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OCCUPATIONAL SAFETY AND HEALTH RISK IN BUILDING CONSTRUCTION PROJECTS: A LITERATURE REVIEW

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Review paper

Abstract. *Construction building projects have the highest accident rates compared to other industrial projects. For this reason, special attention needs to be paid to all stakeholders, starting from management, contractors and the government to reduce the number of work accidents, occupational diseases, especially in the field of construction. Based on the background of the problem and the results of the literature review sourced from journals collected and reviewed discussing occupational safety and health in construction projects in this paper concludes that there are two sources of risk that are very influential namely risks originating from internal and external, both viewed technically and non-technically. Technical results can be seen from the use of 4D-BIM technology, the use of personal protective equipment, the use of construction tools according to their permits and the non-technical results, namely awareness to work safely, knowledge and culture about occupational safety and health, construction building projects have the highest accident rates compared to other industrial projects. For this reason, special attention needs to be paid to all stakeholders, starting from management, contractors and the government to reduce the number of work accidents, occupational diseases, especially in the field of construction. Based on the background of the problem and the results of the literature review sourced from journals collected and reviewed discussing occupational safety and health in construction projects in this paper concludes that there are two sources of risk that are very influential namely risks originating from internal and external, both viewed technically and non-technically. technical results can be seen from the use of 4d-BIM technology, the use of personal protective equipment, the use of construction tools according to their permits and the non-technical results of awareness to work safely, knowledge and culture about occupational safety and health, incentives or gifts given by management and support from the government regarding commitments and supervision for occupational safety and health in construction building projects.*

Key words: *occupational safety and health, construction management, risk management, building construction.*

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1. Introduction

With the rapidly increasing construction projects in the last few decades, the challenges of occupational safety and health in the construction industry have become even greater. The safety record of the construction industry is always bad, it remains one of the most dangerous industries to work. the magnitude of the risk of accidents that occur depends also on the number of risks or hazards identified. Factors that influence include task complexity, organizational factors such as giving incentives or bonuses, personal factors such as fatigue, work environment such as work pressure, and external factors such as weather (Hallowell and Gambatese, 2009). However, the most recognised occupation safety and health hazards on construction sites have been working at height, working underground, working in confined spaces and proximity to falling materials, handling load manually, handling hazardous substances, noises, dusts, using plant and equipment, fire, exposure to live cables, poor housekeeping and ergonomics (Okoye, 2018). Occupational safety and health not only target construction workers from the local area but also need to provide protection to migrant workers (Bust et al. 2008). The reasons construction is risky and prone to occupational safety and health risks are because of the physical environment of the work, nature of the construction work operations, construction methods, construction materials, heavy equipment used, and physical properties of the construction project itself (Laryea and Mensah 2010). To overcome work accidents, efforts are also being made using technology, namely the ongoing BIM Safety research project, which aims to develop and test solutions for planning and safety management of construction sites using a more dynamic 4D site model where the aim of the BIM Safety research project is to develop procedures and use of BIM technology for safety planning, management and communication part of 4D construction planning (Sulankivi et al. 2010). Hazards in the workplace also when combined with task requests, organizational factors, work environment, personal factors, and external factors can produce unacceptable safety risks in the field of personnel and can cause severe injuries at work for that is an important form of approach this behavior is the application of an incentive safety program. Safety incentive programs, if carefully chosen and implemented correctly, can create high safety awareness that leads to reduced risk taking and enhanced behavior safety culture. Safety incentive programs are usually associated with rewards, either extrinsic or intrinsic, given to workers to encourage safe actions and behavior (Karakhan and Gambatese, 2018).

2. Methodology

Writing this article is ba sed on a literature review obtained online from a trusted source that discusses risk identification (Figure 1)and management of occupational safety and health risks which is then reviewed and synthesized to provide the latest information.

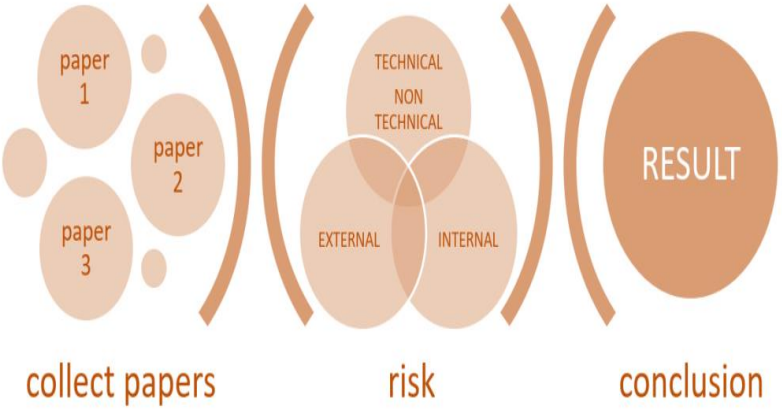

Figure 1. The method to identify risk

3. Result and Discussion

The review of the publication of scientific articles was carried out from several sources, namely: Google Scholar, ASCE, Science Direct, Researchgate, Springer, Proquest, etc. The list of selected articles is analyzed from aspects of identifying occupational safety and health risks in building construction projects as shown in Table 1.

