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Occupational Health and Safety Risk Analysis in Construction Projects: A Systematic Literature Review

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A B S T R A C T

The construction service business world always wants the best results in every project activities carried out. One of the best desired outcomes is the timely completion of a construction project, but this is often not achieved for several reasons, one of which is occupational health and safety incidents that occurs in a construction project. Based on the background of the problem and the results of a literature review sourced from 40 journals from 2011-2021, the journals collected and reviewed discussed occupational health and safety in construction projects. Therefore, it is very necessary to implement an OHS (Occupational Health and Safety) management system during construction work. Occupational health and safety aims to create conditions that support work comfort for workers, so as to improve risk management. Using sources based on previous research, the following will identify the types of occupational safety and health risk factors that most often occur in construction work. The types of risks that will be discussed here will be divided into three types based on internal risk, external risk, and project risk. Types of risk are divided into two types, namely technical and non-technical risks. Based on data from a total of 40 studies that have been reviewed, there are 22 studies that have Project Risk as the risk that causes 76% of risk in a building construction project.

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1. INTRODUCTION

Based on research by Setiawan, et al (2016), work accidents that often occur are electric shocks, falling objects and falling from a height. Accidents that often occur on projects are very dangerous because they threaten someone's life. Building consists of Structural, Architectural, Mechanical and Electrical work groups, Plumbing, Interior, Landscaping, and other additional work. Each occupational group has different occupational health and safety risks. Occupational health is an element related to the work environment and work that affects work productivity (Tarwaka, 2014). Sources of danger come from humans themselves, the equipment used, materials, working methods

and the environment. Therefore, it is necessary to carry out a special analysis of all work items to achieve project objectives, namely cost, quality, time and orderly administration. Occupational safety is the protection of individual well-being against work-related injuries. In addition, occupational health is a state of overall physical, mental and emotional stability. (Mathis and Jackson, 2002 in Dewantari, et al., 2015). The objectives of implementing OHS are, among others (Syah, 2004): (1) Protect workers for their safety rights in doing work for the welfare of life, (2) Ensure the safety of everyone else in the workplace, and (3) Production on construction building projects is maintained and used safely and efficiently. In general, risk is related to unwanted events (Soeharto 1995 in Wardhana 2013). Risk is a form of case that has the possibility to occur naturally in a situation (Fisk, 1997 in Syaranamual and Tandean, 2012). According to Ridley (2008) in Wardhana (2013), risk can also be interpreted as a combination of the probability and severity of damage or loss.

Risk can be distinguished to several types according to the opinion of experts. Among the risk categories according to Charette (1989) in Wardhana (2010) include:

1. Known risks are risks that are disclosed after evaluation of the project plan, business and engineering environment in which the project is being carried out, such as:
   a. Unrealistic delivery date
   b. Lack of documented requirements
   c. Lack of scope
   d. Bad developer environment
2. Forecasted risks are known from previous project experience, for example:
   a. Staff change
   b. Poor communication with customers
   c. Reduces staff effort when ongoing maintenance requests are served.
3. Unknown risk This risk can occur, but it is very difficult to identify beforehand

Risk management is all stages of work related to risk, including assessment, planning, handling and monitoring of accidents (Kerznerr, 2001 in Labombang, 2011). Risk management is a part that cannot be completely eliminated from previously planned project work. According to the Project Management Institute Body of Knowledge (PMBOK, 1992) in Setiawan, risk management is a stage related to the identification, analysis, control of uncertainty, including increasing the results of positive events and reducing the impact of negative events. Risk identification is an attempt to find and understand the risks that will occur in the work of a project carried out by related agencies or individuals.

