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A Critical Review of Safety Leadership Maturity Model in the Construction Industry

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ABSTRACT

The construction industry faces a high safety risk, owing to its high complexity, changeability, and stakeholder involvement. Several publications have focused on the causes of accidents in the industry, and several others have identified safety leadership and the involvement of project owners as the fundamental factors. The maturity model is recognized by many as an effective assessment method for safety leadership in the construction industry. This study aims to determine the most effective model by developing the maturity framework of project owners. Firstly, 31 publications were reviewed under several selection criteria, revealing that maturity models have been used extensively in various industries. Subsequently, two designs were compared, namely, levelling and factorized maturity models, to see which is more effective for assessing the safety leadership of construction project owners. The results show that the factorized maturity model was more suitable, for its ability to adapt to changes. Safety leadership was also observed as a fundamental causative assessment factor by the maturity model framework. The findings provide a good reference for assessing the safety leadership of project owners with the most appropriate maturity model.

1. INTRODUCTION

1.1 Background

The construction industry reportedly causes numerous accidents and deaths among workers. Many argued that safety leadership could directly suppress the casualties and disasters in building projects [1-4]. Several factors, namely, safety and proactive leadership, as well as leader commitment, have been identified to improve safety performance in the construction industry [1, 5, 6]. Under the effect of these factors, the organizational focus would shift towards health and safety governance, which reduces the risk of accidents and disasters. Therefore, many organizations and companies strive to realize zero accidents by improving their safety culture [1, 2, 5, 6].

The previous studies reported that employee protection is promoted by governance [7], and the safety culture is entirely mediated through the communication with safety leaders, as well as the daily report and participation of workers [6]. In other words, safety performance is achieved through continuous communication between safety leaders and construction workers.

An assessment tool is needed to evaluate safety leadership. Several publications resorted to maturity models to achieve adequate safety leadership, and detailed their functions and concepts. For instance, Roghabadi & Moselhi [8] developed a maturity model by a fuzzy decision method. The model provides construction organizations with the insights into the capabilities and weaknesses in risk management, as well as several areas for improvement.

The risk management maturity model (RMMM) was hailed as the best to assess risk management, due to its practicality and flexibility in any condition [9]. The model offers a comprehensive maturity scale, showing both positive and negative sides. Orlando et al. [10] designed a maturity model to assess safety maturity, identify management risks, and support internal controls. But the model requires several prior conditions: the organization must have sufficient capability to implement the model.

Through the above analysis, a literature review was conducted on safety leadership, maturity models, and the contribution of project owners, with a special focus on maturity models. The aims of the review are as follows:

(1) To better understand the maturity models, and assess the safety leadership, functional features, utilized factors or indices, and application methods, through a critical review;

(2) To examine the methodological properties of maturity models in assessing safety performance;

(3) To develop a maturity framework for safety leadership assessment in the construction industry.

1.2 Safety leadership maturity

Despite the considerable literature covering safety leadership, there is inadequate agreement on its definition and assessment methodology. Griffin & Hu [11] treated safety leadership as a specific behavior motivating workers to achieve safety goals. Barling et al. [12] defined safety leadership as a multidimensional construct reflecting a value for safety, which is demonstrated by actions and practices promoting workplace safety. The effectiveness of safety leadership can be assessed by several indices: (1) establishing authority between owners; (2) effective collaboration between parties, (3) reducing conflict between parties, (4) enhancing

safety awareness of each party, (5) good safety policies and practices by each party, and (6) the consistency and sustainability of safety policy implementations [3].

Zhang et al. [6] observed that group safety is highly mediated by participation, as well as leader-worker communication. This means workers can understand the importance of safety within the workgroup, through adequate communication and information exchange. Moreover, executive leaders must actively engage with workers to achieve organizational goals, and provide them with the keys to achieve safety performance and solve common safety problems. To this end, the leaders need to adopt methods for improving job performance, in association with safety departments and management [1]. Skeepers & Mbohwa [13] argued that safety leadership is the commitment, participation, and behavior affecting the safety performance of workers.

