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Literature Review of Project Risk Identification in Steel Building Construction

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Abstract: *The steel construction is one of the vital sectors in the development of modern infrastructure and buildings. However, despite the many advantages that this industry has, steel construction contractors are also faced with a number of challenges that require strategies and innovations to overcome. Risk can be defined as the chance of an adverse event occurring, which is caused by the uncertainty of what will be faced. Construction risk management is the process of identifying, assessing, and controlling potential risks that could affect a construction project. This involves analyzing all aspects of a project and implementing strategies to prevent or minimize the impact of these risks. Here are some steps can take to effectively manage risks in construction projects. Using sources based on the previous research, here will be identifying what types of risk factors are most commonly occurs for steel building construction project. The types of risk that will be discussed here will be divided into three types based on internal risk, external risk, and project risk. Each type of risk includes technical and non-technical risks. Based on the data this study identify that internal risk with technical aspects is the most common type of potential risk occurs on steel building construction project.*
Keywords: *Risk, Steel Building, Steel Structure, Construction Project*.

Introduction

The use of steel in construction began in the 19th century. Since then, steel has been the primary choice for the construction of buildings, bridges, and other infrastructure. Over time, steel processing technology has advanced, allowing for more efficient and effective use of steel. The use of steel structures in construction can save time and money. Steel erection is the process of constructing, modifying, or repairing steel buildings, bridges, and other structures. This process also involves the assembly, connection, and installation of steel beams, metal decks, and planks used in the erection of steel structures

Problems can arise if there is a mismatch between planning and reality in the field. These problems are caused by various factors that are then known as construction project risks. The definition of risk in the context of a project is interpreted as a description of the adverse consequences, both physically and financially, as a result of decisions made or due to environmental conditions around the project. In relation to the concept of opportunity, risk is the chance of an unexpected condition occurring with various consequences that may arise that can cause delays or project failure (Gray & Larson, 2017).

The risks and hazards associated with the installation of steel structures vary from site to site, depending on the type of material, size of the structure, and other working conditions. Before starting any project, a comprehensive job hazard analysis is required to identify potential risks and establish a proper safety plan. Risk management is recognized as an integral part of good management practice. To be most effective, risk management must become part of the culture of the organization. It must be integrated into the organization's philosophy, practices and business plans rather than viewed or practiced as a separate program. (AS/NZS, 2004) When this is achieved, risk management becomes everyone's business in the organization. If for whatever reason it is not possible to integrate risk management throughout the organization, it may still be possible to apply it successfully to individual departments, processes or projects.

Risk management is a process comprising the following main step: risk management, planning, risk identification, risk assessment, risk analysis, risk response, risk monitoring, and risk communication (Giannetti & Ransing, 2016).

Based on (Zavadskas et al., 2010) risk allocation structure by level in construction object can be divided into three groups ; (1) External risk (environmental criteria) such as : political risk, economic risk, social risk, weather risk (2) Project risks (construction process criteria) classify as : time risk, cost risk, work quality, construction risk, technological risk (3) Internal risks (intrinsic criteria) classify as : resource risk, project member risk, construction site risk, documents and information risk. It’s described as shown in Figure 1 below.

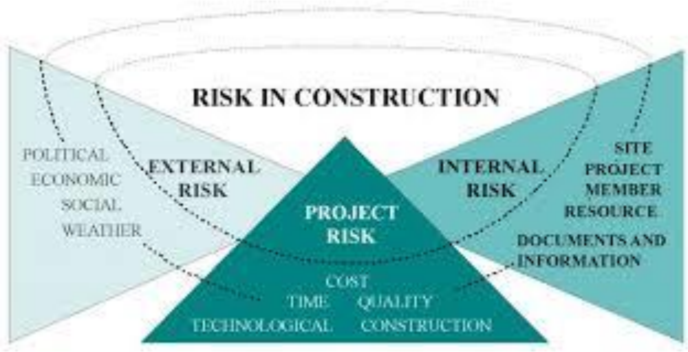

Figure 1. Risk type in construction projects

Research Methods

Knowing the potential project risk factors in the steel building construction because the implementation of steel building construction work is very close to the height factor so there is a high possibility of high risk. The methodology of this paper is based on aliterature review from variousresearch which discussed the identification of risk and risk management on steel building projects. Based on the previous research this study willclassifythe types of risks, whether they are included in internal, project or external risk factors and each types divided again into two parts, technical and non-technical. With 30 selected paper will be reviewed in this paper. The following Figure 2 is the study frame work of this research.