The three categories above are divided into two categories: (a) Technical risk; relates to the assessment of the likelihood that the system embodied in the design when it is built meets the performance requirements, (b) Non-technical risks; is a risk that can affect a particular project directly, the cause of which is an unplanned and unintended event that results in unwanted deviations

2. RESEARCH METHOD

The methodology used in making this paper is by literature review of various studies that address risk identification and risk management for occupational safety and health in construction projects. Based on previous researches, this paper will explain the types of risks that are included in internal, project and external risk factors and each type is further divided into two parts, technical and non-technical. This paper will review 40 selected papers from 2014 to 2021. The following is the study framework of this research. The stages carried out in this research are as shown in Fig. 1.

3. RESULTS AND DISCUSSION

The list of selected articles was analyzed from the aspect of identifying occupational safety and health risks in construction projects (Table 1). Risk factors are divided into three parts, namely factors are divided into three parts, namely internal factors, projects, and external factors.

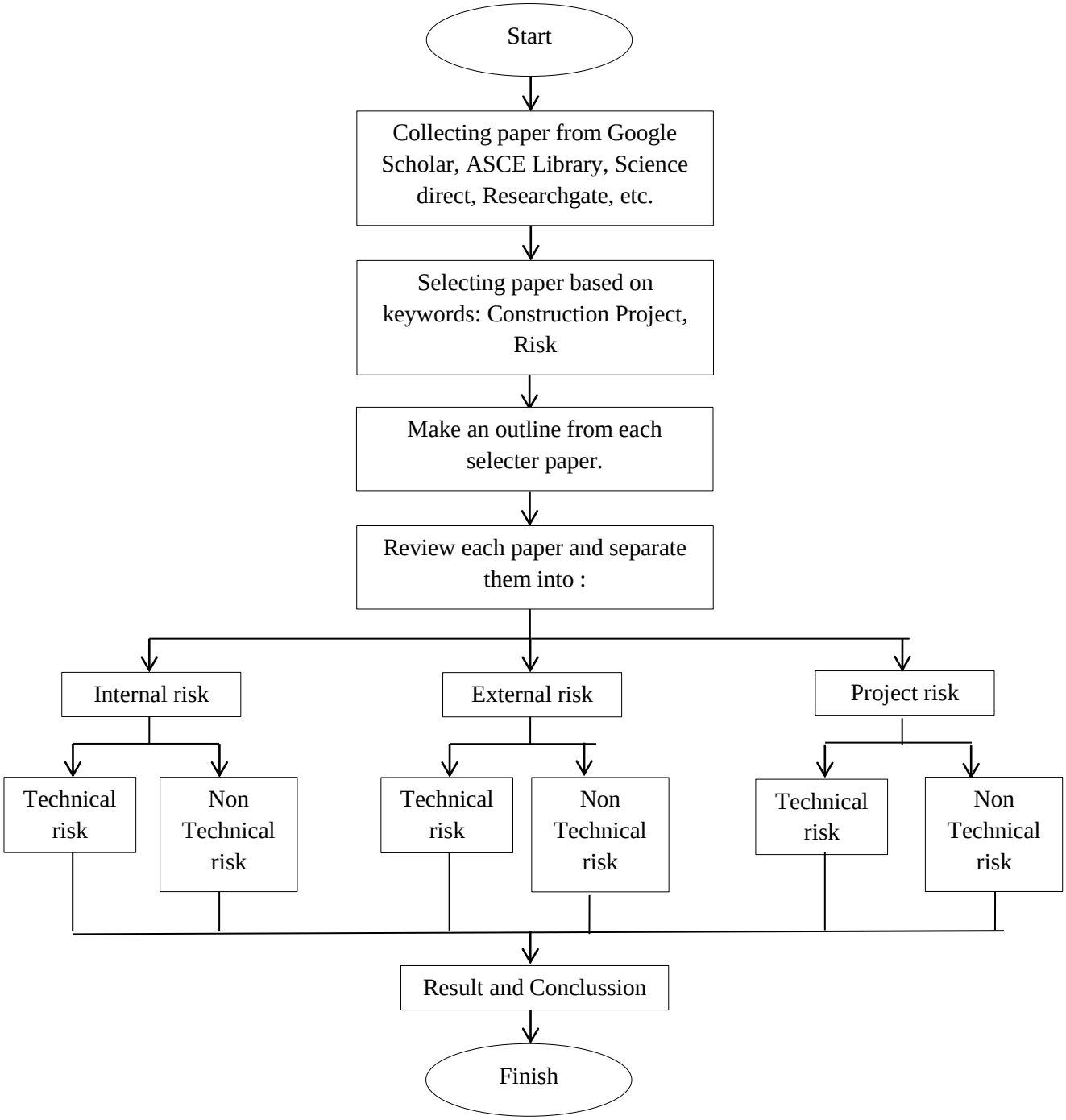

Fig.1. Research flowchart

Table 1. Summary of literature review of risk analysis in construction projects

No	Journal Identity	Location	Risk Category						Type of Risk	Conclusion
			Internal		External		Project			
			T	NT	T	NT	T	NT		
1	(Yuliani, 2017)	Indonesia					✓		Material Collapse	6 risks are classified as Extreme Risk, 17 risks are classified as High Risk, 8 risks are classified as Moderate Risk and 9 risks are classified as Low Risk.
2	(Bria & Loden, 2016)	Kupang					✓		Worker safety	The risk is caused by the negligence of the workers