Considerable evidence shows that the leadership influences construction safety. A proactive leader with mature safety features produces less adverse outcomes, such as accidents or deaths [2]. For a construction project, 15% of the cost is incurred by accidents. The elimination of building risks would greatly benefit project owners. According to Grill et al. (2018), immature leaders with passive or avoidant behaviors weaken the safety climate at the construction site [14]. Similar conclusions were drawn by Salamzadeh & Hajiseydjavadi [4], who observed a significant mutual correlation between leadership style and organizational maturity: the organizational attitude towards safety is affected by the maturity of both workers and leaders.

Compared to workers, leaders boast profound knowledge, skills, and attitudes, and exert a huge influence on the safety construction culture. Thus, they are the most appropriate targets for training [15]. A good safety climate spurs the sustainable development of safety. Moreover, workers are unable to promote and perform safety behaviors, without the support from leaders. In fact, the leadership maturity, a sign of the owners' commitment and internal motivation, is positively correlated with work performance, schedule, and cost [16]. That is, the owners are committed to educating and facilitating project teams and values, as well as improving performance in construction safety.

Every owner should prioritize safety in the pursuit of zero accidents [17]. This means project owners need to make efforts as safety leaders in the construction industry. For example, they ought to get involved in the communication between project parties, select suitable parties, and execute safety measures actively. In addition, the owners must contribute to the communication, evaluation, and improvement of workers' safety performance throughout the project [1].

2. METHODOLOGY

A maturity model can evaluate the maturity stages or levels of an organization, by assessing organizational completeness against multidimensional criteria [18]. The number of stages or levels depends on the problems in each practical context (e.g., organization, and government institution). The model is usually developed based on the literature and the developer's experience [18], aiming to depict the essential or critical features of the specific maturity of an organization.

A broader definition goes that a maturity model should explain the improving method of performance, with the knowledge of each required step [19]. Such a model would cover a broad or specific object and scope, through several topics. For instance, Knode [1] constructed a maturity model to assess the ownership and accountability of workers. Machfudiyanto et al. [20] established a maturity model to evaluate the construction industry in Indonesia, which improves the understanding and applicable scope of maturity models. Rasid et al. [21] developed a maturity model to evaluate the knowledge of project management. Kang et al. [22] put forward a maturity model to assess the information integration for the capital project industry, pointing out that the maturity of safety leadership significantly affects the attitudes of an organization and its workers towards safety culture [4].

The previous literature was collected from conference reports, academic journals, and government publications in the following electronic databases: Science Direct, Google Scholar, The American Society of Civil Engineers (ASCE), U.K. Health and Safety Executive (H.S.E.), Bersin by Deloitte, LeanCor Supply Chain Group, and Partnership for Public Service. All the data sources are opensource and reliable. For comprehensiveness, the selected literature all contains the following contents:

(1) Title, authors, and year of publication;
(2) Name of journal, conference, or theses;
(3) Country of origin of the authors;
(4) Industry;
(5) Data collection method, i.e., the way to acquire the data for developing/evaluating the maturity model;
(6) Data evaluation method, i.e., the way to use major tools to develop/evaluate the maturity model;
(7) Terminology of the maturity model;
(8) Level descriptor/factor, which classifies maturity models into the levelling and factorized maturity models based on the descriptor and factor/variable. Note that a levelling maturity model has a descriptor for each level – the higher the level, the more mature the object; a factorized maturity model identifies the object's maturity attributes with factors/variables.

3. RESULTS

3.1 Types of industries

Based on the above criteria for literature query, a total of 31 publications were selected, including 15 academic papers, 5 professional/company reports, 9 conference reports, and 2 university theses. Every publication uses maturity model as the primary tool, and comes from a reliable source. Table 1 provides the details of these publications.

Table 1. Reviewed publications on maturity models

Publication	Sector	Frequency
[10, 23-32]	Non-specific sector	11
[33]	Military	1
[34]	Supply chain	1
[2, 5, 22, 35-42]	Construction	11
[21]	Public agency	1
[43, 44]	Petrochemical	2
[45]	Housing	1
[46]	Healthcare	1
[47]	Manufacture	1

We mainly searched for the publications from 2010 to today. However, several older publications were retained, because

they are very relevant to the development and evaluation of the maturity model. In addition, two studies with no publication date were also included for their high relevance. Overall, this critical review covers 4 publications before 2010, 6 between 2020 and 2015, 18 between 2016 and 2020, and 2 in 2021 as shown in Figure 1.