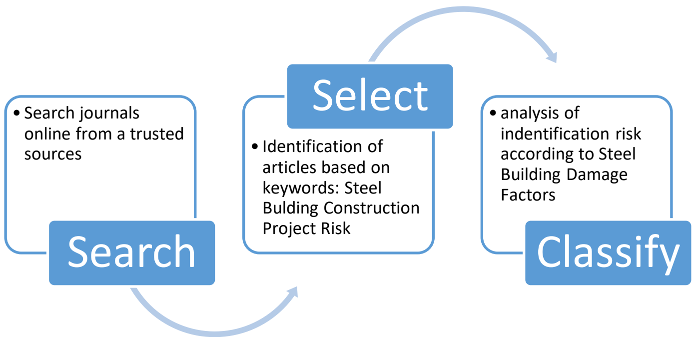

Figure 2. Study Framework

Result And Discussion

The list of selected articles is analyzed from the aspect of risk identification in steel building construction project, risk factors are divided into three parts, including internal, projects and external factors. The following results from Table 1 have been analyzed.

Table 1. Summary literature review of risk assessment

No	Paper	Risk Factor						Result
		Internal		Project		External		
		T	NT	T	NT	T	NT	
1	(Chou et al., 2020)	□	x	x	x	x	x	The results indicate a high safety risk of the project and the need for maintenance and repair. The improved CIM model has higher stability and adaptability for analyzing the safety risks of steel structure than the standard CIM model.
2	(Krentowski, 2014)	x	x	x	x	□	x	The most important thing is to establish inventory, effectively grasp situation, and enhance the rescue as a battle with the deployment. Enhance the structural materials and decoration materials of lightweight steel structure buildings and enhance the safety of the site by strengthening structural strength and fireproof materials or flame retardant materials.
3	(Dunant et al., 2018)	□	x	x	x	x	x	In the course of the analyses and calculations, it was established that the main cause of the disaster lay in a faulty design of the butt joints between the segments of the steel plate girders. Another factor having impact on the failure was the numerous mistakes in the design and fitting of the steel purlins. The excessive snowfalls were not the main cause of the disaster but were only an additional one.
4	(Song et al., 2007)	x	□	x	x	x	x	Finally, found an empirical explanation for the anecdotal evidence that reuse is favoured by low prices of steel: the potential cost savings for reused steel goes up when the price of steel goes down.
5	(Rad & Banazadeh, 2018)	x	x	x	□	x	x	With this result, the research presents an active and expansive administration system than limited existing activities. This research established a system for the safety management of steel-frame work, applying FMEA sheet based on the analysis of precedents.
6	(Dobiášová & Kubečka, 2014)	x	x	x	x	□	x	Finally, modeling uncertainty can be included in further performance assessments. Parameters such as the initial and post-elastic stiffness, characteristic strength, and the temperature can be affected by the modeling uncertainty and treated as random variables in addition to the RTR uncertainty. Since the distribution of the mechanical characteristics depends on the manufacturer, a uniform distribution function is recommended.
7	(Lagaros, 2014)	□	x	x	x	x	x	Implementation of system revision was at the beginning complicated, but after time it improved was prevent serious mistakes in project, many collision between technologies and construction and this system of revision overcame language barrier and overall ease communication.
8	(Faggiano et al., 2008)	□	x	x	x	x	x	In particular randomness on the seismic demand and incident angle along with the uncertainty on the material properties, the fioor mass and the structural damping properties are considered.
9	(Kook & Kim, n.d.)	x	x	x	x	x	□	In this paper an overview on the risk assessment of steel structures in seismic areas, which may be subjected to fire following earthquake, is briefly presented. The importance of a multi-disciplinary approach to face up the problem is recognised and underlined. The necessity of considering both a