3	(Muflihah & Pudjihardjo, 2019)	Semarang					✓		Work safety project site	Risks caused by worker skills and work environment
4	(Kadek et al., 2021)	Bali					✓		Structural work	The risk is caused by the negligence of the workers
5	(singgih, 2011)	Surabaya		✓					Material risk	Risk caused by falling material
6	(Agusman et al., 2021)	Jakarta	✓				✓		Time, Cost and Equipment	The dominant project technical risk is work safety, then there is also a risk of time, cost, construction equipment/technology.
7	(J. et al., 2017)	Yogyakarta					✓		Worker safety	Using the FMEA method to anticipate work accidents.
8	(siahaan, 2015)	Jakarta		✓					Worker safety	The highest work accident is a worker falling from a ladder with a Risk Level L (Low) of 52%. The highest work accident is the human factor with a Risk Level L (Low) of 56%.
9	(Enny A Muslim, 2014)	Kalimantan					✓		Worker safety	Risks that fall into the Extreme Risk (E) category are 7 risks (19%), High Risk (H) are 12 risks (32%), Moderate Risk (M) are 10 risks (27%), Low Risk (L) are 8 risks (22%).
10	(Wisudawati & Patradhiani, 2020)	Palembang					✓		Material risk	The risk caused by the material
11	(Indrayani, 2017)	Kalimantan		✓			✓		Worker safety	The results of the risk assessment show 4% risk in the low category, 48% in the moderate risk category, 39% in the high risk category, and 9% in the extreme risk category.
12	(Setiawan et al., 2019)	Indonesia		✓					Safety information	9 risks are in the Extreme (E) category, 6 risks are in the High (H) category, 12 risks are in the Moderate (M) category, and the remaining 7 risks are in the Low (L) category.
13	(Abas et al., 2020)	Malaysia		✓					Safety information	Primary responsibility for site safety is traditionally and generally ascribed to the general/main contractor.
14	(Islam et al., 2017)	Bangladesh	✓						Worker safety	The main cause of fatal accidents is falling from different heights.