By country/region, the United States has the greatest number of publications. Brazil and the United Kingdom each has 3 publications. One publication comes from Australia, Canada, China, Croatia, Hong Kong, Indonesia, Iran, Malaysia, Nigeria, Portugal, Thailand, and Turkey each.

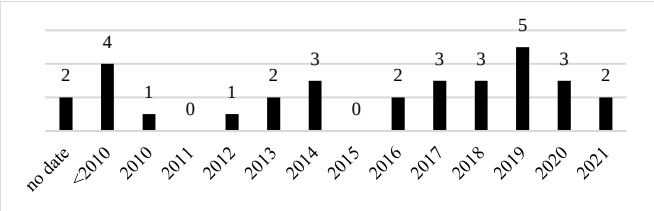

Figure 1. The year of publication

In terms of industry, the construction industry has the most publications (11) [2, 5, 22, 35-42]. Eleven publications are general discussions, falling to the category of non-specific [10, 23-32]. Two belong to the petrochemical industry [43, 44]. The remaining two belong to the category of miscellaneous.

3.2 Data collection and evaluation methods

Among the reviewed publications, the most popular data collection methods are the questionnaire survey and literature review, which are adopted in 16 [5, 10, 21, 28, 29, 31, 32, 35, 36, 39, 41-44, 46, 47] and 10 [23-27, 30, 33, 34, 37, 38] publications, respectively. Other methods are preparatory techniques for questionnaire surveys, namely, semi-structured interviews, workshops, and group discussions. Albert et al. [35] collected data through a questionnaire survey, and quantified the data by regression analysis, before developing a maturity model. Maryani et al. [37] developed a safety maturity level by a questionnaire survey and fuzzy methods. Some scholars collected a decent number of relevant studies through literature review [23-26, 33, 37, 38], and often perform a qualitative analysis to build the maturity model. The qualitative analysis extracts the most relevant parts of each publication, and compose them into a finding.

3.3 Type of publication

The reviewed publications could be divided into a development group, and an evaluation group. Overall, 21 reviewed publications focus on the development of the maturity model, while 10 focus on the evaluation of the model (Table 2). The development group has a relatively broad scope, and carries out quantitative and empirical analyses on both specific and non-specific industries. Through qualitative analysis, Kwak & Ibbs [27] provided a perfect example of the maturity model development in a non-specific industry [27]. Meanwhile, the evaluation group typically tackled a specific industry, such as contracted construction [2]. Another example was observed, which primarily focuses on assessing the maturity of a country [28].

Table 2. Type of publications

Publication	Type of Study	Frequency
[5, 22-27, 29, 30-34, 36-38, 40, 41, 43, 45, 48]	Maturity model development	21
[2, 10, 21, 28, 35, 39, 42, 44, 46, 47]	Maturity model evaluation & assessment	10

3.4 Structure and terminology

The maturity models have similar information, albeit the difference in context and industry. Each model in the reviewed publications has the following information: (1) several levels or multiples factors, (2) descriptors of each level or factor, (3) a generic description of the maturity model, and (4) a generic description of each level or factor.

The terminology of the maturity model varies with information structures. It usually provides the industrial context and ultimate goals of the maturity model [18]. Each maturity model can be assessed uniformly, because the critical review requires similar information. The most popular terminology is the leadership maturity model [23]. The other terminologies were developed based on each context, e.g., (i) construction safety maturity model [36], (ii) safety culture maturity model [29], and (iii) health and safety culture maturity model [38]. Factorized maturity models differ slightly in terminology, namely, food safety culture maturity index [48] and Safety Culture [47].

3.5 Safety and leadership-related maturity models

The maturity models in the reviewed publications have various functions, which need to be used in accordance with the specific context. The maturity model levels of safety leadership provide an important reference for maintaining safety performance [19]. In addition, some of the reviewed publications indirectly assessed safety protection and management, providing comprehensive knowledge in the critical review of safety leadership maturity.