								building scale and a regional scale for the management of the emergency is also pointed out.
10	(S. H. Hwang & Lignos, 2018)	x	x	□	x	x	x	The study was intended to analyze the schedule risk management focusing on structural steel work. The schedule risk management tool hereby proposed will provide the guidelines that will enable the site engineers with different levels of experience and expertise to identify the potential risks at early stage and to deal with the risks in timely manner, thereby mitigating the project risks as a whole.
11	(S. H. Hwang et al., 2019)	x	x	x	x	□	x	This paper proposes a nonmodel-based framework for rapid seismic risk and loss assessment of instrumented steel frame buildings in the aftermath of an earthquake. It is shown that the proposed framework can effectively serve for pre-disaster risk management.
12	(Hong et al., 2020)	x	x	x	x	x	□	This paper evaluated seismic risks in modern, code-compliant, steel-frame buildings that utilize special moment frames (SMFs). The seismic risk was quantified in terms of collapse risk and economic risk.
13	(S.-H. Hwang & Lignos, 2017)	□	x	x	x	x	x	The FEM results were in good agreement with the SCC test results, which were performed fol- lowing the Design and Construction Rules for Mechanical Components of PWR Nuclear Islands (RCC-M). This study provides a basis for the manufacturing process of austenitic stainless-steeltube-to-tubesheet hydraulically expanded joints.
14	(Yeganeh et al., 2022)	□	x	x	x	x	x	This paper assessed the effect of analytical modeling assumptions on the collapse risk and the earthquake-induced economic losses for typical archetype steel-frame buildings.
15	(Ummah, 2019)	x	x	□	x	x	x	The results revealed that the risks in the construction and operation phases are higher than those in the design phase. The results also show that involving safety as a project object in the risk management process could eventuate acceptable results.
16	(IA et al., 2016)	x	x	x	□	x	x	This paper examines an innovative project delivery system for structural steel buildings in the context of several case studies of actual projects.
17	(Anastasiadis, 2021)	x	x	□	x	x	x	Since the data collected in the productivity study represent the type of data that would be available within organizations, this research demonstrates how such data can be used for controlling, improving, measuring and evaluation the productivity of construction of steel structure projects for construction processes of steel structures.
18	(Gardner & Key, 2021)	x	□	x	x	x	x	The paper is focused on failures, in quasi-static loads, of the first stage in the design and construction phase of a project, the human nature represents the central core for any structural failure, and this is attributed to a coupling of the lack of knowledge, as well as management and organizational inefficiencies.
19	(Shahtaheri et al., 2017)	x	x	□	x	x	x	Responding to the need for stakeholders to be provided actionable tools to address non-compliance, the Australian Steel Institute (ASI) has developed the National Structural Steelwork Compliance Scheme (NSSCS) which includes a third party certification scheme for both Australian and overseas located steel fabricators.
20	(J. P. Hwang et al., 2015)	□	x	x	x	x	x	The proposed methodology links a structural analysis framework which aims to predict the performance of various assembly configurations to construction costs and various types of project risks.
21	(Petroutsatou & Kantilierakis, 2023)	x	x	□	x	x	x	In the present study, the corrosion risk of steel fibre in concrete was evaluated by a monitoring of corrosion behaviour, chloride transport and microscopic examination at the interface of the steel fibre.

