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Project Risks Identification of Steel Construction on Industrial Buildings : A Systematic Literature Review

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A B S T R A C T

Risk is defined as an uncertain event or condition that, if it occurs, can have either a positive or negative effect on the project objectives. This effect can be avoided by using risk management methods, to identify risks, assessing risks either quantitatively or qualitatively, and choosing the appropriate method for handling risks will minimalized the effects. In the study, the scope was to identify the potential risk occurs on steel building work based on the previous research. Using sources based on the previous research, here will be identifying what types of risk factors are most commonly occurs for steel building work. 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 structure building work.

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1. INTRODUCTION

Based on the structure and type of building, the industrial sector is one of the users of steel buildings because the need for maximum free space in any industrial activity. For this requirements, using long spans between columns cannot be avoided. steel buildings tend to have high tensile resistance (Tn) capabilities are certainly very suitable for long span structures.

In modern construction, steel structures are used for almost every type of structure including heavy industrial buildings, high-rise buildings, equipment support systems, infrastructure, bridges, towers, airport terminals, heavy industrial plants, pipeline, etc.

Steel structure includes sub-structures or parts in a building made of structural steel. Structural steel is a steel construction material made with a certain shape and chemical composition according to the specifications on the project. The main component of structural steel are iron and carbon. Manganese, alloys, and certain chemicals are also added to iron and carbon for added strength and durability. But like any other building project, steel buildings also have risks.

Risk is defined as an uncertain event or condition that, if it occurs, can have either a positive or negative effect on the project objectives. Known risks have been identified, analyzed, and can be managed using the processes in this knowledges area. Known risks may be assigned a contingency reserve as part of managing them. Unknown risks cannot be ascertained or managed adequately in advance. A common method for dealing with unknown risks is to allocate management reserves in the form of extra money, time, or resources. Risk management activity was designed to assist the practitioner to observe the type of risk and to determine the best solution of the risk. It is a tool to identify the source of risk as well as to predict the impacts and to find the implementation of the ways to overcome the Risk (Dewi et al., 2020).

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). On another literature, Zavadskas et al., (2010) state that risk management is activity process about defining sources of uncertainty (risk identification), estimating the consequences of uncertain events/conditions (risk analysis), generating response strategies in the light of expected outcomes and finally, based on the feedback received on actual outcomes and risks emerged, carrying out identification, analysis and response generation steps repetitively throughout the life cycle of an object to ensure that the project objectives are met.

The risks are very important for safety in steel manufacturing. If risks are identified early on, the risk potential can be reduced by taking suitable measures, and proactive risk management is rendered possible (Klöber-Koch et al., 2018). All sources of risks need to identified, to determine the project activities in steel manufacturing into high risks, moderate risks, or low risks.

Risk identification should address internal, project, or external risks. Based on Zavadskas et al., (2010) project risks can be divided into three groups ; External, Project and Internal. External risks (environmental criteria) such as,

- Political risk
- Economic risk
- Social risk
- Weather risk

Project risks (construction process criteria) classify as below:

- Time risk
- Cost risk
- Work quality
- Construction risk
- Technological risk

Internal risks (intrinsic criteria) classify as below:

- Resource risk
- Project member risk
- Construction site risk
- Documents and information risk

Risks identification is also concerned with opportunities (positive outcomes) as well as threats (negative outcomes). Risk identification may be accomplished by identifying causes and effects (what could happen and what willensure) or effects and causes (what outcomes are to be avoided or encouraged and how each might occur) (Duncan, 2013).

After describing the risk identification, the following are section details phase of risk assessment which consists of the following sub-processes based on (Klöber-Koch et al., 2018) :

1. Criteria selection
2. Information gathering
3. Criteria assessment
4. Multidimensional assessment
5. Graphical representation and comparison with acceptance limits
6. Risk Prioritization

Research by Zavadskas et al., (2010) described that risk control establishes a plan, which reduces or eliminates sources of risk and uncertainty impact on the project's deployment, options available for mitigation are:

− Commercial insurance
− Self insurance
− Merger and diversification

2. RESEARCHMETHOD

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 willclassify the 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 from 2002 to 2021 will be reviewed in this paper. The following is the study frame work of this research.