No	Journal Identity	Location	Risk Category						Type of Risk	Conclusion
			Internal		External		Project			
			T	NT	T	NT	T	NT		
15	(Jeschke et al., 2021)	United Kingdom	✓	✓					Safety and worker information	The risk that occurs is caused by the tool and the relationship between workers.
16	(Taghipour, 2015)	America		✓		✓			Safety information and planning failure	Risks caused by design, redundant approval procedures in government administrative departments and inappropriate construction program planning.
17	(Obolewicz & Dąbrowski, 2018)	United Kingdom					✓		Worker safety	The risk is caused by the negligence of the workers.
18	(Borys, 2015)	Australia		✓					Worker safety	Lack of professional workers.
19	(Amirah et al., 2013)	Malaysia		✓					Financial Risk	The financial aspect of safety and health issues has been neglected because everyone wants safety, but no one wants to pay a penny for it.
20	(ElSafty et al., 2012)	Florida, USA	✓		✓				Safety information, workers and materials	Risk is caused by contractors or subcontractors, engineers, equipment manufacturers and architects.
21	(Amirah et al., 2013)	Malaysia		✓				✓	Safety and environmental information	Risk of non-compliance with the requirements of the Work Safety Law.
22	(Lakhiar et al., 2021)	Malaysia		✓					Safety of workers and material tools	Risk workers generally work in an unsafe environment.
23	(Chen et al., 2012)	China					✓		Material risk	The risk is caused by dangerous goods, boilers and pressure vessels.
24	(Umar & Wamuziri, 2016)	Oman		✓					Work environment, weather and worker risks	Risk of accidents from dust and fumes, asbestos, awkward working positions, heavy loads, adverse weather conditions, working at heights, noise, vibration from tools.
25	(Nabilah Ghazali et al, 2014)	Malaysia		✓					Worker safety	Contractor's non-compliance with OHS policies.
26	(Riham el nagar et al, 2015)	America	✓	✓		✓			Environmental and Budget Risk	Risk is caused by the natural environment, incentive factors and project budgets, plans, and safety training.
27	(Mo et al., 2018)	Korea		✓		✓			Environmental risk	The risk is caused by construction workers and the environment.
28	(Mokeira Abaya & Ondieki, 2021)	Kenya		✓				✓	Material and labor risks	Risk of exposure to chemicals, falling objects, exposure to harmful radiation, exposure to hazardous gases, slippery floors, and incidents.
29	(Hamid et al., 2019)	Malaysia		✓					Safety information	Non-compliance with K3.
30	(Andersson, 2014)	Sweden					✓		Material tool risk	The risk caused by construction material tools.
31	(Atmaja et al., 2018)	West Sumatera	✓	✓					Worker and Material Risk	Risks caused by management factors, human and technical factors.

No	Journal Identity	Location	Risk Category						Type of Risk	Conclusion
			Internal		External		Project			
			T	NT	T	NT	T	NT		
32	(Winda PurnamaTaguha et al., 2018)	Manado					✓		Material risk	Risks caused by material tools
33	(Rawis et al., 2016)	Manado					✓		Material and labor risks	Risks caused by material tools and construction workers
34	(Nurainiyah & Agustapraja, 2019)	Lamongan					✓		Material risk	Risks caused by material tools
35	(Saraswati et al., 2020)	Surabaya						✓	Worker safety	Risks caused by workers not wearing APD
36	(Sari et al., 2016)	Indonesia					✓		Material risk	Risks caused by material
37	(Danial et al., 2015)	Malang						✓	Worker safety	Risks caused by workers
38	(Munang et al., 2018)	Purwokerto		✓					Project management risk	Work accidents that occur are caused by the lack of proper management of risk
39	(Syahriadi, 2020)	Depok					✓		Labor risk	Risks that cause fires due to negligence of workers throwing cigarette butts carelessly
40	(Indrayani, 2017)	Surabaya					✓		Labor risk	workers fall from heights, workers are electrocuted, workers are crushed by lifting materials, fire or explosions, and scaffolding collapses.