22	(Rashid et al., 2015)	x	x	□	x	x	x	Through a literature review and interviews with experienced site engineers, a risk registry was compiled by the authors concerning sixteen (16) risks encountered in the construction process. The TOPSIS multi-criteria analysis program is used for the prioritization of risks.
23	(Tylek et al., 2017)	x	□	x	x	x	x	This study is one of the few that has been done in the area of crew productivity for the Construction of steel structure projects modeling using Matlab.
24	(Leu & Chang, 2013)	□	x	x	x	x	x	Analyses indicate that human errors are the major cause of structural failures, but they are not included in design methods of contemporary structural codes. Structural reliability is instead provided by the application of quality management and control systems.
25	(Yang & Chan, 2018)	□	x	x	x	x	x	This study addresses the development of a safety risk-assessment model for SC projects by establishing the Bayesian networks (BN) based on fault tree (FT) transformation. The model accurately provides site safety-management abilities by calculating the probabilities of safety risks and further analyzing the causes of accidents based on their relationships in BNs.
26	(Hidayah, 2021)	x	□	x	x	x	x	The fast construction of structural steelwork can result in an early return on investment, which may outweigh the high construction cost. This advantage will be particularly significant for retail building projects with high land prices in Hong Kong. This study offers strategies for facilitating the fast construction of structural steelwork.
27	(Elsanadedy et al., 2021)	□	x	x	x	x	x	Furthermore, now the Internal Risk has become the most influental risk, particularly the structural design aspects and to avoid unfavorable events, its better to do the mitigation starting from the designing phase by reviewing the proposed design until the risk possibility is optimum minimalized.
28	(Harris & Michel, 2019)	x	x	□	x	x	x	Steel frame buildings are susceptible to progressive collapse when few structural elements (especially columns and beam- column joints) get damaged so that the neighboring structural members fail to redistribute the gravity loading. Thus, the limited damage can cause failure to adjacentmembers that may ultimately result in progressive collapse risk of the building.
29	(Lee et al., 2020)	□	x	x	x	x	x	The results indicate that the analytical fundamental period is affected when an importance factor greater than 1.0 is used for design, as is required for assigned higher risk categories. Moreover, the database of measured vibration data taken from steel buildings used to establish the empirical formula adopted by ASCE/SEI 7-16 to compute the approximate fundamental period did not include buildings designed with an importance factor.
30	(Lee et al., 2020)	x	x	□	x	x	x	From the sensitivity analysis, the sensitivity for cover depth and diffusion coefficient to corrosion-free life were independent to binder type in mixes, whilst the surface chloride concentration and chloride threshold level were much affected by binder. In particular, the corrosion free life for OPC was much more sensitive to these parametric values, compared to other mixes. This may arise from the higher chloride threshold level, of which the variation would result in asignificant change in the corrosion-free life.

Note :
T : Technical
NT : Non-TechnicaL

The construction of a steel building cannot be separated from uncertain risks. To approach the uncertainty, it can be anticipated through risk management. From the identification stage, it can be seen the possibility of potential risks and then analyzed the magnitude of the probability of emergence and the impact that will arise.

This paper proposes a novel risk analysis model to assess the safety of steel-structure buildings, the vector entropy method and weight clustering were used to improve the controlled interval and memory (CIM) model, The Jiangxi Exhibition Center in China, which has a steel truss roof, is used as a case study and the results indicate a high safety risk of the project and the need for maintenance and repair (Chen et al., 2024).

Research in Taiwan, steel structure is exposed to temperatures above 600 °C will begin to break and bend, causing deformation and eventually collapse. To develop a disaster reduction strategy based on the results of the parametric analysis of this study for buildings with accommodation inside the factory (improvement): utilizing factory fire prevention analysis, factory symposium, fire prevention announcement, fire equipment inspection and maintenance, etc., to achieve disaster reduction (Chou et al., 2020).

A general conclusion that a properly designed roofing structure would have with stood the collapse even if had been subjected to twice as much snow load considering the safety coefficients applied in the European Standards (Krentowski, 2014). Another study detailed analysis of the costs and risks of a reused steel in United Kingdom. This is done by establishing a cost model and interviewing the expertsabput describing the risks on a construction project involves steel reuse (Dunant et al., 2018).