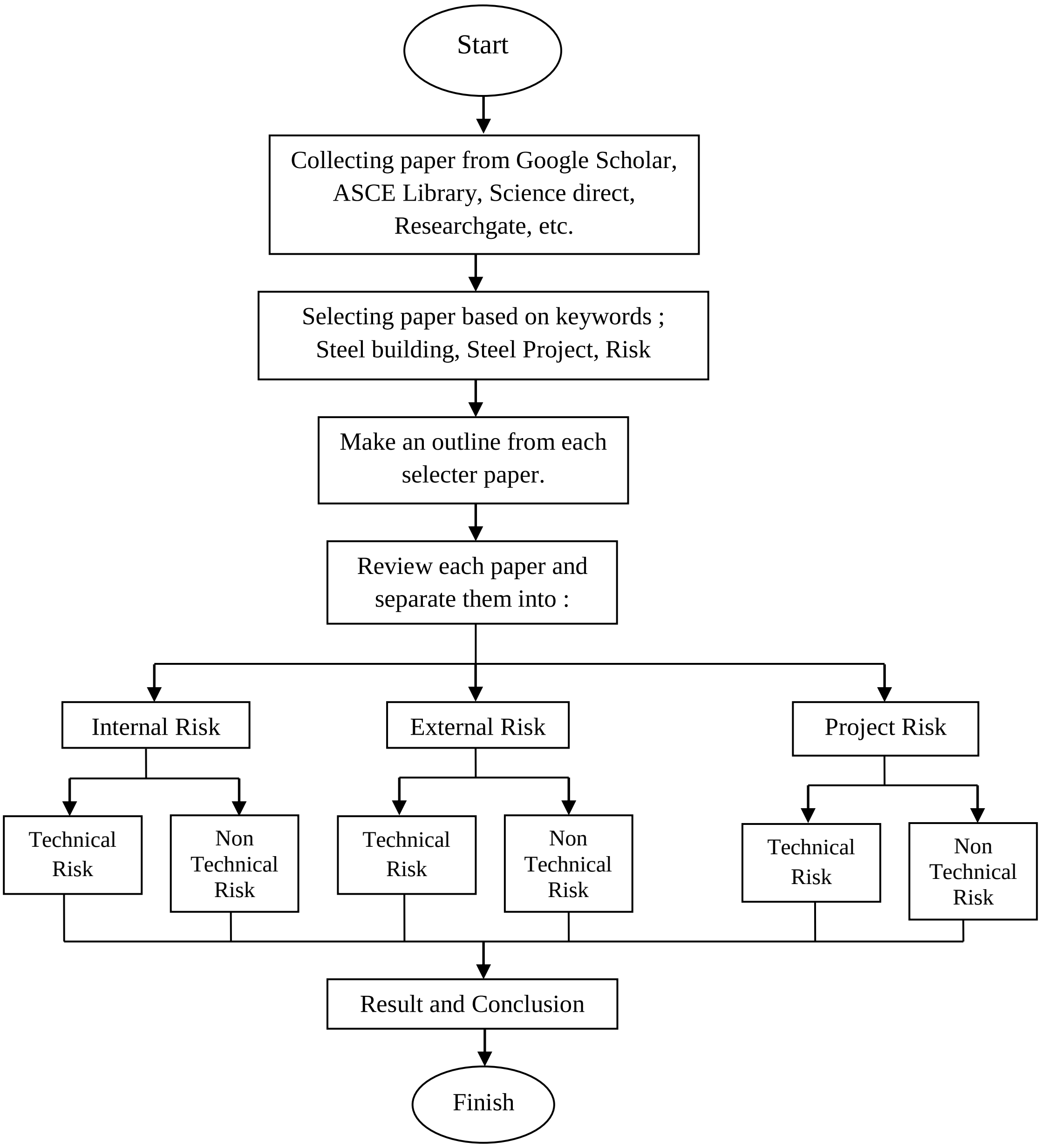

Fig. 1. Study framework

3. RESULTS AND DISCUSSION

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

Table 1. Summary literature review of risk identification in steel construction on industrial buildings