Overall, seven [5, 23, 30, 31, 33, 34, 39] and seventeen [2, 10, 24, 25, 28, 29, 32, 35, 36, 38, 40, 42-44, 46-48] publications candidly focused on leadership and safety maturity model, respectively. Therefore, safety culture is the most common topic in explaining the maturity model, e.g., hospital settings [46] and industrial organizations [29]. In this critical review, no publication was found related to the safety maturity of project owners in the construction industry.

3.6 Level descriptors and factors

In the reviewed publications, two kinds of maturity models were used as the primary references, namely, the levelling and factorized methods. The levelling method describe maturity in 3 to 5 levels. The higher the level, the greater the maturity. Meanwhile, the factorized method uses factors or variables to describe the maturity of an object. The object maturity is proportional to the number of factors being satisfied.

Overall, 21 publications adopt the levelling method, with five maturity model levels being mostly utilized [43]. Only a few used 3 or 4 levels of maturity. Meanwhile, the factorized maturity models containing 3, 5, 7, 8, and 9 factors were found in 11 publications [2, 5, 10, 36, 38, 39, 41, 42, 44, 47, 48]. Table 3 summarizes the two types of maturity models.

Table 3. Level descriptors and factors

Publication	Descriptor	Frequency
Levelling Maturity Model		
[22, 35, 45]	3 Level	3
[30, 31]	4 Level	2
[21, 23-29, 32-34, 37, 38, 40, 43, 46]	5 Level	16
Factorized Maturity Model		
[41]	3 Factor	1
[10, 36, 39, 44]	5 Factor	4
[2, 5]	7 Factor	2
[47]	8 Factor	1
[38, 42, 48]	9 Factor	3

3.7 Model object

The maturity model has been utilized in various industries. Even in the same industry, the model could be measured by different indices. For example, Skippers & Bell and Stiles [39, 41] took project manager and general construction terms as objects in the building industry, respectively.

Overall, 14 of the reviewed publications have non-specific objects, while other publications emphasize organizational leadership maturity. In the construction industry, the focus is mostly on the contractors and professionals involved in building projects, such as the project manager. However, no publication was found to emphasize on the owners of construction project. Table 4 sums up the objects of the maturity models in the 31 reviewed publications.

Table 4. Objects of maturity models

Publication	Sector	Frequency
[10, 22, 24-28, 30-32, 34, 35, 37, 38]	Non-specific object	14
[23, 29, 43-48]	Organization/company leader for regular business process	8
[21, 33]	Government institution and military	2
[2, 5, 40-42]	Construction contractors and professionals in project	6
[39]	Construction contractors project manager (specific)	1

Table 5 details the 31 reviewed publications.

Table 5. Details of the reviewed publications

References	Country of Origin	Sector	Method		Maturity Model Terminology	Level Descriptor/Factor
			Data Collection	Data Evaluation		
[2]	The U.S.A.	Construction	Case study	Choosing by Advantage (C.B.A.)	Safety Maturity Factors and Indicators	• Factor 1: Safety leading indicators • Factor 2: Safety lagging indicators • Factor 3: Safety and supervisory personnel • Factor 4: System maturity and resiliency • Factor 5: Preconstruction services • Factor 6: Technology and innovation • Factor 7: Safety Culture
[5]	The U.S.A.	Construction	Questionnaire	Delphi Round	Professional Leader Competencies	• Factor 1: Communication skills • Factor 2: Ethic/responsibility • Factor 3: Professionalism • Factor 4: Critical thinking/ problem solving • Factor 5: Big picture thinking • Factor 6: Ambition/drive • Factor 7: Self-awareness
[10]	Portugal	Non-specific sector	Questionnaire	Inferential statistical analysis	Culture Maturity Levels	• Factor 1: Information • Factor 2: Operational learning • Factor 3: Involvement • Factor 4: Communication • Factor 5: Commitment
[21]	Malaysia	Public Agency /Government Institution	Questionnaire	Inferential statistical analysis	PM Knowledge Areas Maturity Level	1. Level 1: Basic PM Process 2. Level 2: Individual Project Planning 3. Level 3: Systematic Project Planning and Control 4. Level 4: Integrated Multi-project Planning and Control 5. Level 5: Continuous PM Process Improvement
[22]	The U.S.A.	Construction	Interviews	Information Integration	Capital Project Information	1. Level 1: Business Efficiency 2. Level 2: Business Effectiveness