Note ✓= discussed

Yuliani's research (2017), conducted on construction projects confirms that 6 risks are classified as Extreme Risk, 17 risks are classified as High Risk, 8 risks are classified as Moderate Risk and 9 risks are classified as Low Risk. Research conducted on a construction project in Kupang, workers fell from stairs with a Risk Level L (Low) of 52%, did not wear personal protective equipment (PPE) with a Risk Level L (Low) of 56%, the risk control was daily K3 inspections for the use of PPE. self) complete, tighten management supervision of workers who do not wear personal protective equipment, provide and complete safety signs in construction projects if they are not available or incomplete. (Bria & Loden, 2016). Based on research by Muflihah and Pudjihardjo (2019), in a construction project located in Semarang analyzed that the application of Occupational Health and Safety is influenced by the competence of skills / skills of workers, conditions (physical, psychological, and physiological), training and skills, conditions of the work environment. Research on construction projects in Bali shows that there are 36 risks that are at priority level 1 that cause the impact of death and permanent injury, namely on basement wall and floor slab work, roof work, wall work, structural wall and column work, reinforced concrete foundation structures and flooring, railing work, swimming pool structure, ceiling work, and door window work. (Kadek et al., 2021). The highest OHS risk analysis in Surabaya is on fallen material / most of the material lifted in material lifting activities using tower cranes is caused by the process of packing goods / materials that are not right, slings and shackles are damaged (Singgih, 2011)

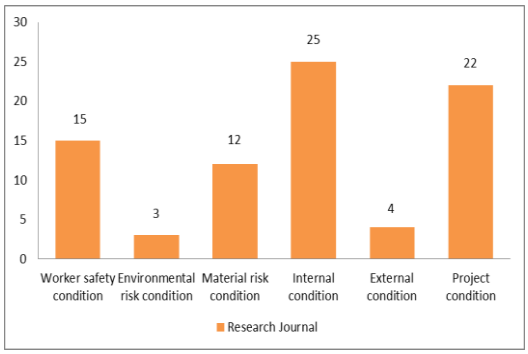

Fig 2. List of jornal's risk conditions

In the Fig. 2, based on data from a total of 40 reviewed studies, the most dominant occupational health and safety risk conditions are internal conditions in a building construction project. Agusman et al (2021) explains that construction projects in Jakarta have the dominant project technical risk is work safety, then there is also a risk of time, cost, construction equipment/technology. J. et al (2017) projects in Yogyakarta with the analysis of the results of this FMEA method need to be followed up. The recommended method to follow up on the results of this FMEA is a dynamic system model. The dynamic system will give quantitative results in the form of ratio data that can be used as a consideration for work safety management to anticipate the occurrence of work accidents with high risks and minimize these risks. In addition, the dynamic system can also facilitate work safety management to see the results of decisions made when work accident parameters are changed. The highest work accident in Jakarta is a worker falling from a ladder with a Risk Level L (Low) of 52%. The highest work accident is the human factor with a Risk Level L (Low) of 56%. (Siahaan, 2015). Kalimantan, Risks that fall into the category of Extreme Risk (E) are 7 risks (19%), High Risk (H) are 12 risks (32%), Moderate Risk (M) are 10 risks (27%), Low Risk (L) as many as 8 risks (22%). (Enny A Muslim, 2014). Wisudawati & Patradhiani (2020), a construction project in Palembang, the installation of foundations has 5 potential hazards, wall installation has 6 potential hazards, frame installation has 6 potential hazards, roof truss installation has 5 potential hazards, and finishing has 5 potential hazards.

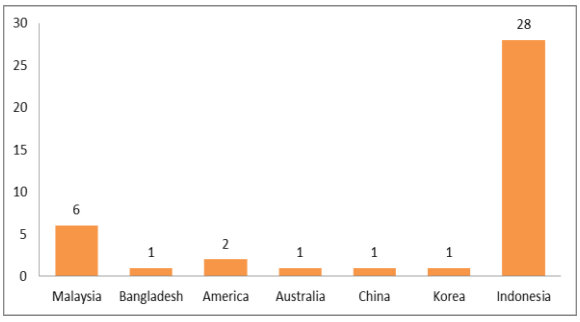

Fig 3. Research articles based on location of research in risk construction projects.

