINDINGS FROM A LARGE-SCALE FINNISH LIGHT-RAIL PROJECT