Table 1: Review of identifying occupational safety and health risks in building construction projects

No	Paper Identity	Risk Identification				Results
		Internal		External		
		T	NT	T	NT	
1	Hallowell and Gambatese, (2009)	✓	x	x	x	Results indicate that there are 13 major activities required to construct concrete formwork and the highest risk activities are applying form oil, lifting and lowering form components, and accepting materials from a crane.
2	Okoye, (2018)	✓	x	x	x	The study found that masonry, carpentry (including formwork and roofing), and iron bending and steel fixing are common building trades associated with high risks; whereas electrical fitting and installation, painting, tiling, and plumbing are medium risk building trades.
3	Bust et al. (2008)	x	✓	x	x	The challenge of converting the health and safety systems to accommodate a multi national / cultural workforce is being addressed using initiatives such as, translation of health and safety materials, use of interpreters and an increased use of visual methods for communicating health and safety messages.
4	Laryea and Mensah (2010)	x	✓	x	x	The primary reasons are a lack of strong institutional framework for governing construction activities and poor enforcement of health and safety policies and procedures.
5	Kahkonen et al. (2014)	✓	x	x	x	providing more illustrative site layout and safety plans, providing methods for managing and visualizing up-to date plans and site status information, as well as by supporting safety communication in various situations, such as informing site staff about coming safety arrangements or warning about risks
6	Karakhan and Gambatese, (2018)	x	✓	x	x	Incentives are motivations associated with future rewards, either extrinsic or intrinsic, that are contingent upon the fulfillment of future conditions determined ahead of time before the start of work operations.
7	Lin Mills, (2000)	x	✓	x	x	Existing government safety regulations place considerable pressure on all firms, to protect the construction workforce.
8	Cooke et al. (2008)	✓	x	x	x	The ToolSHeD™ DS tool addresses an issue of emerging importance, i.e. the need to address OHS in construction design. The potential to reduce OHS risks during the design stage of buildings and other structures has gained considerable recognition among industry policy-makers and legislators.
9	Pinto et al. (2011)	✓	x	x	x	This knowledge should be further extended to support a more in-depth risk analysis and modeling in the construction industry
10	Johnstone et al. (2014)	x	✓	x	x	Situations where the legal responsibilities of employers are more ambiguous and attenuated.While subcontracting and the leasing of workers had been a long-term feature of the some industries (like construction), the expansion of these practices to other industries creates additional logistical demands on often already stretched inspectorates.
11	Baxendale and Jones (2000)	x	✓	x	x	The CDM Regulations are aimed at improving the overall management and coordination of health and safety throughout all stages of a CP with the aim of reducing the number of serious and fatal accidents and causes of ill health that occur in the industry.
12	Manu, et al. (2017)	x	✓	x	x	While the study has shown that in each country there are practices that are not commonly implemented by contractors (and hence need attention from contractors and relevant bodies/ institutions in the countries).
13	Holmes et al. (1999)	✓	x	x	x	The risk of occupational skin disease is perceived to be unknown and associated with delayed effects. The risk of falling from height is perceived to be highly relevant to the work of small business construction firms.
14	Fortunato III et al. (2012)	✓	x	x	x	The results indicate that (1) workers on LEED construction projects are exposed to work at height, with electrical current, near unstable soils, and near heavy equipment for a greater period of time than workers on traditional projects; (2) workers are exposed to new high-risk tasks such as constructing atria, installing green roofs, and installing photovoltaic (PV) panels; and (3) some credits result in a positive impact on construction worker safety and health when low volatile organic compound (VOC) adhesives and sealants are specified.
15	Windapo, (2013)	x	✓	x	x	Regulatory requirements by contractors because of cost implications will lead to unsafe work condition, injuries and fatalities on construction sites
16	Yuan, et al. (2018)	✓	x	x	x	The results of performing SEM indicated that the direct impacts of construction workers' P&M health on work efficiency and productivity were identified to be much more important than that of the SNC. In addition, construction workers' social capital can indirectly influence the work efficiency and productivity by affecting the construction workers' P&M health.
17	Wu et al. (2018)	x	✓	x	x	This study contributes to the current stress-management research by developing a reliable factor structure of construction workers' job stress, including the job itself, family-work conflict, career development, organizational style, interpersonal relationship, and role management.
18	Wachter and Yorio, (2014)	x	✓	x	x	Results indicate the following: there is a significant negative relationship between the presenceof ten individual safety management practices, as well as the composite of these practices, with accidentrates; there is a significant negative relationship between the level of safety-focused worker emotionaland cognitive engagement with accident rates; safety management systems and worker engagementlevels can be used individually to predict accident rates; safety management systems can be used topredict worker engagement levels; and worker engagement levels act as mediators between the safetymanagement system and safety performance outcomes (such as accident rates).