No.	Paper Identity	Safety Risk Factor						Result
		Internal		External		Project		
		T	NT	T	NT	T	NT	
1	(Kook & Kim, n.d.)	*x*	*x*	*x*	*x*	√	*x*	The study intended to identify the process of the structural steel work as well as the schedule risk factors that may occur from the activities at each stage. 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.
2	(Harris & Michel, 2019)	√	*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. Consequently, if the performance objective is to achieve uniform risk within a category, then the design period should vary as a function of the risk category.
3	(S.-H. Hwang & Lignos, 2017)	√	*x*	*x*	*x*	*x*	*x*	The effect of analytical modeling assumptions on the collapse risk and the earthquake-induced economic losses for typical archetype steel-frame buildings with special concentrically braced frames ranging from 2 to 12 stories. This was achieved through the development of analytical model representations of the bare SCBF only (namely, the B model) as well as models that explicitly captured the effect of the gravity framing and the composite floor action (namely, the CG model) on the steel-frame building's structural response.
4	(Zehtab Yazdi et al., 2021)	√	*x*	*x*	*x*	*x*	*x*	The present paper proposes a detailed seismic risk prioritization process for steel school buildings using a hierarchical structure through a fuzzy inference system method and applies it to a case study on steel school buildings in Tehran. This study aims at drawing on a seismic risk prioritization method using a fuzzy model based on a solid, efficient, and complete structure for steel school buildings, and its results as a case study indicate the number of Tehran's school buildings with high seismic risk requiring retrofit studies.
5	(Zhang et al., 2019)	√	*x*	*x*	*x*	*x*	*x*	The results of this study indicate that under light saline exposure, the galvanic corrosion rate of galvanized ASTMA325 bolts used with A1010 steel was similar to the corrosion rate of A325 bolts used with ASTMA588 weathering steel. Under heavy saline exposure, however, the galvanic corrosion rate of A325 bolts was significantly higher when used with A1010 steel than when used with A588 weathering steel. Reducing the galvanic corrosion rate can be achieved by painting the joints of the steel girders, thereby reducing the cathode-to-anode area ratio. The results of this study suggest that the corrosion compatibility of the bolt and steel materials must be considered when designing corrosion-resistant A1010 steel bridges, and that the compatibility must be confirmed with an experimental validation.
6	(Dewi et al., 2020)	√	*x*	*x*	*x*	*x*	*x*	The results of the analysis show that unrealistic schedules, skill not appropriate, not available equipment, transportation barriers to the workshop, fluctuations in steel material prices,

