Risk Identification and Common Risks in Construction: Literature Review and Content Analysis

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Abstract

Risk identification is a critical stage in the risk management process, as it provides a basis for subsequent stages and ensures the effectiveness of risk management. Despite an abundance of published articles focused on construction risk identification, no systematic review and content analysis of the literature on risk identification in construction has yet been performed. This paper examines common risk identification tools and techniques and risk classification methods; it also identifies, categorizes, and ranks common risks for construction projects. In order to achieve these objectives, a systematic review and detailed content analysis of 130 selected articles from 14 renowned academic journals in construction management published during 1990–2017 was conducted. This paper addresses the lack of a systematic review and content analysis of published articles related to risk identification, and it provides researchers and industry practitioners with data on the most common risks affecting construction projects. Thus, this paper serves as a useful reference for future risk identification, analysis, and modeling purposes.

Keywords: Construction; Risk management; Risk identification; Risk classification; Content analysis.

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Introduction

Studies confirm that construction is a highly risk-prone industry because of certain distinctive characteristics of construction projects (El-Sayegh and Mansour 2015; Zeng et al. 2007). Construction projects are characterized by their varying degrees of uniqueness and complexity, the active involvement of multiple stakeholders, capital intensiveness, dynamic environments, long production durations, and exposure to external environment and weather conditions (Taroun 2014). Such characteristics contribute significantly to the existence of high uncertainty and risk in construction projects. Risks and uncertainties are indeed inherent in every construction project from initiation through to completion—and even during the operation phase of the constructed facility—regardless of the size, nature, complexity, and location of the project. Failure to deal sufficiently with potential risks and uncertainties throughout the project life cycle can often have detrimental consequences on project objectives. Risk management, therefore, should be applied as an integral part of project management for the successful delivery of construction projects in terms of time, cost, quality, safety, and environmental sustainability (Zou et al. 2007).

There are several definitions of risk in the literature, and the definitions vary based on the industry and context in which they are used. Risk is often defined in terms of uncertain events and their impact on project objectives. The Project Management Institute (PMI 2013) defines risk as "an uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives." While risk and uncertainty are considered distinct terms and concepts by some authors, others consider them to be synonymous. The uncertainty of an event is the "state of full or partial deficiency of information that may hinder the understanding or knowledge of the event causing this risk" (ISO 2009). In this paper, risk is considered a concern if and only if an event or its effect is associated with a certain degree of uncertainty. According to Al-Bahar and Crandall (1990) and Lam et al. (2007), risk is characterized by three components: the risk event (what might happen to the detriment or in favor of the project), the uncertainty of the event (the chance of the event occurring), and the potential loss or gain (the consequence of the event happening).

The identification of possible sources of risk is an essential stage in the risk management process because it allows project parties to discern specific instances of uncertainty; thereby, the potential impact of these uncertainties can be analyzed and appropriate strategies for mitigating their effects can be developed (Zayed et al. 2008). Furthermore, structured and detailed risk identification provides a basis for later stages and ensures risk management effectiveness (Banaitiene and Banaitis 2012). Published literature is one of the main sources of information for identifying risks (both positive and negative) in construction projects. Researchers have previously identified numerous risks affecting construction projects, and these identified risks have been used for risk assessment, analysis, and modeling purposes. Although much effort has been expended on identifying risks from the literature, existing literature reviews are not exhaustive, they lack systematic analysis, and they are limited to only a few papers. Moreover, a detailed content analysis has not been done on articles that deal with risk identification tools and techniques, classification methods, and common risks in construction management. Content analysis is a systematic technique for collecting and organizing information and for examining trends and patterns qualitatively and quantitatively in written and other recorded materials (Krippendorff 2013; Chan et al. 2009). The objectives of this paper are twofold. The first objective is the examination of common risk identification tools and techniques and risk classification methods employed in construction risk management processes. The second objective is the identification, categorization, and prioritization of potential risks affecting construction projects through an extensive review of articles published in academic journals specializing in civil engineering, construction engineering and management, and project management; this research also involves conducting a detailed content analysis of the journal articles.