19	Cheung, et al. (2004)	x	✓	x	x	The combined effect of these components results in a system that enables speedy performance assessment of safety and health activities on construction sites. With the CSHM's built-in functions, important management decisions can theoretically be made and corrective actions can be taken before potential hazards turn into fatal or injurious occupational accidents.
20	Zhou et al. (2012)	x	✓	x	x	Bringing these strands of literature together suggests new kinds of interventions, such as the development of tools and processes for using digital models to promote mindfulness through multi-party collaboration on safety.
21	Howard et al. (2017)	✓	x	✓	x	This paper describes the four major uses of UAVs, including their use in construction, the potential risks of their use to workers, approaches for risk mitigation, and the important role that safety and health professionals can play in ensuring safe approaches to the their use in the workplace.
22	Badri, et al. (2012)	x	✓	x	x	A new concept called risk factor concentration along with weighting of risk factor categories as contributors to undesirable events are used in the analytical hierarchy process multi-criteria comparison model with Expert Choice software.
23	Ringen et al. (1995)	x	✓	x	x	Potential solutions are in labor-management site safety and health planning and management. education and training of workers and supervisors, new technologies, federal regulation, workers' compensation law, medical monitoring, and occupational health delivery.
24	Idoro, (2011)	x	✓	x	x	Thus, the results reveal the challenges facing Nigerian contractors and other stakeholders working to improve the OHS performance of the industry. The findings indicate the need for effective risk management and regulation and control of OHS in the Nigerian construction industry.
25	Martinez-Aires, et al. (2018)	✓	x	✓	x	The main result shows that the growing implementation of BIM in the Architecture, Engineering and Construction (AEC) industry is changing the way safety can be approached. Potential safety hazards can be automatically identified and corresponding prevention methods can be applied using an automated approach.
26	Badri, et al. (2018)	x	✓	x	✓	As major changes are implemented, previous gains in preventive management of workplace health and safety will be at risk. If we are to avoid putting technological progress and OHS on a collision course, researchers, field experts and industrialists will have to collaborate on a smooth transition towards Industry 4.0.
27	Carter and Smith, (2006)	x	✓	x	✓	A max. of only 6.7% of the method statements analyzed on these projects managed to identify all of the hazards that should have been identified, based upon current knowledge. Maximum hazard identification levels were found to be 0.899 _89.9%_ for a CP.
28	Rahmawati et al. (2019)	✓	✓	x	x	Project Safety Review, Safety Inspection, Installation project signs, Safety morning, Personal Protective Equipment, Safety Net Installation, Installation of Safety Line, Installation of lighting to clean up the Project area is the application of the K3 program that is carried out.
29	Astiningsih et al. (2018)	x	✓	x	x	There was an association between safety inspection and the use of PPEs (p = 0,024; α=0,05); safety supervision and the use of PPEs (p = 0,024; α=0,05); safety morning and the use of PPEs (p = 0,043; α=0,05).
30	Hidayat, (2018)	x	✓	x	x	K3 risk is known to be levelneach risk is 1 risk classified as high risk, 41 risk classified as medium, and 9 risks classified as Low Risk.
31	Bria and Loden, (2017)	x	✓	x	x	Alternative risk controls that can carried out at the risk of workers falling, controlling the risk is a daily K3 inspection for the use of PPE (Personal Protective Equipment) complete, tightening management supervision of workers who do not wear personal protective equipment, provide and complete the signs safety in construction projects if none o incomplete.
32	Atmaja et al. (2018)	✓	✓	✓	x	Construction site of cronbach's values alpha count obtained by 0.908 means that it can it is said that for characteristic variables Reliable site construction because of the alpha value between 0.61 - 0.80. Could concluded the consistency of the questions for the sub-variables is necessary training on the importance of OSH in a the project is very consistent and very appropriate.
33	Suparman and Fitriani, (2016)	✓	✓	x	x	There are 64 occupational injury risks, i.e., 13 low risk, 47 medium risk, and 4 high risk. It can be concluded that the highest risk factor for the workers is inhaled the welding smoke with the risk index of 16.
34	Endroyo, (2010)	x	x	x	✓	Educational factors correlated 0.30 (significance: 0.048) contribute to attitude of K3, and was another factor correlations were not significant. All these factors have only to give efectif contribution about to 0.213 (21.3%) of the attitude factor K3. It means that about of 78.7% which can not be explained and is a problem to be studied again.
35	Wijaya and Paing, (2018)	x	✓	x	✓	Dominant factor affecting k3 there are 5 namely change workers must be responsible for K3, K3 regulations and procedures are very in need, K3 regulations are easily applied consistently, the results of the work are fulfilling standard quality and the absence of work accidents in the work environment for certain reasons.
36	Sutrisno, et al. (2000)	x	✓	x	✓	Measurement of the influence of the safety climate on the most influential safety behavior on variable X (climate safety) of the Y variable (safety behavior), namely Communication, Perception of someone's involvement in K3 and Accidents / incidents/ nearmiss.
37	Pradipta, et al. (2015)	✓	✓	x	x	The most determining factor for the lack of completeness of K3-L is the Factor Handling of Work Accidents where workers do not apply implementation of Standard Operating Procedure (SOP) at work and less implementation of health insurance implementation.
38	Milen, et al. (2012)	x	✓	x	x	All the three project cases has a medium risk due to accident caused by ignoring the safety standards and procedure are obvious.