This research established a system for the safety management of steel-frame work, applying FMEA sheet based on the analysis of precedents. The construction accident includes not only at some special work, but also many dangerous essential parts at construction industry as a whole (Song et al., 2007).

Study by (Rad & Banazadeh, 2018) aimed to do a probabilistic risk-based performance Evaluation of base-isolated steel structure with special moment frames. It is assumed that the archetypes are located in the San Diego region, California, USA. Design based on ASCE/SEI 7–2016 and simulated in OpenSees. (Dobiášová & Kubečka, 2014) shows the example of the blast furnace on steel construction project risk assessment documentation in Ukraine. Evaluation is performed by expert Universal Matrix of Risk Analysis (UMRA) and in the second part will be aligned with the evaluation using RPN index.

Evaluate a risk assessment framework which allows considering sources of uncertainty both structural capacity and seismic demand on a steel projects. Using several modelling and finite element analysis also the incremental dynamic analysis methodology (Lagaros, 2014). The necessity of considering both a building scale and a regional scale for the management of the emergency is also pointed out, with regard to the building scale, the necessity of integrating the fire design of steel structures into the general design process is recognised, and the Performance-Based Design is assumed as the most suitable technical approach (Faggiano et al., 2008).

This study was implemented based on understanding of existing studies and interview with the experts, the result was divided into each stage and presented as a work-flow; the pre-construction stage, shop fabrication stage and site erection stage (Kook & Kim, n.d.). The proposed framework can facilitate building-specific seismic risk and loss assessment within minutes after an earthquake provided that the recorded floor absolute acceleration histories at discrete locations along the height of the building are accessible illustrative examples including actual instrumented steel frame buildings that experienced the 1994 Northridge earthquake in Los Angeles (S. H. Hwang & Lignos, 2018).

This paper quantifies the collapse risk and earthquake- induced economic loss in low- to mid-rise steel frame buildings assigned to different risk categories, which are designed with perimeter special moment-resisting frames in highly seismic regions in North America based on the design provisions; ANSI/AISC 341-05 and ASCE/SEI 7-10 (S. H. Hwang et al., 2019). The FE model established in this paper can be used to evaluate the residual stress of the tube in the hydraulically expanded joint of austenitic stainless steel, and the results of this study can provide a reference for the manufacturing process of austenitic stainless steel tube-to-tubesheet hydraulically (Hong et al., 2020).

Research before by (S.-H. Hwang & Lignos, 2017) for the seismic events, an appreciable contributor to total losses in steel-frame buildings with special concentrically braced frames is structural repairs because of steel brace flexural buckling. It is suggested that dual-parameter rather than drift-based steel brace fragility curves should be used in loss computations conditioned on a single seismic intensity. Otherwise, the expected annual losses should be used as a metric for building-specific loss assessment of steel-frame buildings with special concentrically braced frames.

By using interview in the LSF systems in a pilot study in Iran as a developing country29 significant risks are extracted in design, construction and operation and then evaluated by proposed fuzzy method. Results showed that the share of the risks in these steps are 21%, 31% and 48% respectively, the results revealed that the risks in the construction and operation phases are higher than those in the design phase (Yeganeh et al., 2022).

Convincing a bonding company that it’s worth the risk requires a robust balance sheet and a proven track record. In the case of KL&A, it was the personal relationships that the steel construction partner had developed during his years as a fabricator that made it possible to obtain a bond (Ummah, 2019).

This paper as a basis for controlling and improving productivity and construction performance for the construction of steel structure projects. The ability of the estimating team to accurately determine productivity for different activities will have a significant impact on crew cost component, time schedule of the project and improve projects’ performance (IA et al., 2016). Practically, the structural failure does not originate from only one source. It is a process of cumulated causes; at a critical and under suitable conditions, they form the state of collapse. Furthermore, in steel construction industry there is a long chain of stakeholders (investors, designers, fabricators, workers, inspectors, etc); all of that with different interests and level of knowledge (Anastasiadis, 2021).