The rest of this paper is organized as follows. In the second section, an overview of the risk identification process is provided, along with a review of the tools and techniques used for risk identification and the methods employed for risk classification in construction projects. In the third section, the research methodology adopted in this paper is briefly discussed. In the fourth section, the results of the content analysis of the common risk identification tools and techniques, risk classification methods, and common risks in construction projects are presented. Conclusions and future work are discussed in the final section.

Literature Review on the Risk Identification Process, Tools and Techniques, and Classification Methods

In this section, a comprehensive literature review is provided on topics related to the objectives of this paper: the risk identification process, tools and techniques needed for risk identification, and classification methods for categorizing identified risks are all discussed separately in the following subsections.

Risk Identification Process

Risk identification is the process of systematically and continuously identifying possible risks and their potential consequences on a project using different risk identification tools and techniques, classifying the risks into different categories, identifying their root causes, and documenting the characteristics of each risk (Al-Bahar and Crandall 1990). In some cases, primary risk responses may also be identified at the risk identification stage. Risk identification is the first and possibly the most important stage in the risk management process because subsequent stages can only be performed on potential risks that have been identified (Zayed et al. 2008; Banaitiene and Banaitis 2012; Hwang et al. 2013). The risk identification process should equally focus on the identification of positive risks or opportunities, which have beneficial effects on project objectives (Hillson 2002). However, common practice is to concentrate more on the identification and management of negative risks, and opportunities tend to be overlooked or addressed reactively (Hillson 2002). Risk identification is an iterative and continuous process. It should be carried out rigorously on a regular basis throughout the project life cycle, as new risks may appear and previously identified risks may cease to exist (PMI 2013). El-Sayegh (2008) pointed out that attempting to identify all potential risks for a construction project is laborious, counterproductive, and impractical. Hence, the focus should be on the identification of the most critical and frequently occurring risks.

Risk identification is a process of discovery, and thus it calls for creative thinking, imagination, and leveraging project team experience and knowledge (Chapman and Ward 2003). According to Mojtahedi et al. (2010) and PMI (2013), the identification of risks in construction projects requires the participation of project stakeholders, project team members, the risk management team (if assigned), subject matter experts who are not members of the project team, project managers of other projects, and risk management experts, depending on the type of project. Involving the project team in the risk identification process can develop and maintain a sense of ownership and responsibility for identified risks and their respective response strategies (PMI 2013). In addition to the involvement of combinations of experts and stakeholders, inputs and sources of information such as historical project data, published literature on risk, standard checklists, risk breakdown structures, and risk registers facilitate the identification of risks and contribute to the comprehensiveness of the risk identification process. Tools and techniques and classification methods involved in the risk identification process for construction projects are discussed below.

Risk Identification Tools and Techniques

In the literature, risk identification is one of the most widely studied stages of risk management. As a result, a wide array of tools and techniques exist for risk identification. These tools include documentation reviews, information-gathering techniques (brainstorming, the Delphi technique, interviewing, root cause analysis, questionnaires, risk workshops), checklist analysis, assumption analysis, diagramming techniques (cause-and-effect diagrams, system or process flow charts, influence diagrams), SWOT analysis, expert judgment, fault tree analysis, decision tree analysis, and failure mode and effect analysis (PMI 2013; Grimaldi et al. 2012; Marle and Gidel 2012). Hillson (2002) suggested that an appropriate combination of tools and techniques should be employed in risk identification, as there is no single "best method." The selection of appropriate tools and techniques for risk identification requires taking into account criteria such as project phase; complexity of the project; availability of skilled personnel familiar with the risk identification tools and techniques; risk maturity of the organization; the approach (analogical, heuristic, or analytic) to be applied for risk identification; and simplicity of use, interaction considerations, and completeness of the tools and techniques (Grimaldi et al. 2012; Marle and Gidel 2012). Despite the availability of several risk identification tools and techniques, only a few are frequently used in the construction industry. Based on an investigation conducted by Lyons and Skitmore (2004), brainstorming, case-based approaches, and checklists are the most commonly used risk identification techniques. Irrespective of the tools and techniques used to identify risks on a project, the main outputs of the identification process are presented in the risk register. The risk register contains detailed information on the identified risks, and it can help the project team assess, review, track, mitigate, and control project risks periodically throughout the project life cycle. Additionally, a well-documented risk register can be a useful reference for future risk identification and the main source of information for developing a risk knowledge database.