No.	Paper Identity	Safety Risk Factor						Result
		Internal		External		Project		
		T	NT	T	NT	T	NT	
								wrong specifications from owner, incorrect interpretation of specifications, misinterpretation of drawings, incorrect volume, material storage, wrong cutting, incorrect installation, and wrong order are factors with moderate and high risk.
7	(Elsanadedy et al., 2021)	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
8	(Dobiášová & Kubečka, 2014)	√	x	x	x	x	x	In case project of blast furnace in Alchevsk was the first risk factor many specialized, which practically each specialized was designed in different part of world. And based on this study 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.
9	(Lagaros, 2014)	√	x	x	x	x	x	In this work fragility curves associated with different limit-states of steel and steel-reinforced concrete composite buildings are developed, considering the influence of various sources of uncertainty. In particular randomness on the seismic demand and incident angle along with the uncertainty on the material properties, the floor mass and the structural damping properties are considered. material and floor mass were found to be very significant sources of uncertainty.
10	(Kim et al., 2018)	√	x	x	x	x	x	With some combined analyses, weighted individual risk soring resulted in the following top five most impactful international steel project risks: procurement of raw materials; design errors and omissions; conditions of raw materials; technology spill prevention plan; investment cost and poor plant availability and performance.
11	(Dube, Prof S K; Mali, 2018)	x	x	x	x	√	x	Based on this paper the risk from steel projects are down below : a) Risk of Project cost over-run during Development Phase. b) Risk with New/ outdated Technology. c) Risk in Transportation during Construction Phase. d) Risk related to Disputes among Contractors. e) Risk of Delays.
12	(Shi et al., 2020)	√	x	x	x	x	x	This study presents a methodology to generate probabilistic seismic demand models and hazard curves for steel frames with or without shape memory alloy (SMA) bracing systems under mainshock – aftershock sequences. risk-based seismic performance evaluation study was conducted to generate seismic demand hazard curves for maximum and residual interstory displacement response. Results reveal the advantages of SMA braces in enhancing post-event functionality of steel frame buildings. In addition, defining damage states based on residual drifts is recommended while comparing the aftershock performance of conventional steel moment resisting frames with self-centering steel buildings.
14	(Faggiano et al., 2008)	x	x	x	√	x	x	This paper shows a preliminary brief overview of the most relevant research on the risk of fire following earthquake. Therefore, a methodology, conceived in the framework of the performance-based approach, for the assessment of the fire resistance of steel structures damaged by earthquake. The necessity of considering both a building scale and a regional

No.	Paper Identity	Safety Risk Factor						Result
		Internal		External		Project		
		T	NT	T	NT	T	NT	
								scale for the management of the emergency is also pointed out.
15	(Kihira, 2007)	x	x	x	√	x	x	To reduce risks for anomalous rusting to occur on weathering steel structures, a computerized corrosion prediction system have been developed. Therefore, all corrosion risks can be monitored by the inspection of steel member surfaces.
16	(Campione et al., 2020)	√	x	x	x	x	x	In this paper, the risk of failure of the Salso River railroad steel bridge is analyzed. Static verification of steel bridges under permanent and accidental loads utilized actually in the Italian Code was carried out. The results obtained showed that for this bridge, there are no risks of failure and stresses in maim members are lower than strength of materials such as for compressed steel strut and masonry piers.
17	(Dunant et al., 2018)	√	x	x	x	x	x	Steel reuse has been identified as an effective method to reduce the carbon and energy impact of construction, it is in effect only a marginal practice.Rather, reused steel is somewhat more expensive than new elements, except in certain circumstances such as when the reused elements are available from a nearby site, or when testing elements can be avoided. Further, we show that neither the costs of steel reuse, nor the risks, nor its benefits are spread equitably throughout the construction industry supply chain.
18	(Leu & Chang, 2013)	x	x	x	x	√	x	There are four primary accident types at steel building construction (SC) projects: falls (tumbles), object falls, object collapse, and electrocution. There are several traditional systematic safety risk assessment approaches, and to overcome the limitations of traditional approaches, 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 BN-based safety risk-assessment model was validated against the safety inspection records of six SC building projects and eight projects in which a site accident occurred. 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.
19	(Al-Kawari & Hushari, 2019)	√	x	x	x	x	x	This paper recommended that loose steel slag aggregate may not use internally in direct contact with humans. However, it could be used in external construction applications below the ground surface. Asphalt made with up to 40% steel slag aggregate could be safely used in road applications in cities. However, concrete made with up to 50% slag aggregate could be safely used in construction applications.
20	(Hong et al., 2020)	√	x	x	x	x	x	Stress corrosion cracking (SCC) is one of the main failure modes of tube-to-tubesheet expanded joints in tubular heat exchangers, and the residual tensile stress is an important factor in the development of these cracks. 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 expanded joints.
21	(Molina Hutt et al., 2019)	√	x	x	x	x	x	This study benchmarks the performance of older existing tall steel MRF buildings designed following historic code-prescriptive requirements (UBC 1973) against modern design standards (IBC 2015) by means of risk-based assessments of alternative designs of a 50-story archetype office building, located at a site in San Francisco, CA. The results, which highlight contributions from structural repairs, non-structural