Australian Steel Institute (ASI) has developed the National Structural Steelwork Compliance Scheme (NSSCS) as an easily actionable tool to help ensure stakeholders and our community have compliant risk-minimised structures, strongly recommends third-party certification of steelwork and is seeking to have the following wording included in specifications for all government building projects: “Compulsory auditing and certification of all Steel Fabricators by Steelwork Compliance Australia (SCA) to meet the requirements of AS/NZS 5131 prior to tendering on government projects.” (Gardner & Key, 2021). Dimensional and geometric tolerance strategies demonstrated in the case study of this research considers hypothetical probability values for the alignment and rework risk functions based on empirical data and statistical analysis of construction projects and product development processes. As the probability ranges, fabrications costs, and rework/alignment/safety risks will vary for different types of structural systems, this research provides a functional methodology for assessing the tradeoffs of various structural assembly configurations and finding the optimal design configuration (Shahtaheri et al., 2017).

From a homogeneous database of 71 steel structure projects constructed in the last decade, several curves are derived concerning productivity per work phase. Through a literature review and interviews with experienced site engineers, Furthermore, the investigation of the risks related to this kind of structure showed that five were classified as "high" risks that should be investigated in terms of their consequences and occurrence, are: (i) significant worker accidents, (ii) inability to collect (agreed) receivables, (iii) competition, (iv) investment failure, and (v) increased administration expenses. Moreover, the TOPSIS entropy method revealed that the same risks are more important and ranked them by taking into account (a) probability, (b) severity, and (c) vulnerability weights (Petroutsatou & Kantilierakis, 2023).

It was designed model on Matlab in measuring and evaluation the crew productivity of construction of steel structure projects based on the several factors that affect the construction of steel structure process. It is recommended that contracting and consulting firms to improve the crew productivity for the construction of steel structure projects before starting and during the construction of projects (Rashid et al., 2015). The following may be suggested in order to improve checking and supervision to avoiding human errors: • Frequent professional training. • Using a checklist. • Better selection of checkers and field inspectors, for example, selection according to psychological predispositions, increasing of knowledge requirements associated with appropriate salary. • Gathering, analysis and dissemination of conclusions and recommendations formulated on the basis of structural failure investigations among civil engineers (Tylek et al., 2017). Research by (Leu & Chang, 2013) developed a safety risk-assessment model for steel construction projects by establishing the Bayesian networks (BN) based on fault tree (FT) and was validated against the safety inspection records of six steel construction building projects and eight projects in which a site accident occurred in Taiwan. The most common risk found in a steel projects are based resource risk, project member risk, site risk and documents risk, there are 18 study which as the identified risk, means 60% risks in a steel projects (Hidayah, 2021). Double angle bolted web-cleats connection (specimen D-A-B-3D) had the largest resistance to progressive collapse risk in terms of peak load and dissipated energy. This connection was followed by the welded shear plate connection (specimen S-P-W-3D). These two types are thus recommended for design codes of practice to be used as simple shear beam-column connections in multistory steel framed buildings in order to minimize the progressive collapse risk and then save human lives (Elsanadedy et al., 2021).

Fifty-four steel buildings in california with three different seismic force-resisting systems (moment frame, concentrically and eccentrically braced frame) are designed for a region of high seismicity for Risk Category II, III, and IV. The results indicate that the analytical fundamental period is affected when an importance factor greater than 1.0 is used for design, as is required for assigned higher risk categories. Moreover, the database of measured vibration data taken from steel buildings used to establish the empirical formula adopted by ASCE/SEI 7-16 to compute the approximate fundamental period did not include buildings designed with an importance factor (Harris & Michel, 2019). (Lee et al., 2020) evaluated for the risk of steel corrosion in concrete subjected to a chloride-bearing corrosive environment, depending on binder type in concrete mix. The experiment tested four replicate specimens with a different types of mix. The information on chloride transport and corrosion resistance was further investigated to quantitatively rank the impact of each parametric value on the corrosion-free life.

The following is the articles based on year of research in steel building projects shown Figure 3 below.