39	Novianto and Sri, (2016)	x	✓	x	x	Free variables occupational safety (X1) and health (X2) against K3 problem simultaneously and partial positive and significant influential variable against the performance of construction workers on the project construction of the Fly Over Palur, where the influence of variable X1 amounted to 1,903 (54,38%) and X2 of 1,098 (45,62%)
40	Hakim, (2017)	x	✓	x	x	In the risk matrix analysis there are 3 jobs that are categorized as high risk include worker falls from height at reinforcement, formwork and parapet, full electric shock on electrical installation work, and materials falls from a height and hit the worker in erection work.
41	Sanjaya et al. (2012)	x	✓	x	x	That the connection of factors that influence K3 to implementation of K3 in building construction was high (0.614), determination coefficient about 0.377 that showed the mean of K3 in building construction about 37.7 % which were determined by three factors that influenced K3, while 62.3 % were determined by the other factors. The result of relative distribution counting showed that supervising factor gave biggest influence to K3 in building construction.
42	Hartanto and Siahaan, (2018)	x	✓	x	x	The five independent variables of this order of magnitude of influence are caused by OSH Management System (X2) 73,4%, Self Protective Equipment Mechanism (X3) 60,9%, Definition and Initiation OSH (X1) 42,6%, OSH Risk (X5) 7,9% and OSH Facility and Infrastructure (X4) 3,5% so that which needs to be handled by the project leader is based on the order of the percentage.
43	Kani, et al. (2013)	x	✓	x	x	That there are still many workers who do not know about K3. What is meant by K3, how to apply K3, and so forth. This shows that there is still a lack of attention or commitment from the contracting company to implement the K3 program well.
44	Munang, et al. (2018)	x	x	x	✓	Assessing railway double rail project has identified 19 unexpected risks as a high risk and 12 unacceptable risks that are required risk mitigation to reduce the impact.
45	Triaswati et al. (2014)	x	✓	x	✓	From the K3 management system It is planned that a risk control fee of Rp 310,266,500.00 is obtained be a reference in suppressing the accident rate.
46	Soputan, et al. (2014)	x	✓	x	x	A high risk value is obtained, i.e. the material is dropped from height and override workers with a risk index of 20 and risk classification to Very High risk. For risk classification at the High Risk level as many as 21 variables can be endangering workers and jobs, while for classification at the Medium Risk level obtained as many as 18 variables.
47	Indah, (2017)	✓	✓	x	x	The level of K3 implementation on aspects of the personal protective equipment (60%), the role of emergency condition (75%), Structural work, Scaffolding and Ladder (66.7%), Use of Toxic and Dangeorus Materials (62.9%), Health and Hygiene of Work Environmental (89.2%).
48	Handayani and Prihatiningsih, (2018)	x	✓	x	x	It is found that the cause of risk in OHS for construction sector is dominated by structure criterion (44%), followed by preparation criterion (17%), sub-structure criterion (21%) and finishing criterion (19%). The biggest cause of occupational accidents is human factor by 77%,
49	Tannya et al. (2017)	x	✓	x	x	the most influential inhibiting factor is the lack of knowledge about SMK3 from the company and its employees. Of the inhibiting factors that have been obtained, it is suggested several alternative solutions

Note: √ (discussed), X (not discussed), T – technical, NT - nontechnical

3.1. Internal Technical Risk

Results indicate that there are 13 major activities required toconstruct concrete formwork and the highest risk activities are applying form oil, lifting and lowering form components, and accepting materials from a crane (Hallowell and Gambatese, 2009). The study found that masonry, carpentry (including formwork and roofing), and iron bending and steel fixing are common building trades associated with high risks; whereas electrical fitting and installation, painting, tiling, and plumbing are medium risk building trades. It also found that the rate of occurrence and magnitude of impact of different safety risk factors differ across the building trades, which could be attributed to the differences in activities and modes of operation in different building trades (Okoye, 2018). The main objective of the BIM Safety research project is to develop procedures and use of BIM technology for safety planning, management, and communications, as part of the 4D-construction planning (Sulankivi et al. 2010). Developed to help construction designers to integrate the management of OHS risk into the design process (Cooke et al. 2008). For the construction industry, discussing their limitations and pointing advantages of using fuzzy sets approaches to deal with ill-defined situations (Pinto et al. 2011). The results indicate that (1) workers on LEED construction projects are exposed to work at height, with electrical current, near unstable soils, and near heavy equipment for a greater period of time than workers on traditional projects; (2) workers are exposed to new high-risk tasks such as constructing atria, installing green roofs, and installing photovoltaic (PV) panels; and (3) some credits result in a positive impact on construction worker safety and health when low volatile organic compound (VOC) adhesives and sealants are specified. It is expected that these results can be used by practitioners to focus attention and resources on new highrisk work environments (Fortunato III et al. 2013). This review explores relationships between construction safety and digital design practices with the aim of fostering and directing further research. It surveys state-of-the-art research on databases, virtual reality, geographic information systems, 4D CAD, building information modeling and sensing technologies, finding various digital tools for addressing safety issues in the construction phase, but few tools to support design for construction safety (Yhou et al. 2012). Using UAVs in carrying out planned or reactive maintenance inspections of tall structures, such as skyscrapers, bridges, and towers where access can be costly and pose a risk to workers of falling from a great height, appears to be a clear benefit for construction managers and workers (Howard et al. 2012). The main result shows that the growing implementation of BIM in the Architecture, Engineering and Construction (AEC) industry is changing the way safety can be approached. Potential safety hazards can be automatically identified and corresponding prevention methods can be applied using an automated approach (Martinez-Aires et al. 2018). The use of appropriate methods of implementation, weak supervision of construction implementation in the field, not yet fully implementing the regulations regarding existing K3, weak supervision of the implementation of K3, inadequate both in the quality and quantity of the availability of Personal Protective Equipment (PPE) availability (Rahmawati et al. 2019). Technical equipment factors, factory ugliness problems, equipment used, machines that are no longer suitable for use (Atmaja et al. 2018). The factors assessed by respondents are still not fulfilling K3L completeness, namely lack of fire fighting equipment, no medical equipment / first aid kit at the project location, signs not properly installed, and lack of data collection for workers who experience illness or work accidents (Milen, 2012). The constraints to applying OHS in general are budget constraints, the culture of workers who are not