In figure three based on data from a total of 40 reviewed studies, each country in a building construction project has its own risks in occupational safety and health, both small and large risks. In construction projects in Kalimantan, the risk assessment results show 4% risk in the low category, 48% in the moderate risk category, 39% in the high-risk category, and 9% in the extreme risk category. (Indrayani, 2017). 9 risks in the Extreme (E) category, 6 risks in the High (H) category, 12 risks in the Moderate (M) category, and the remaining 7 risks in the Low (L) category are in one of the projects in Jakarta (Setiawan et al., 2019). The primary responsibility for site safety is traditionally and generally ascribed to the general/main contractor in Malaysia. (Islam et al., 2017). The main cause of fatal accidents on construction projects in Bangladesh is falling from different heights. The risks are caused by tools and the relationship between workers. United Kingdom. (Jeschke et al., 2021)

According to Taghipour (2015) research in America analyzing the risks caused by design, excessive approval procedures in administrative government departments and inappropriate construction program planning. Obolewicz & Dabrowski (2018) research analyzes the negligence of construction workers in the UK. According to Borys (2015) on construction projects in Australia is the lack of professional workers. On a construction project in Malaysia analyzed that the financial aspects of safety and health issues have been neglected because everyone wants safety, but no one is willing to pay a penny for it. (Amirah et al., 2013). Elsafty et al (2012) Risk is caused by contractors or subcontractors in Florida, engineers, equipment manufacturers, and architects.

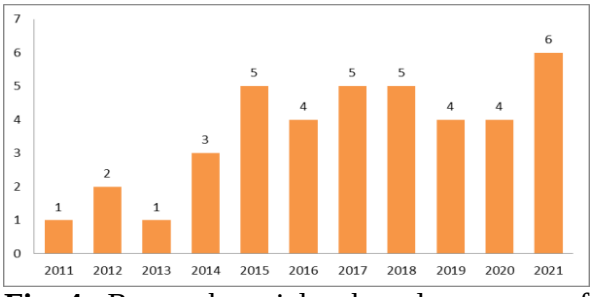

Fig 4. Research articles based on year of research in risk construction projects

In figure four the journal references in this study range from 2011-2021 which is still relatively new for occupational safety and health research so that it is easy to compare for further research. Based on data from a total of 40 reviewed

studies, in 2021 there are occupational safety and health risks in a building construction project.
OHS risk that occurs due to non-compliance with the requirements of the Work Safety Act in Malaysia. (Amirah et al., 2013). Risk workers generally work in an unsafe environment in Malaysian projects. (Lakhiar et al., 2021). According to Chen et al (2012) on construction projects in China, the risk is caused by dangerous goods, boilers and pressure vessels. In Umar & Wamuziri's (2016) research in the Oman project the risk of accidents from dust and steam, asbestos, awkward working positions, heavy loads, bad weather conditions, working at heights, noise, vibration from tools. On construction projects in Malaysia, work accidents are caused by contractors' non-compliance with OHS policies. (Nabilah Ghazali et al, 2014)

According to Riham el nagar et al (2015). On construction projects in America, risks are caused by the natural environment, incentive factors and project budgets, plans, and safety training. According to Mo et al (2018) in Korea, the risk is caused by construction workers and the environment. Risks of exposure to chemicals, falling objects, exposure to hazardous radiation, exposure to hazardous gases, slippery floors, and incidents occurring in the Kenya project. (Mokeira Abaya & Ondieki, 2021). Non-compliance with OHS on construction projects in Malaysia causes work accidents. (Hamid et al., 2019). Andersson (2014) Risks in construction projects in Sweden caused by construction materials. Risks caused by construction projects in Padang are caused by management, human and technical factors. The level of knowledge, understanding, behavior, awareness, attitudes, and actions of the working community in efforts to overcome work safety problems is still very low and has not been placed as a basic need for overall welfare improvement, including increasing work productivity. (Atmaja et al., 2018). The risk of work accidents in Manado caused by material tools. (Winda Purnama Tagueha et al., 2018).