Risk Classification Methods

Risk classification (or categorization) is an integral part of risk identification. It helps the project team structure the diverse and varied risks that may affect a construction project. The structured classification of risks contributes to the effectiveness and quality of the risk identification process and creates a better understanding of the nature of risks and their sources (Bu-Qammaz et al. 2009). Moreover, a logical and structured classification of risks assists in the reduction of redundancy and ambiguity in the risk identification stage and provides for easier management of risks in the later stages of risk management. In the literature, various approaches have been recommended for classifying risks on construction projects. Some of the approaches adopt a broad categorization, while others use categories that are more detailed. Risks can be categorized based on their source, nature, occurrence at different stages of the project, impact on project objectives, the party who might be the originator of the risk, and a three-level meta-classification approach (macro-, meso-, and micro-level).

Using the initial source of risks as a basis, Tah and Carr (2000), El-Sayegh and Mansour (2015), and Al-Sabah et al. (2014) classified risks into two main categories: internal risks (those that are project-related and that usually fall under the control of the project management team) and external risks (those risks that are beyond the control of the project management team). Each author partitioned these main categories (internal and external) into detailed subcategories according to the nature and type of the projects. Several researchers, including Elbarkouky et al.

(2016), Boateng et al. (2012), and Tavakolan and Etemadinia (2017), used the nature of risks as the criteria for classifying risks into distinct groups. For example, Tavakolan and Etemadinia (2017) classified risks into nine groups: financial, contractual, design, health and safety, management, construction, social/political, external, and procurement/supply. Li and Zou (2011), Goh et al. (2013), and Lee and Schaufelberger (2014) categorized risks based on the project stage at which the risks would occur. For example, Goh et al. (2013) categorized risks into five groups: planning, design, procurement, construction, and hand over stage risks. Zou et al. (2007) categorized risks into five groups based on their respective impact on project objectives: cost-, time-, quality-, environment-, and safety-related risks. Such categorization may result in redundancy, as a single risk may have an impact on more than one project objective. According to the party who might be the originator of the risk, Wang and Yuan (2016) classified risks into five groups: client-, designer-, contractor-, subcontractor-, and authority-related risks. Hwang et al. (2013) and Bing et al. (2005) adopted a three-level meta-classification approach and grouped risks into macro-level risks (risks beyond the system boundaries of the project), meso-level risks (risks within the system boundaries of the project and directly related to the nature of the project), and micro-level risks (risks that are project party-related, that is, risks associated with the relationships between the parties involved in the project).

According to Ebrahimnejad et al. (2010), the classification of risks based on either the source or the nature of those risks are the most widely used methods for risk identification on construction projects. Risk classification methods selected for construction projects may differ based on the type of project, the type of procurement method employed, and the project party conducting the risk identification and assessment. Regardless of the categorization scheme adopted, the various categories of risks are organized and presented using a risk breakdown structure (RBS). According to PMI (2013), an RBS is defined as "a hierarchically organized depiction of the identified project risks arranged by risk category and subcategory that identifies the various areas and causes of potential risks." RBSs show the risk categories and sub-categories within which risks may arise as well as the risks at the lowest level for risk identification, assessment, mitigation, and reporting purpose.

Research Methodology

A three-stage process (Figure 1) was adopted in this paper to (1) examine common risk identification tools and techniques and risk classification methods and (2) using content analysis, identify, categorize, and rank common risks in construction projects from selected articles published in academic journals related to construction engineering and management. These stages are described in the following subsections.