familiar with the application of OHS and the impact of the application on the cost and selling price of property construction (Handayani and Prihatiningsih, 2018).

3.2. Internal Non Technical Risk

This context we argue that it is crucial to identify the sorts of (audio)visual narratives and forms that can effectively communicate about Health and Safety in ways that are meaningful and relevant to construction workers employed in multicultural contexts (Bust et al. 2008). The primary reasons are a lack of strong institutional framework for governing construction activities and poor enforcement of health and safety policies and procedures (Laryea and Mensah, 2010). The results show that the major factors influencing safety performance were; company size, and management and employee commitment to OHS (Lin andMills, 2001). The efforts by OSHA to make prime contractors take responsibility for their subcontractors would place pressure on them to take control of subcontractors in a way that threatens this distancing and the manipulation of legal forms it entails (Johnstone et al. 2000). The CDM Regulations are aimed at improving the overall management and coordination of health and safety throughout all stages of a construction project with the aim of reducing the number of serious and fatal accidents and causes of ill health that occur in the industry (Baxendale and Jones, 2000). Overall, the findings offer an opportunity for contractors and key industry stakeholders (e.g. state authorities) to reflect on their approach/initiatives to improving H&S management in construction (Manu et al. 2018). Social, economic and cultural factors of workers and lack of discipline among workers in complying with K3 provisions, including the use of PPE for work accidents (Rahmawati et al. 2019). The workforce still lacks understanding of PPE knowledge (Astiningsih et al. 2018; Munang et al. 2018). 1 variable with a high level of risk (High Risk) in casting jobs, namely workers falling from a height, fall of equipment / material, injured workers will be in direct contact with tools, workers exposed to dust, workers slip, until workers are exposed to electrical contact (Hidaya, 2018; Soputan et al. 2014; Indah, 2017). From the multiplication of risk frequency and risk impact, it is also obtained the criteria for the highest causes of work accidents are human beings with Risk Level L (Low) by 56% and subc criteria for the highest causes of accidents is not using PPE with Risk Level L (Low) by 56% (Bria and Loden, 2017; Handayani and Prihatiningsih, 2018). Human Factor It means that workers do not know safe procedures or dangerous actions: unable to meet work requirements so that actions occur below standard, knowing all the rules and work requirements but not complying with them (Altmaja et al. 2018). The highest risk obtained in the Palembang Musi VI Bridge construction project is risk factor 17.E is absorbed by welding fumes with a risk index of 16 (Suparman and Fitriani, 2016). Factors that influence occupational safety and health on the performance of construction work construction projects in Surabaya are communication between the contractor and the owner (Wijaya and Paing, 2018). Based on the partial regression test (backward method - Enter method), the X variable which influences Y variable is communication, perception of someone's involvement in K3, accident/incident/nearmiss (Sutrisno et al. 2000). The most decisive factor for the lack of completeness of K3-L on the Hotmix road project of the Sumbawa Regency Public Works Office is the Factor in Handling of Work Accidents where workers do not implement the Standard Operating Procedure (SOP) at work and lack the implementation of health insurance (Milen, 2012). The highest and most frequent risk is the X.15 variable, where workers do not use PPE in the field as an accident factor that occurs in construction projects (Novianto et al. 2016). The independent variable

Occupational Health Safety (X1) and Occupational Health (X2) on K3 problems simultaneously and partially have a significant and positive effect on the performance variable of construction workers on the Fly Over Palur development project, where the influence of variable X1 is 1,309 (54.38%) and X2 of 1,098 (45.62%) (Hakim, 2017). The highest risk index is known, that is, the variable of Workers falls from height in construction, formwork and parapet work with a total risk index of 13.8. The lowest risk index is found in the variable Workers exposed to respiratory disorders due to compressors on road markings with a total risk index of 5.5 (Sanjaya et al. 2014). The factor which gives the biggest influence/contribution to K3 on building construction projects is the supervision factor (Hartanto and Siahaan, 2018). The results of these five independent variables in order of magnitude of influence are caused by the K3 Management System (X2) 73.4%, the Mechanism of Personal Protective Equipment (X3) 60.9%, the Definition and Initiation of the K3 (X1) 42.6%, the K3 Risk (X5) 7.9% and K3 Facilities and Infrastructure (X4) 3.5% (Kani et al. 2013). Work accidents on construction projects are caused by human factors that neglect work safety by behaving unsafe at work (Soputan et al. 2014). K3 management plays a very important role in accident prevention in construction projects. The role starts from planning, organizing, implementing, monitoring. Furthermore, it can also be viewed from human components, materials, money, machines / tools, work methods, information. The final results of this study are: the order of the top 3 (three) of the factors that influence the implementation of the K3 work system namely (costs for PPE providers, joking while doing work, lack of knowledge of workers on the dangers and risks of the work done) (Sihombing et al. 2014).