No.	Paper Identity	Safety Risk Factor						Result
		Internal		External		Project		
		T	NT	T	NT	T	NT	
								repairs and impeding factor delays, indicate that non-structural repairs and impeding factor delays are the greatest downtime contributors.
22	(S. H. Hwang et al., 2019)	x	x	x	√	x	x	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. The emphasis of this paper is on the effects of assigned risk category on the seismic risk, including both collapse risk and economic risk, assessed in a probabilistic manner.
23	(Tanner, 2008)	√	x	x	x	x	x	This paper aim to develop a simple methods, model, and decision criteria geared to the practical application of risk analysis in steel structures design.
24	(Celano et al., 2018)	√	x	x	x	x	x	This study evaluate the risk-targeted safety factor and behaviour factor for selected steel structures. It was shown that the values of the behaviour factors quite significantly depend on the seismic hazard function although only the sites with the same level of seismic intensity were taken into account. It is hoped that the calibration of risk-targeted behaviour factors and safety factors for steel structures is the first step to more comprehensive procedure for resilience-targeted design of petrochemical plant, which will overcome the current code provisions.
25	(Rad & Banazadeh, 2018)	√	x	x	x	x	x	The performance of base-isolated steel structures having special moment frames is assessed. The TCFP systems represent superior performance than LRB systems in lower intensities. For longer periods and taller structures, the isolation type has less effect on the performance of NSC. Finally, the archetypes have less than 1% risk of collapse in 50 years; nevertheless, high-rise structures with RI = 2.0 have more than 10% probability of collapse given the maximum earthquake.
26	(Jung et al., 2018)	x	x	x	√	x	x	The present study concerns the resistance of silica fume (SF) concrete against chloride-induced corrosion, when SF concrete is built in a chloride-bearing environment. Chloride transport and critical chloride threshold level were experimentally obtained, which were subsequently used for the Fick's 2nd law to calculate the corrosion-free life.
27	(Steffens et al., 2002)	x	x	x	√	x	x	Damage of reinforced concrete structures is often caused by corrosion of steel reinforcements due to carbonation. It is verified by using results from experimental tests reported in the literature. Taking into account changing atmospheric conditions, structures are investigated with respect to the corrosion risk of steel reinforcements. Together with threshold values taken from the literature, the numerical results give the corrosion risk of reinforced concrete structures.
28	(Lee et al., 2020)	x	x	x	x	√	x	The sensitivity to corrosion-free life in concrete structures exposed to chlorides was evaluated with respect to different binder in mix. Portland cement had the highest sensitivity for the chloride threshold level and surface chloride concentration to corrosion-free life, whilst these sensitivities in other mixes were lower in a similar range between them. Either a double of the chloride threshold level or half of the surface chloride in Portland cement mix could produce the corrosion-free life in an equated range for 65% ground granulated blast furnace slag mix at an equivalent condition. As for cover depth and apparent diffusion coefficient, their sensitivity to corrosion-free life was independent to binder type, which nevertheless affects the corrosiveness.

No.	Paper Identity	Safety Risk Factor						Result
		Internal		External		Project		
		T	NT	T	NT	T	NT	
29	(Yu et al., 2017)	x	x	x	x	√	x	In order to overcome the disadvantages of traditional deterministic methods, a probabilistic evaluation method to assess the corrosion risk of steel reinforcement in concrete was proposed based on the probabilistic prediction model of concrete resistivity. Finally, a probabilistic evaluation method for corrosion risk of steel reinforcement in concrete was developed by means of the proposed probabilistic prediction model of concrete resistivity. Analysis results show that the proposed probabilistic evaluation method can not only identify the dominant risk of reinforcement corrosion, but also determine the probabilities of steel reinforcement under different corrosion risk levels (e.g. negligible, low, moderate, and high), which could avoid the misjudgment of corrosion risk of steel reinforcement often encountered by the traditional deterministic evaluation methods.
30	(J. P. Hwang et al., 2015)	x	x	x	x	√	x	In the present study, the corrosion risk of steel fibre in concrete was assessed by measuring the corrosion rate of steel fibre in chloride-contaminated mortar. it was found that the corrosion resistance of steel fibre against chloride was slightly higher than for reinforcing steel rebar in concrete, presumably due to the presence of mille scale on the surface; the chloride threshold level ranged 0.8–1.0% by weight of cement.