Journal Selection

In stage 1, journals that have an important impact and prominent position in the research community of construction engineering and management were selected. The selection of journals was based on purposive/selective sampling (Xiong et al. 2015); that is, those journals extensively used to conduct literature reviews and content analysis specifically on risk-related topics in construction engineering and management by different authors (Yu et al. 2018; Islam et al. 2017; Taroun 2014) were considered. Also, the 2016 Scopus journal metrics (CiteScore) and the research conducted by Wing (1997) on the ranking of construction management journals were referred to when choosing the journals. Journals that have a CiteScore of 0.70 and above based on the 2016 Scopus journal metrics were considered. Only those journals that published at least three papers related to the topic of this study during the period 1990-2017 were chosen. The following

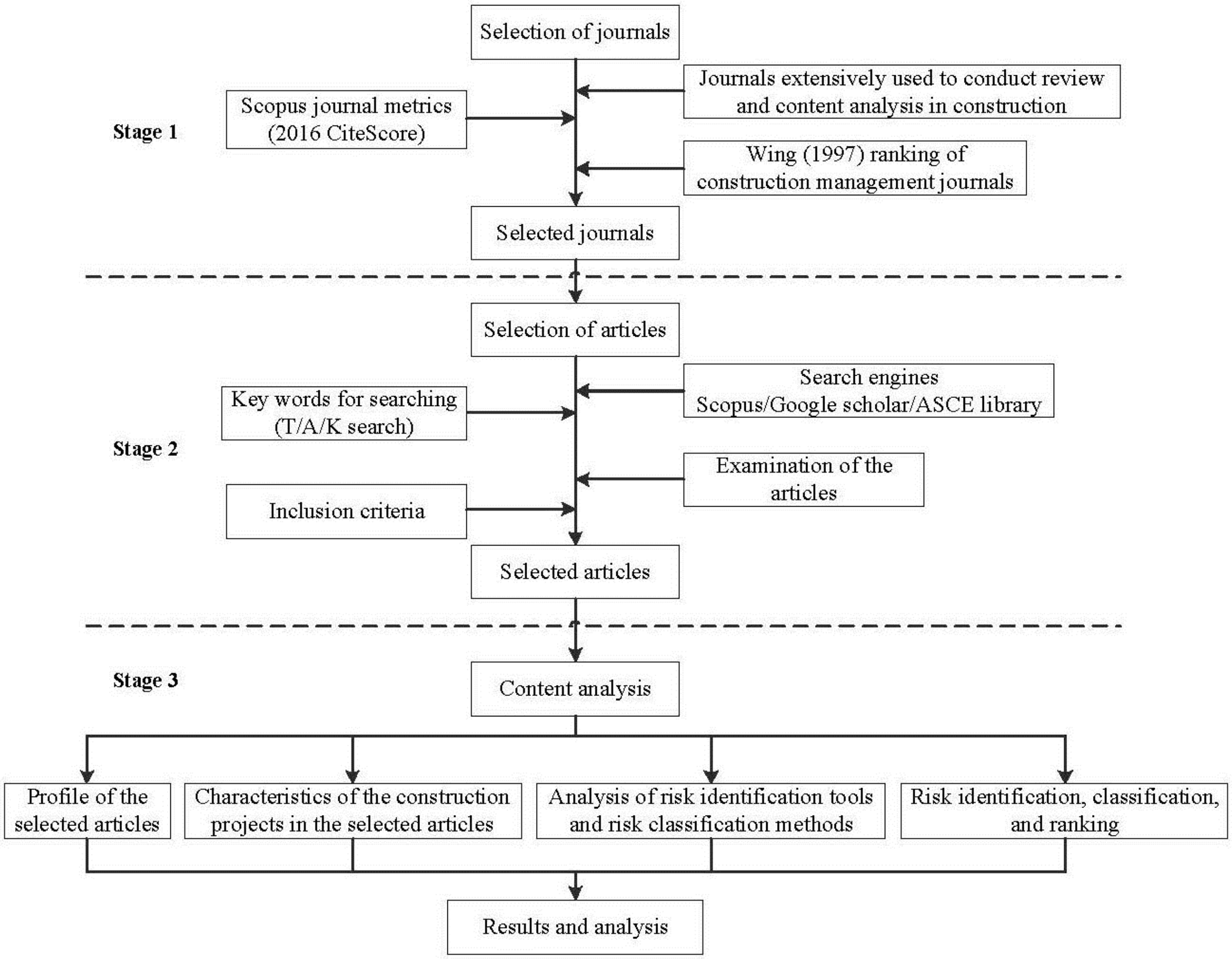

Fig. 1. Research methodology for article selection and content analysis.