According to Rawis et al (2016), the risk of construction projects in Manado is caused by material tools and construction workers. Research by Nurrainiyah & Agustapraja (2019) on construction projects in Lamongan, the risks caused by material tools. The risk of work accidents caused by workers who do not wear PPE in Surabaya. According to research by Sari et al. (2016), work accidents in Indonesian construction projects are caused by material tools. According to Danial et al (2015) the risk of work accidents in Malang is caused by negligent workers. Work accidents that occur are caused by inappropriate risk management in the construction project in Purwokerto. (Munang et al., 2018). In a construction project in Depok, the risk that causes a fire is due to the negligence of workers throwing cigarette butts carelessly. (Syahriadi, 2020). According to Indrayani (2017) the risk of work accidents in Surabaya is due to workers falling from a height, workers being electrocuted, workers being hit by lifting materials, fire or explosions, and scaffolding collapsing. The following are some efforts to reduce the occurrence of occupational safety and health risks in construction projects, where in previous studies no one has written about this:

OHS Performance Monitoring and Evaluation

Monitoring and evaluation of OHS performance carried out in the company includes Inspection, Testing and Measurement. Procedures must be established and maintained in accordance with OHS goals and objectives and the frequency is adjusted to the object referring to applicable regulations and standards, in general, including: (a) Personnel involved must have experience and expertise, (b) Examination records must be maintained and available, (c) Adequate equipment and methods, and (d) Corrective action must be taken immediately when a non-conformity is found.

OHS Policy

The company's OHS policy in this case is to conduct an initial review and determination of commitments and OHS policies on building construction implementation projects with the aim of being one of the controls and periodic evaluations of occupational safety and health risks. Commitment to implementing good K3 procedures will create a vision and mission for the company to prevent work accidents and provide welfare for workers who can work safely and comfortably. The following 8 principles of safety for construction workers in the implementation of building construction projects include: (1) Every worker involved in the project is required to wear ID card, helmet, and shoes when entering the work area, (2) All new

workers/visitors are briefed by the safety officer (safety induction), (3) Discuss with all staff to ensure that the work carried out is in accordance with the procedure, (4) Everyone at the project site, whether workers, staff, or visitors, must wear PPE, (5) Make sure the tools and work equipment used are proper and in accordance with the type of work and meet the criteria, (6) Everyone who has finished working with moving equipment must make sure personally that the power of the equipment has been turned off and safety signs have been put up, (7) Everyone who works at a height of more than 2 meters must wear a seat belt/body harness, and (8) Everyone who does welding work must be careful of flammable materials nearby and must be provided a fire extinguisher.