References	Country of Origin	Sector	Method		Maturity Model Terminology	Level Descriptor/Factor
			Data Collection	Data Evaluation		
				Maturity Model (IIMM)	Integration Maturity Model	3. Level 3: Business Transformation
[23]	The U.S.A.	Non-specific sector	Literature review	Empirical analysis	Leadership Maturity Model	1. Level 1: Introspective 2. Level 2: Synergistic 3. Level 3: Operational 4. Level 4: Systemic 5. Level 5: Strategic
[24]	The U.K.	Non-specific sector	Literature review	Empirical analysis	Safety Culture Maturity Model	1. Level 1: Emerging 2. Level 2: Managing 3. Level 3: Involving 4. Level 4: Cooperating 5. Level 5: Continually Improving
[25]	The U.S.A.	Non-specific sector	Literature review	Empirical analysis	Safety Culture Maturity Model	1. Level 1: Beginning 2. Level 2: Developing 3. Level 3: Performing 4. Level 4: High Performing 5. Level 5: Excelling
[26]	China	Non-specific sector	Literature review	Empirical analysis	Maturity Model	1. Level 1: Initial experience 2. Level 2: Theory accumulation 3. Level 3: Systematic theory 4. Level 4: Standard theory 5. Level 5: Scientific theory
[27]	The U.S.A.	Non-specific sector	Literature review	Qualitative analysis with PM knowledge areas	Project Management Process Maturity $(PM)^2$ Model	1. Level 1: Ad-hoc 2. Level 2: Planned 3. Level 3: Managed at Project Level 4. Level 4: Managed at Corporate Level 5. Level 5: Continuous Learning
[28]	Thailand	Non-specific sector	Questionnaire	Statistical analysis	Maturity Roadmap	1. Level 1: Safety moment in all meeting 2. Level 2: Safe and happy workplace 3. Level 3: Safety care and safety share 4. Level 4: Safety is a license to operate 5. Level 5: Safety mindset
[29]	Brazil	Non-specific sector	Questionnaire	Statistical descriptive	Safety Culture Maturity	1. Level 1: Pathological 2. Level 2: Reactive 3. Level 3: Bureaucratic 4. Level 4: Proactive 5. Level 5: Sustainable
[30]	The U.S.A.	Non-specific sector	Literature review	Empirical analysis	Leadership Maturity Model	1. Level 1: Minimum competencies 2. Level 2: Proactive 3. Level 3: Operates effectively and efficiently 4. Level 4: Expand market share
[31]	The U.K.	Non-specific sector	Questionnaire	Statistical analysis	The Leadership Maturity Model	1. Level 1: Systemic Leadership 2. Level 2: Scalable Leadership 3. Level 3: Integrated Leadership 4. Level 4: Foundational Leadership
[32]	Iran	Non-specific sector	Questionnaire	Targeted Hazard Identification System (THIS)	Safety Participation Maturity Model (SPMM)	1. Level 1: Emergence of P.M.S. 2. Level 2: Management participation 3. Level 3: Individual involvement 4. Level 4: Group participation 5. Level 5: Continuous improvement of participation
[33]	Croatia	Military	Literature review	Empirical analysis	Leadership Maturity Framework	1. Stage 0: Incorporative 2. Stage 1: Impulsive 3. Stage 2: Imperial 4. Stage 3: Interpersonal 5. Stage 4: Institutional 6. Stage 5: Interindividual