3.3. External Technical Risk

Using UAVs in carrying out planned or reactive maintenance inspections of tall structures, such as skyscrapers, bridges, and towers where access can be costly and pose a risk to workers of falling from a great height, appears to be a clear benefit for construction managers and workers (Howard et al. 2018). The main result shows that the growing implementation of BIM in the Architecture, Engineering and Construction (AEC) industry is changing the way safety can be approached. Potential safety hazards can be automatically identified and corresponding prevention methods can be applied using an automated approach (Martinez-Aires et al. 2018). Work environment factors, the physical environment of the workplace and the wider psychological social environment (Atmaja et al. 2018).

3.4. External Non Technical Risk

Researchers, field experts and industrialists will have to collaborate on the implementation of measures based on a comprehensive vision of managing change in order to ensure a smooth and safe transition to the new paradigm. Acknowledgments The authors thank the Natural Sciences and Engineering Research (Badri et al. 2018). This is achieved using a central safety database that contains knowledge relating to safety that exists within the organization as a whole, that is construction tasks, hazards, and the relationships between them (Carter and Smith, 2006).There is no significant relationship between internal factors (level of education, experience, certification) and external (level of commitment of the company) with the attitude of K3 (Keselamatan et al. 2010). While from the education factor also said there were differences between employees with the level of junior high, high school and bachelor

education (Sutrisno et al. 2000). The results showed that the construction of a double track railway project had a high risk because it directly intersected with an active train line so that there were identified 19 unexpected risks (Triaswati et al. 2014).

4. Conclusion and Recommendation

This paper concludes that there are two sources of risk that are very influential namely risks originating from internal and external, both viewed technically and non-technically. technical results can be seen from the use of 4d-BIM technology, the use of personal protective equipment, the use of construction tools according to their permits and the non-technical results of awareness to work safely, knowledge and culture about occupational safety and health, incentives or gifts given by management and support from the government regarding commitments and supervision for occupational safety and health in construction building projects. The use of appropriate methods of implementation, weak supervision of construction implementation in the field, not yet approved the implementation of existing K3 laws and regulations, weak oversight of OHS operations, inadequate both in quality and relevance supported by Personal Protective Equipment (PPE), Social environmental factors workers' economy and culture and lack of worker discipline in regulations on K3, including the use of PPE due to work (Construction and Human Resources Development Agency, 2007)(Rahmawati et al. 2019).

References

Astiningsih, H., Kurniawan, B., & Suroto, S. (2018). Hubungan penerapan program k3 terhadap kepatuhan penggunaan apd pada pekerja konstruksi di pembangunan gedung parkir bandara ahmad yani semarang. *Jurnal Kesehatan Masyarakat (e-Journal)*, *6*(4), 300-308.

Atmaja, J., Suardi, E., Natalia, M., Mirani, Z., & Alpina, M. P. (2018). Penerapan Sistem Pengendalian Keselamatan dan Kesehatan Kerja pada Pelaksanaan Proyek Konstruksi di Kota Padang. *Jurnal Ilmiah Rekayasa Sipil*, *15*(2), 64-76.

Awuy, T., Pratasis, P. A., & Mangare, J. B. (2017). Faktor-faktor Penghambat Penerapan Sistem Manajemen K3 Pada Proyek Konstruksi Di Kota Manado. *Jurnal Sipil Statik*, *5*(4).

Badri, A., Boudreau-Trudel, B., & Souissi, A. S. (2018). Occupational health and safety in the industry 4.0 era: A cause for major concern?. *Safety Science*, *109*, 403-411.

Badri, A., Nadeau, S., & Gbodossou, A. (2012). Proposal of a risk-factor-based analytical approach for integrating occupational health and safety into project risk evaluation. *Accident Analysis & Prevention*, *48*, 223-234.

Baxendale, T., & Jones, O. (2000). Construction design and management safety regulations in practice - progress on implementation. *International Journal of Project Management*, *18*(1), 33-40.

Bria, T. A., & Loden, O. (2017). Manajemen Risiko Keselamatan Dan Kesehatan Kerja (K3) Pada Proyek - Proyek Konstruksi Di Kota Kupang. JUTEKS - Jurnal Teknik Sipil, 1(2), 96.

Bust, P. D., Gibb, A. G., & Pink, S. (2008). Managing construction health and safety: Migrant workers and communicating safety messages. *Safety science*, *46*(4), 585-602.

Carter, G., & Smith, S. D. (2006). Safety hazard identification on construction projects. *Journal of construction engineering and management*, *132*(2), 197-205.

Cheung, S. O., Cheung, K. K., & Suen, H. C. (2004). CSHM: Web-based safety and health monitoring system for construction management. *Journal of Safety Research*, *35*(2), 159-170.