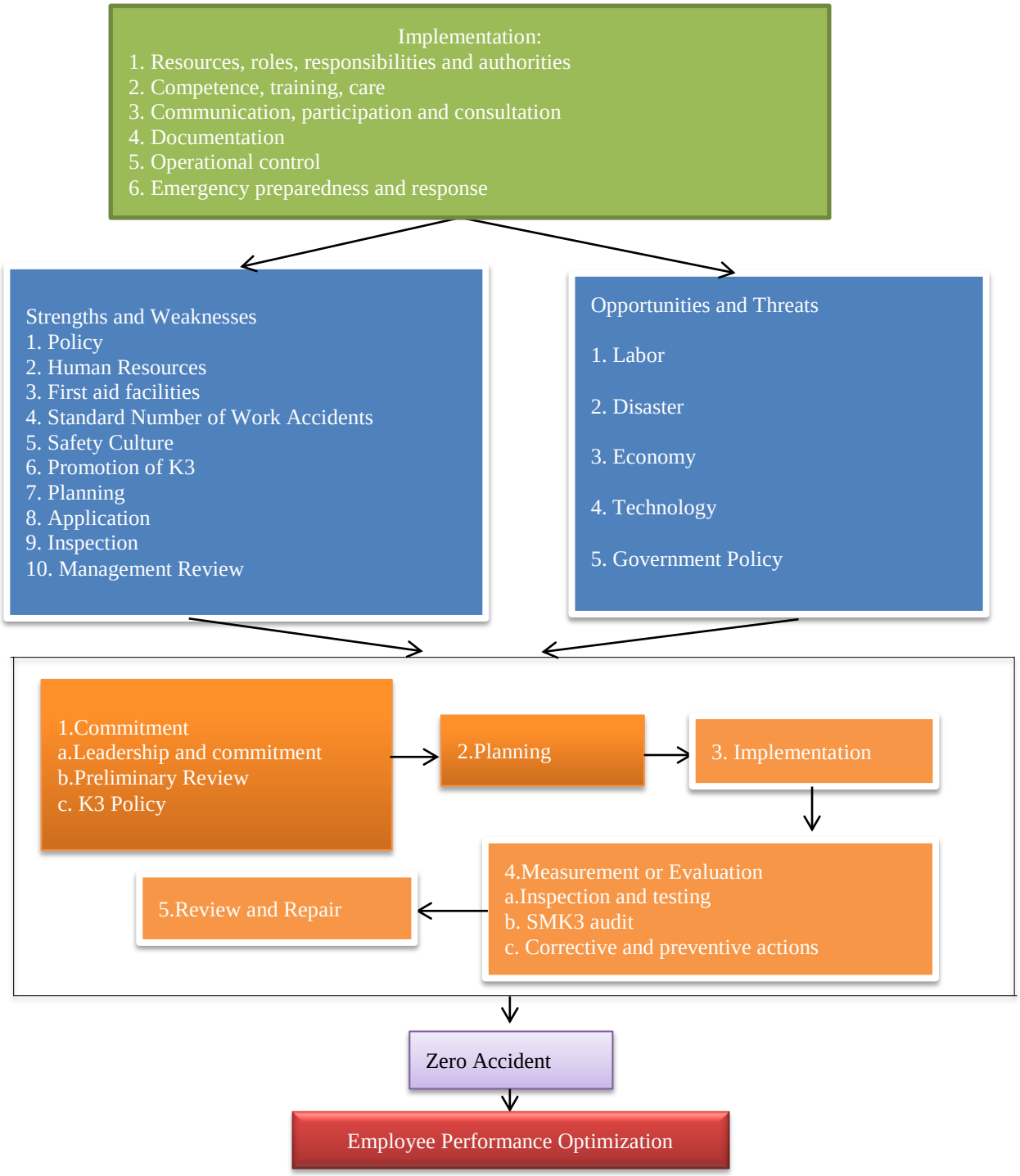

Fig 5. Future study framework

4. CONCLUSION

Based on the results of the literature review of the 40 journals above, we can conclude that:

a. Project risk is the most common occupational health and accident risk found in building construction projects. From a total of 40 studies that have been reviewed, there are 22 studies that have Project Risk as a risk which has been the cause of 76% of risk in a building construction project.
b. Internal risk is the cause of 21% of occupational health and accident risks in building construction projects.
c. Technical aspects, both Internal Risk and Project Risk, are the most influential causes of occupational health and accident risks in a building construction project.
d. Non-Technical External Risk is the cause of the least influence on the risk of health and work accidents in a building construction project.

Furthermore, the current project risk is the most influential risk, especially in the aspect of material falling from a height and worker negligence, risk control based on a risk control hierarchy is carried out by engineering with good work methods, APK by providing warning signs, PPE by using work shoes, helmets, gloves, seat belts, work shoes and not all contractor companies explain the risk of accidents and control the risks that occur in the project clearly. So, it is necessary to review the contractor when conducting research on OHS risk analysis and to review further literature regarding the identification of other project risks with different objects.

SUGGESTION

Controlling risk must first identify the risks that will occur later so that the risks that will occur can be minimized or even lost. Efforts to control occupational safety and health risks are: (a) Identify the risks that will occur, (b) Formulate the impact that will occur, (c) Analyze the causes of the risks that will occur, and (d) Deciding the handling of the risks that will occur later. Completeness of body armor and project area is very much needed, both the availability of personal protective equipment, light fire extinguishers and warning signs are very important at the project site, because the project location is a very risky place for work accidents. The completeness has been regulated in the law so that if it does not meet what is required in the law, the project or contractor can be terminated

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