References	Country of Origin	Sector	Method		Maturity Model Terminology	Level Descriptor/Factor
			Data Collection	Data Evaluation		
[34]	The U.S.A.	Supply chain	Literature review	Empirical analysis	Lean Supply Chain Leader Maturity Model	1. Level 1: Unstable 2. Level 2: Process and People Visibility 3. Level 3: Functional Improvement 4. Level 4: Value Stream Improvement 5. Level 5: Flow-High Performance
[35]	The U.S.A.	Construction	Questionnaire	Regression analysis	Safety Meeting Quality Measurement Tool	1. Level 1: Least Mature 2. Level 2: Less Mature 3. Level 3: Mature
[36]	Indonesia	Construction	Questionnaire	Fuzzy method	Construction Safety Maturity Model	• Factor 1: Information and Communication • Factor 2: Commitment • Factor 3: Organizational Learning • Factor 4: Leadership • Factor 5: Competence
[37]	Hong Kong	Construction	Literature review	Empirical analysis	Maturity Level in the Conceptual Sustainable Development Maturity Model	1. Level 1: Initial 2. Level 2: Repeatable 3. Level 3: Defined 4. Level 4: Managed 5. Level 5: Optimizing
[38]	Australia	Construction	Literature review	Empirical analysis	Health and Safety Culture Maturity	1. Level 1: Pathological 2. Level 2: Reactive 3. Level 3: Bureaucratic 4. Level 4: Proactive 5. Level 5: Generative
[39]	The U.S.A.	Construction	Questionnaire	360º Measurement Process	Basic Leadership Practices	• Factor 1: Model the way • Factor 2: Inspire a shared vision • Factor 3: Challenge the process • Factor 4: Enable others to act • Factor 5: Encourage the heart
[40]	The U.K.	Construction	Semi-structured interview	Maturity assessment tool	Safety Culture Maturity	1. Level 1: Infancy 2. Level 2: Developing 3. Level 3: Evident 4. Level 4: Established 5. Level 5: Excellence
[41]	Indonesia	Construction	Questionnaire	Inferential statistical analysis	Knowledge Management Maturity	• Factor 1: People • Factor 2: Process • Factor 3: Technology and Infrastructure
[42]	Nigeria	Construction	Questionnaire	Statistical analysis	Factor weighting of maturity	• Factor 1: Leadership • Factor 2: Policy • Factor 3: People • Factor 4: Partnership and resources • Factor 5: Process and strategy • Factor 6: People results • Factor 7: Customer results • Factor 8: Societal results • Factor 9: Performance results
[43]	Brazil	Petrochemical	Questionnaire	Inferential statistical analysis	Maturity of Safety Culture	1. Level 1: Pathological 2. Level 2: Reactive 3. Level 3: Bureaucratic 4. Level 4: Proactive 5. Level 5: Sustainable
[44]	Turkey	Petrochemical	Questionnaire	Structural Equation Modelling	Perceived Safety Culture	• Factor 1: Management commitment • Factor 2: Employees personnel attitude

References	Country of Origin	Sector	Method		Maturity Model Terminology	Level Descriptor/Factor
			Data Collection	Data Evaluation		
						• Factor 3: Co-workers safety support • Factor 4: Workplace pressure • Factor 5: Safety management systems
[45]	The U.S.A.	Housing	Interviews	Qualitative analysis	Tiered Maturity Model	1. Tier 1: Life Safety & Survival Actions 2. Tier 2: Re-establishing Operations 3. Tier 3: Developing Community Partnerships
[46]	Canada	Healthcare	Questionnaire	Manchester Patient Safety Culture Assessment Tool	Level of Safety Maturity	1. Level 1: Pathological 2. Level 2: Reactive 3. Level 3: Bureaucratic 4. Level 4: Proactive 5. Level 5: Generative
[47]	Indonesia	Manufacture	Questionnaire	Triangular Fuzzy Number	Safety Culture Variable	• Factor 1: Commitment • Factor 2: Leadership • Factor 3: Responsibility • Factor 4: Engagement & involvement • Factor 5: Risk • Factor 6: Competence • Factor 7: Information & communication • Factor 8: Organizational learning
[48]	Brazil	Food industry	Workshop and interviews	Exploratory Factor Analysis (E.F.A.)	Food Safety Culture Maturity Index	• Factor 1: Pressure at work • Factor 2: Infrastructure • Factor 3: Management system • Factor 4: Risk perception • Factor 5: Responsibility • Factor 6: Leadership • Factor 7: Teamwork • Factor 8: Communication • Factor 9: Commitment