Note :
T: Technical
NT: Non-Technical

The risk factors were sorted from those applicable to the commerce buildings with 20 stories or higher. 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.). Research by Harris & Michel (2019), evaluate the use of Seismic Analysis Provisions in ASCE/SEI 7-16. The model implemented into Fifty-four steel buildings (4-, 8-, and 16-story) 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 result is modification of the formulation that been used before.

Research by Hwang & Lignos (2017), assessed the modeling assumptions (the CG model and the B model) on the collapse risks for typical archetype steel-frame buildings with special concentrically braced frames ranging from 2 to 12 stories. Typical archetypes were designed in two different seismic zones in urban California (SDC Dmin and SDC Dmax). Hwang & Lignos (2017), proposes a detailed seismic risk prioritization process for steel school buildings in Tehran, Iran, using a hierarchical structure through a fuzzy inference system method. The results was validated through a comparison with the existed risk results of 122 steel school buildings in all 19 districts of Tehran and for each input parameters. Research by (Zehtab Yazdi et al., 2021), intended to better understand the galvanic corrosion risk of using ASTM A325 Type I bolts with ASTMA1010 steel girders in the construction of A1010 steel bridges and to explore options for mitigating the risk based on experiment under several environmental conditions (Zhang et al., 2019).

The object of study by (Dewi et al., 2020) is steel structures for nuclear power plant construction type Light Water Reactor (L.W.R.) in Indonesia. Based on technical consultation with interviewees from the steel industry on experienced project stakeholders in this industry and helps to identify risks. This method was also based on the purpose sampling test method with the determination of one industry of existing steel industries.

Research by Elsanadedy et al., (2021) showed the risk of progressive collapse of steel frame assemblies was experimentally investigated under middle column loss event. The specimens were divided into two groups (4 specimens in each group), And the progressive collapse was modeled by placing a quasi-static loading on the center column at a downward displacement rate of 100mm/s. Behavior of different joints was numerically compared with respect to their failure modes and load versus displacement characteristics. Research by 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.

Research by Lagaros (2014), 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. Research by Kim et al., (2018) aim to aid decision-makers in the risk assessment and mitigation of overseas steel-plant projects. Through an exhaustive literature review, survey of subject-matter experts, two case studies, and an analytic hierarchy process (AHP) using the fuzzy inference system (FIS) to decide the most impactful international steel project risks.

Research by (Dube and Mali 2018), confirmed thar the risk analysis of steel plant is done by using The Risk Priority Number (RPN) methodology. This study based on case from Aditi Metallurgical & Alloys Pvt.ltd a steel plant project located in India. The objective of research by Shi et al., (2020) is to develop the steel moment resisting frames (SMRF) designed with and without SMA cable bracing system and subjected to mainshock–aftershock sequence using the Open Sees. Then, aftershock analyses were carried out at three damage states. A risk-based seismic performance evaluation study was conducted to generate maximum and residual interstory displacement response.