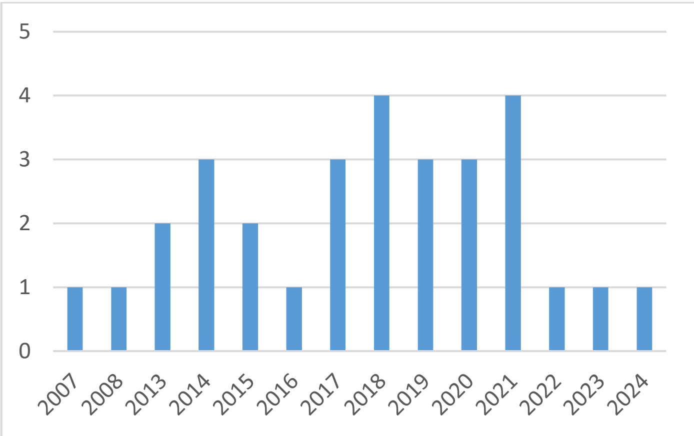

Figure 3. List of Journal's Year Published

The research reviewed above are took from the span of 2007 – 2024. Most of the research are from 2021 and 2018 with each 4 researches, and the least of all are from 2007, 2008, 2016, 2022, 2023 and 2024 with only one research. The following is the research distribution data based on risk category shown Figure 4 below.

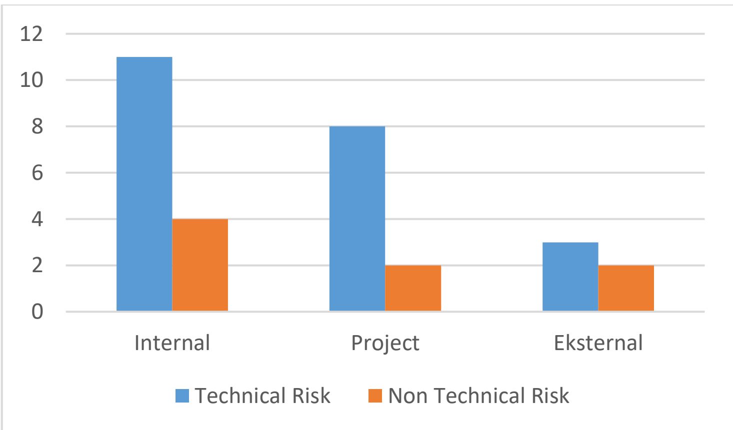

Figure 4. Research articles based on risk category

The result of this paper literature review there are 15 study which has Internal Risks as the identified risk, means that Internal Risks has become the cause of 50% risks in a steel building construction project. Meanwhile Project Risk has become the cause of 33.33% based from 10 study and External Risk are only 5 study it is mean has 16.67%

risks presentation in a steel building construction. Technical aspects in both Internal and Project Risks is the most influental cause in a steel building construction projects. Non Technical External risks are the least influental cause in a steel building construction projects. in general terms it can be seen in the Figure 5 following.

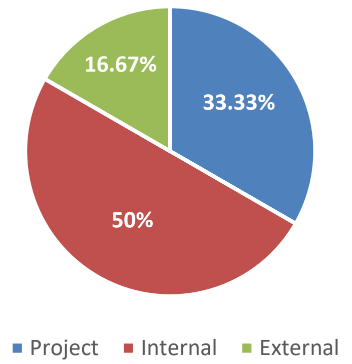

Figure 5. Presentation of risk identification

Conclusion

Based indentification above can conclude that Internal Risks are the most common risk found in a steel building construction projects, most of the risks are from the Technical category, either Internal nor Project Risks. And the least category is Non Technical category from the External risks. Furthermore, now the Internal Risk has become the most influental risk, particularly the structural design aspects and to avoid unfavorable events, its better to do the mitigation starting from the designing phase by reviewing the proposed design until the risk possibility is optimum minimalized.It is also necessary to further literature review on another project risks identification with different object.

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