4. DISCUSSION

4.1 Comparison between levelling and factorized maturity models

The maturity models are extensively adopted for many industries and objects. As stated in Section 3.6, 21 and 10 reviewed publications employ the levelling and factorized methods, respectively. For example, Machfudiyanto et al. [20] developed a levelling model to evaluate the maturity of stakeholders in Indonesia's construction sector [20]. Their model divides safety performance into five levels: basic level (safety moment in all meetings), reactive level (safe and happy workplace), compliant level (safety care and share), proactive level (safety license to operate), and resilient (safety mindset).

Compared with the factorized model, the levelling model can be implemented in a highly structured manner to assess an object, for it provides the tactical steps required to increase maturity during the realization of goals [49]. Despite this advantage, the levelling model faces several defects related to the unpredictable changes of business process. To adapt to these changes, it is important to modify the levelling within the model, and to obtain new organizational procedures.

This critical review reveals that the factorized model uses a list of variables needed for the compliance of an object. The list is determined based on the compliance level of the required factors, aiming to flexibly track organizational changes. At each level, the compliance level of each factor can be adjusted according to the current or future business processes. For instance, the first level of the maturity model requires the first and second factors. When the business process is involved, they need to be replaced by the second and third factors. However, the first factor is still required in the second level.

4.2 Maturity models in construction project safety

Every project is highly unique and dynamic, especially in the construction industry [50]. This is because the dynamic and changeability of a project hinge on the level of safety risk [10]. The maturity model provides a better knowledge of the capabilities and weaknesses of applied business processes. As a result, it has been widely adopted to assess the ability of a company to maintain safety [8]. The high changeability of construction projects leads to a high usage of factorized maturity models. Among the reviewed publications, seven and four construction publications employ the factorized and levelling maturity models, respectively. The reason is that the factorized method better track the dynamics of construction projects. In addition, six of eleven publications [2, 5, 24, 41, 45, 48] in the construction industry evaluate the maturity model of a construction contractor or professional. In particular, one publication focuses on a project manager. This

reflects the fact that the changeability of a construction project is enhanced by the large number of stakeholders [50].

The construction projects have a structure of objects: (1) the project owner as the service user, (2) contractors as service providers, (3) planning and designing consultant, (4) supervisory consultant, (5) sub-contractors, and (6) the affected communities. There is a hierarchy among each kind of stakeholders, which further complicates the structure of objects in each construction project. In general, a contractor team typically contains project and site managers, supervisors, engineers, and other staff. During the construction process, the complex structure of the team increases the possibility of volatility.

The contractors, who are directly related to the construction site, become the most frequently assessed objects of maturity models. That is, they attract much attention during the occurrence of accidents or deaths. Before the provision of contracts, the safety maturity level of the contractor is crucial to the assurance of construction safety [2]. It is the duty of the contractor and project owner to guarantee organizational safety. Therefore, many publications find that the maturity of the project owner is positively correlated with safety performance. The active participation of the project owner, especially on-site involvement, determines the quality of safety management [17]. The other determinants include (1) selecting a competent contractor, (2) the safety requirements in the contract, and (3) implementing safety objectives in the project. The contract between the project owner and service provider aims to ensure safety performance [51]. All safety requirements on the project must be clearly stated in the contract by the project owner. Therefore, a maturity model for construction project owners is crucial in this process.

4.3 Correlation between safety leadership and maturity

Safety culture is fundamental to safety performance [19, 52]. It is strongly influenced by safety leadership [53], the primary requirement for effective safety management, specifically for construction project owners [54]. Subsequently, the determinants of safety performance have been evaluated from the angle of safety leadership, a sub-system of protection-centered management [55]. Several publications claim that safety leadership directly affects the effective implementation of safety management [56], suggesting that the safety performance is shaped by the safety culture [57], and formed by the decent leadership of the related stakeholders.