A nonmodel-based framework were developed in instrumented steel frame buildings with steel moment-resisting frames (MRFs). The proposed framework is demonstrated through a number of illustrative examples including actual instrumented steel frame buildings that experienced the 1994 Northridge earthquake in Los Angeles. This framework can facilitate the decision-making for effective pre-disaster measures for earthquake disaster risk management of building assets (Hwang & Lignos, 2018)

The present work proposes a systematic management method for Risk Based Minimum Maintenance (RBMM) of weathering steel bridges that occurs in Japan. With the helps of computer aided corrosion prediction system, risk monitoring and risk navigation make possible to realize ultra long life of weathering steel structures bridges (Faggiano et al., 2008). Research by Kihira (2007), analyzed the fire following earthquake that possibly occurs in high-rise building at seismic urban areas. Based on previous research and coupled temperature-displacement numerical analyses. The case study examined was that of a bridge railroad steel bridge having a total length of 112 m and constituted by three isostatic, reticular beams having a Pratt type composition. A static verification of the steel bridge under permanent and accidental loads conducted using Italian Building Code to find out the risks of failure (Campione et al., 2020). Study by Dunant et al., (2018) is a 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.

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. Research by Al-Kawari & Hushari (2019), measured and calculated the risk of radioactivity's, radiation exposure and hazard index of adding steel slag to asphalt in two different outdoor cases, in a car parking and children's playing areas. The steel slag obtained from Qatar.

The cause of failure risk 304L tube-to-tubesheet expanded joints steel used in a nuclear power plant were evaluated by the Finite Element Method (FEM) and Stress Corrosion Cracking (SCC) test to reveal the cause of crack formation. The the specimen were tested following the RCC-M standard (Hong et al., 2020). Study by Molina Hutt et al., (2019) is benchmarks the performance of older existing tall steel moment resisting frame buildings designed following historic code-prescriptive requirements (1973 Uniform Building Code) against modern design standards (2015 International Building Code). The comparison is based on seismic risk assessments of alternative designs of a 50-story archetype office building, located at a site in San Francisco, CA.

The 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). Research by (Tanner, 2008) to develop a simple methods, models and decision criteria geared to the practical application of risk analysis in design. The sample categories for this research are CC2 (residential and office buildings) up to 10 storey and CC3 (densely occupied buildings) up to 30 storey using the Spanish Design Codes. The risk-targeted safety factor and risk-targeted behaviour factor is applied to a set of simple steel moment resisting frames, considering different modelling approaches, different locations and different target probabilities of failure used in a petrochemical plants. The frames were obtained from typical steel buildings designed by Tsitos et al. (2017) in accordance to Eurocode 3 (CEN, 2005) and eurocode 8 (cen, 2004) (celano et al., 2018).
Study by Rad & Banazadeh (2018) aimed to do a probabilistic risk-based performance Evaluation of base-isolated steel structures 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.

Jung et al., (2018) present the risk of corrosion steel structures built in a chloride-bearing environment. Based on a experiment to assess the resistance of steel to chloride-induced corrosion, corrosion behaviour of steel, chloride transport and chemistry at chlorides. Research by Steffens et al., (2002) is the development of a theoretical model to predict carbonation of steel in a reinforced-concrete structures. The model is solved by an efficient numerical method using a finite element concept and numerical time integration techniques.

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. Research by Yu et al., (2017) proposed a probabilistic evaluation method to assess the corrosion risk of steel reinforcement in concrete resistivity, in terms of the major influential factors, was developed by using the Bayesian theory and the Markov Chain Monte Carlo (MCMC) method. The major influential factors including water-to-cement ratio, chloride content, ambient temperature and ambient relative humidity on concrete.

Hwang et al., (2015) showed the risk of adverse effect of steel fibre in concrete was evaluated in terms of corrosion of steel fibre and ionic penetration. An experiment was conducted, a microscopic examination at the interface of steel fibre was simultaneously made by the scanning electron microscopy to determine the mechanism of corrosion and ionic transport in steel fibre concrete. The following is the research distribution data based on country of origin (Fig. 2).

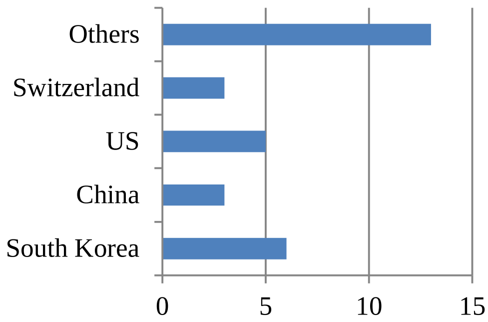

Fig. 2. Research articles based on location of research in steel building projects.