Cooke, T., Lingard, H., Blismas, N., & Stranieri, A. (2008). ToolSHeDTM. *Engineering, Construction and Architectural Management.*, vol. 15, no. 4, pp. 336-351.

Endroyo, B. (2010). Faktor-faktor yang berperan terhadap peningkatan sikap keselamatan dan kesehatan kerja (k3) para pelaku jasa konstruksi di semarang. *Jurnal Teknik Sipil dan Perencanaan*, *12*(2).

Fortunato III, B. R., Hallowell, M. R., Behm, M., & Dewlaney, K. (2012). Identification of safety risks for high-performance sustainable construction projects. *Journal of Construction Engineering and Management*, *138*(4), 499-508.

Hakim, A. R. (2017). Implementasi Manajemen Risiko Sistem Kesehatan, Keselamatan Kerja dan Lingkungan (K3L) pada Pembangunan Flyover Pegangsaan 2 Kelapa Gading Jakarta Utara. *Media komunikasi teknik sipil*, *23*(2), 113-123.

Hallowell, M. R., & Gambatese, J. A. (2009). Activity-based safety risk quantification for concrete formwork construction. *Journal of construction engineering and management*, *135*(10), 990-998.

Handayani, D. I., & Prihatiningsih, T. (2018). Multi Kriteria Terhadap Penilaian Penyebab Kejadian Risiko Kecelakaan Kerja Untuk Proyek Kontruksi Dengan Metode Analytical Network Process. *J@ ti Undip: Jurnal Teknik Industri*, *13*(1), 27-36..

Hartanto, D., & Siahaan, R. (2018). Pengaruh pengetahuan keselamatan dan kesehatan kerja terhadap perilaku pekerja konstruksi pada proyek jalan tol bogor ringroad seksi IIB Dani. P- ISSN : 2407 – 1846 e-ISSN : 2460 – 8416, 1–11.

Hidayat, R. (2018). Analisis Manajemen Risiko Terhadap Aspek Keselamatan dan Kesehatan Kerja pada Kontrak Konstruksi. Repositori Institusi USU.

Holmes, N., Lingard, H., Yesilyurt, Z., & De Munk, F. (1999). An exploratory study of meanings of risk control for long term and acute effect occupational health and safety risks in small business construction firms. *Journal of Safety Research*, *30*(4), 251-261.

Howard, J., Murashov, V., & Branche, C. M. (2018). Unmanned aerial vehicles in construction and worker safety. *American journal of industrial medicine*, *61*(1), 3-10.

Idoro, G. I. (2011). Comparing occupational health and safety (OHS) management efforts and performance of Nigerian construction contractors. *Journal of Construction in developing Countries*, *16*(2), 151-173.

Indah, A. (2017). Evaluasi Penerapan Keselamatan dan Kesehatan Kerja (K3) Pada Proyek Bangunan Gedung di Kabupaten Cirebon. *Jurnal Teknik Sipil & Perencanaan, Vp*, *19*, 1-8.

Johnstone, R., Mayhew, C., & Quinlan, M. (2000). Outsourcing risk-the regulation of occupational health and safety where subcontractors are employed. *Comp. Lab. L. & Pol'y J.*, *22*, 351.

Kani, B. R., Mandagi, R. J. M., Rantung, J. P., & Malingkas, G. Y. (2013). Keselamatan Dan Kesehatan Kerja Pada Pelaksanaan Proyek Konstruksi (Studi Kasus: Proyek Pt. Trakindo Utama). Jurnal Sipil Statik, 1(6), 430–433.

Karakhan, A., & Gambatese, J. (2018). Hazards and risk in construction and the impact of incentives and rewards on safety outcomes. *Practice Periodical on Structural Design and Construction*, *23*(2), 04018005. Practice Periodical on Structural Design and Construction, DOI: 10.1061/(ASCE)SC.1943-5576.0000359.

Laryea and Mensah (2010). Health and safety on construction sites in Ghana. The Construction, Building and Real Estate Research Conference of the Royal Institution of Chartered Surveyors, ISBN 978-1-84219-619-9.

Lin, J., & Mills, A. (2001). Measuring the occupational health and safety performance of construction companies in Australia. *Facilities*., vol. 19, no. 3/4, pp. 131-138.

Manu, P., Mahamadu, A. M., Nguyen, T. T., Ath, C., Heng, A. Y. T., & Kit, S. C. (2018). Health and safety management practices of contractors in South East Asia: A multi country study of Cambodia, Vietnam, and Malaysia. *Safety science*, *107*, 188-201.

Martinez-Aires, M. D., Lopez-Alonso, M., & Martinez-Rojas, M. (2018). Building information modeling and safety management: A systematic review. *Safety science*, *101*, 11-18.

Milen, A. E. (2012). Analisis Level Keselamatan Kerja (K3) Proyek Konstruksi Terhadap Risiko dan Manajemen K3 (Studi Kasus : Proyek Pembangunan Terminal II Bandara Radin Inten II , Gedung Parkir Bandara Radin Inten II , Showroom Auto 2000) b . Proyek Pembangunan Gedung Pa. 1(1), 1–10.