In this critical review, several publications were found to assess the utilization of maturity models towards leadership evaluation [5, 23, 33, 39]. Many results were used to derive a maturity model for safety leadership, for the project owners are expected to enhance the safety performance of construction services. Our study provides a different perspective than previous reports, which mostly focus on construction contractors.

4.4 Framework of safety leadership of project owners

After the critical review, a maturity model framework was developed to measure the safety leadership of project owners, based on three critical elements: the structure of the construction project, the causes of safety performance, and the type of the maturity model. The importance of measuring the safety leadership maturity of project owners has already been briefly analyzed in the previous parts. Motivated by project organization and safety leadership, the evaluation of construction safety performance is a must to assure that all stakeholders have sufficient administrative maturity. The assessment of safety leadership maturity plays an important role in understanding the capacity of a construction project, and developing a specific maturity model for that project.

As shown in Figure 2, the final element in the proposed maturity model framework is the selection of the model type (levelling or factorized). Section 4.1 reports that the factorized model is more suitable for the construction industry than the levelling model, thanks to its good adaptability to the organizational changes of the business process. Besides, the factorized model is superior by virtue of the extensive project structure in the construction industry.

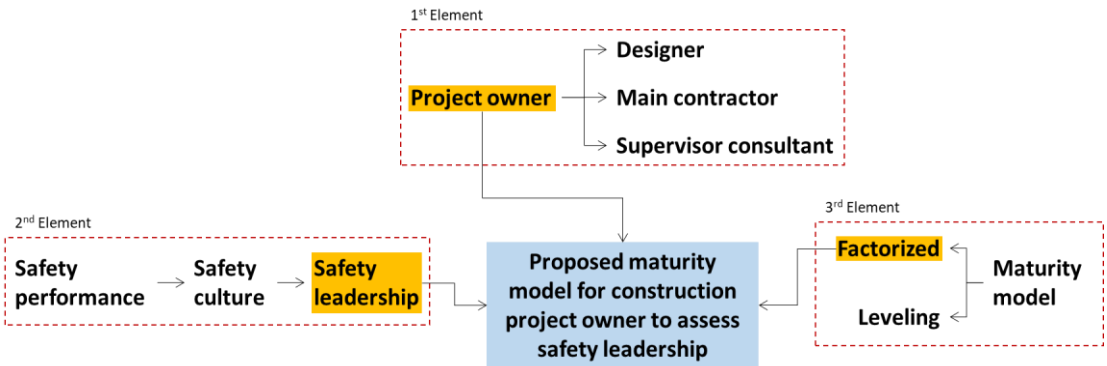

Figure 2. Our framework of safety leadership of construction project owners

5. CONCLUSIONS

This study carries out a critical review on the publications of the maturity model. Several topics were added to complete the model design, i.e., safety leadership and construction project owner. The critical review notices the extensive use of the maturity models in various industries, e.g., petrochemical industry, healthcare, military, government institutions, and construction. A wide range of subjects were covered in the maturity models of the reviewed publications. Approximately 24 of the 31 publications consider multiple safety and leadership factors to evaluate specific or non-specific objects. Different types of maturity models have been applied differently in multiple industries. The levelling and factorized methods are suitable for the organization with low and high business changeability, respectively. Furthermore, the

construction industry could be classified in the factorized sector. A high safety risk is generated by the high volatility in the stakeholder-based projects. As a result, the contractors often directly communicate with the construction site, trying to avoid becoming the scapegoat of accidents.

Several previous studies confirmed that project owners also contribute to safety performance [17, 51]. To guarantee the safety performance, project owners should enhance the safety culture of the stakeholders through decent leadership [52]. This helps in providing the term of safety leadership, based on the ways that the project owners ensure safety performance through their leadership. Under the proposed framework, the factorized maturity model is more suitable for assessing the safety leadership of construction project owners.

Based on the above findings, the future studies could further explore the development method of the maturity model. For example, the research team could compare the advantages and disadvantages between qualitative and quantitative analyses, empirical analysis and case study, as well as questionnaire survey and interviews. Since the construction industry offers a myriad of projects, various methods have been well implemented. Hence, more efforts are needed to gain more knowledge of the proposed maturity model.

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