Others (one research each nations) including United Kingdom, Germany, Spain, Slovenia, Qatar, Taiwan, Uni Emirates Arab, Italy, Japan, India, Greece, Iran, and Indonesia.

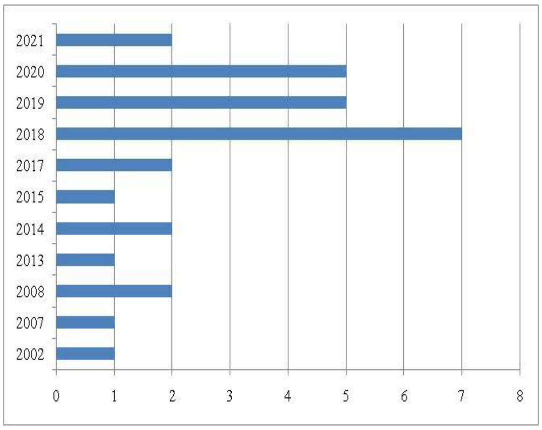

Fig. 3. Research articles based on year of research in steel building projects.

The research reviewed here are took from the span of 2002 – 2021. Most of the research are from 2018 with 7 researches, and the least of all are from 2002, 2007, 2013 and 2015 with only one research. The following is the research distribution data based on risk category,

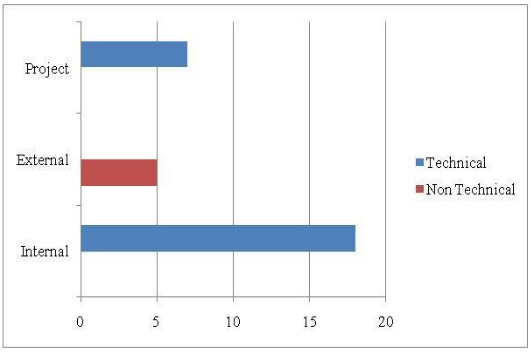

Fig. 4. Research articles based on risk category in steel building projects.

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. Based on Zavadskas*et al*. 2010 Risk allocation structure by level in construction object described as shown in Fig. 5.

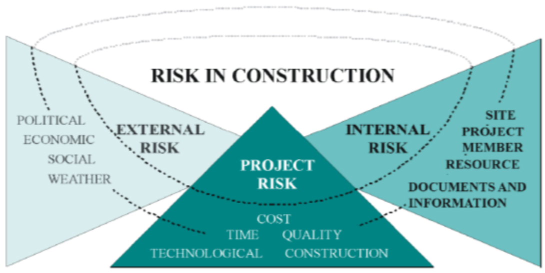

Fig. 5. Risk type in construction projects (Zavadskas et al., 2010).

The sources of risk obtained from the risk identification categories on a previous literature review are as follows :

- Technical Internal Risks, among others have the source of risk that comes from the design structure with a total 15 research, internal technical risk design as a whole become the cause of 1 study, and another two are because of site risk.
- Technical Project Risks mostly have the sources of risk from quality risks with 3 papers, construction risks are the cause of risk in 2 another research, and time risk (schdule) along with the whole construction risks each are the sources of risk in two different study.
- Non Technical External Risks mostly have the sources of risk from environment and weather

cause with 4 study, and the last one from the economic risk.

4. CONCLUSION

Based on literature review from 30 paper above we can conclude that :

- Internal Risks are the most common risk found in a steel projects. From the total of 30 study that had been reviewed, there are 18 study which has Internal Risks as the identified risk, means that Internal Risks has become the cause of 60% risks in a steel projects.
- Project risk has become the cause of 23.33% risk in a steel projects.
- Technical aspects in both Internal and Project risks is the most influental cause in a steel projects.
- Non Technical External risks are the least influental cause in a steel projects.

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 objects.

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