Munang, A., Faisal, R. M., & Mansur, A. (2018). Manajamen risiko keselamatan dan kesehatan kerja (k3) proyek pembangunan jalur ganda kereta API. *Applied Industrial Engineering Journal*, *2*(1), 8-15.

Novianto, A. E., Sugiyarto, S., & Handayani, F. S. (2016). Analisis Pengaruh Kesehatan dan Keselamatan Kerja (K3) terhadap Kinerja Pekerja Konstruksi pada Proyek Pembangunan Fly Over Palur. *Matriks Teknik Sipil*, *4*(4).. (April 2011), 1094–1102.

Okoye, P. U. (2018). Occupational health and safety risk levels of building construction trades in Nigeria. *Construction Economics and Building*, *18*(2), 92-109.

Pinto, A., Nunes, I. L., & Ribeiro, R. A. (2011). Occupational risk assessment in construction industry–Overview and reflection. *Safety science*, *49*(5), 616-624.

Pradipta, H., Unas, S. E., & Hasyim, M. H. (2015). Analisa Kesehatan Dan Keselamatan Kerja Proyek Menggunakan Fault Tree Analysis (Fta)(Study Kasus Pada Proyek Jalan Hotmix Dinas Pekerjaan Umum Kabupaten Sumbawa). *Jurnal Mahasiswa Jurusan Teknik Sipil*, *1*(2), pp-701.

Rahmawati, N. A. F., Martono, M., Sugiharto, S., Setyono, K. J., & Parhadi, P. (2019). Peningkatan Produktivitas Kerja Melalui Penerapan Program K3 Di Lingkungan Konstruksi. *Bangun Rekaprima: Majalah Ilmiah Pengembangan Rekayasa, Sosial dan Humaniora*, *5*(1, April), 1-12.

Ringen, K., Seegal, J., & England, A. (1995). Safety and health in the construction industry. *Annual review of public health*, *16*(1), 165-188.

Sanjaya, P. I., Widhiawati, I. A. R., & Frederika, A. (2012). Analisis penerapan keselamatan dan kesehatan kerja (k3) pada proyek konstruksi gedung di kabupaten klungkung dan karangasem 1. Jurnal Rekayasa Sipil, 1–9.

Sihombing, D., Walangitan, D. R. O., & Pratasis, P. A. (2014). Implementasi Keselamatan Dan Kesehatan Kerja (K3) Pada Proyek Di Kota Bitung (Studi Kasus Proyek Pembangunan Pabrik Minyak Pt. Mns). *Jurnal Sipil Statik*, *2*(3).

Soputan, G. E., Sompie, B. F., & Mandagi, R. J. (2014). Manajemen Risiko Kesehatan dan Keselamatan Kerja (K3)(Study Kasus Pada Pembangunan Gedung SMA Eben Haezar). *Jurnal Ilmiah Media Engineering*, *4*(4). 229–238.

Sulankivi, K, Kahkonen K, Makela T and Kiviniemi M (2014). 4D-BIM for Construction Safety Planning. https://www.researchgate.net/publication/228640694.

Sulankivi, K., Kähkönen, K., Mäkelä, T., & Kiviniemi, M. (2010, May). 4D-BIM for construction safety planning. In *Proceedings of W099-Special Track 18th CIB World Building Congress* (pp. 117-128).

Suparman, & Fitriani, H. (2016). Analisa Risiko Kecelakaan Kerja pada Proyek Konstruksi. Jurnal Penelitian Dan Kajian Bidang Teknik Sipil, 5(2), 1–6.

Sutrisno, H. Y., Sandora, R., & Rachman, F. (2000). Pengaruh Iklim Keselamatan Terhadap Perilaku Keselamatan Pada Proyek Tol Surabaya – Mojokerto Seksi 1B. (2581), 19–23.

Triaswati, R. A. M. N., Valentina, P. C., Utama, M., & Zuhdy, Y. (2014). Kesehatan Kerja (Smk3) Pada Struktur Bangunan Atas. 2014(05), 135–138.

Wachter, J. K., & Yorio, P. L. (2014). A system of safety management practices and worker engagement for reducing and preventing accidents: An empirical and theoretical investigation. *Accident Analysis & Prevention*, *68*, 117-130.

Wijaya, R., & Paing, J. (2018). Analisa faktor-faktor yang mempengaruhi keselamatan kerja karyawan perusahaan kontraktor di Surabaya. *axial: jurnal rekayasa dan manajemen konstruksi*, *6*(2), 79-88.

Windapo, A. O. (2013). Relationship between degree of risk, cost and level of compliance to occupational health and safety regulations in construction. *Construction Economics and Building*, *13*(2), 67-82.

Wu, X., Li, Y., Yao, Y., Luo, X., He, X., & Yin, W. (2018). Development of construction workers job stress scale to study and the relationship between job stress and safety behavior: An empirical study in Beijing. *International journal of environmental research and public health*, *15*(11), 2409.

Yuan, J., Yi, W., Miao, M., & Zhang, L. (2018). Evaluating the impacts of health, social network and capital on craft efficiency and productivity: A case study of construction workers in China. *International journal of environmental research and public health*, *15*(2), 345.

Zhou, W., Whyte, J., & Sacks, R. (2012). Construction safety and digital design: A review. *Automation in Construction*, *22*, 102-111.

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