14 journals were selected: *Expert Systems with Applications* (ESA), *Automation in Construction* (AC), *International Journal of Project Management* (IJPM), *Building and Environment* (B&E), *Journal of Construction Engineering and Management* (JCEM), *Journal of Computing in Civil Engineering* (JCCE), *Journal of Management in Engineering* (JME), *Journal of Infrastructure Systems* (JIS), *Construction Management and Economics* (CME), *Journal of Civil Engineering and Management* (JCiEM), *Engineering, Construction and Architectural Management* (ECAM), *Canadian Journal of Civil Engineering* (CJCE), *International Journal of Construction Management* (IJCM), and *ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A:Civil Engineering* (JRUES). The selected journals were ordered from high to low based on

their CiteScore. Even though the last journal in the list (JRUES) is not included in the Scopus database and does not have a CiteScore, it was selected for this research because of its relevance.

Article Selection

In stage 2, searches for relevant articles were performed using Scopus (Elsevier's abstract and citation database), Google Scholar, and American Society of Civil Engineers (ASCE) library search engines. Keywords used for searching the articles included risk identification, risk assessment, risk analysis, risk management, construction risk, project risk, uncertainty analysis, and project uncertainty. The keywords were selected from previously published articles (Taroun 2014; Islam et al. 2017) that conducted a review on risk-related topics, and they were based on an initial examination of common keywords used in risk management-related articles published in the construction domain. The search was conducted using the title, abstract, and keyword (T/A/K) field of the aforementioned search engines. The search was restricted to articles published from 1990 to 2017 (inclusive). As a result, 484 articles were initially retrieved from the selected journals. The contents of the articles were further examined, and the number of articles was reduced to 130. The following inclusion criteria were used to select the articles: (1) the article should be specifically related to risk in construction projects; (2) the article should contain a list of potential risks affecting construction projects; (3) the article should use at least one technique for identifying risks; and (4) the article should use a specific classification method for categorizing risks or simply list the risks.

Content Analysis

In stage 3, once the articles were identified, detailed content analysis was carried out in order to (1) profile the selected articles based on type of journal and year of publication; (2) characterize the construction projects considered for risk identification in the selected articles based on region and type; (3) examine common risk identification tools and techniques, risk classification methods, and category names used for classifying risks in the selected articles; and (4) systematically identify, categorize, and rank common construction project risks identified from the selected articles. Content analysis is a research technique for determining major facets of and valid inferences from written, verbal, or visual communication messages, either qualitatively or quantitatively, depending on the nature of the project and the issues to be addressed in the research (Krippendorff 2013; Chan et al. 2009). Content analysis is a powerful technique for collecting and organizing information and for examining trends and patterns in documents (Krippendorff 2013). Qualitative content analysis focuses on grouping data into categories, while quantitative content analysis determines the numerical values of categorized data (i.e., frequencies, ratings, and rankings) by simply counting the number of times a topic is mentioned (Chan et al. 2009). In this paper, a combination of both qualitative and quantitative content analysis was adopted.

Results and Discussion

The results of the content analysis are presented in the following subsections. The complete list of selected articles used for the content analysis is provided in Table S1 (see Supplemental Data). The percentage values indicated in the discussion, figures, and tables were determined based on the number of references over the total number of articles considered in the content analysis (i.e., 130 articles).

Profile of the Selected Articles

The selected articles considered for content analysis were profiled based on journal and year of publication. Figure 2 depicts the percentage of the selected articles published in each journal. Close to 60% of the selected articles were published in five journals: JCEM (17.69%), IJPM

(16.92%), CME (9.23%), JME (7.69%), and JCiEM (7.69%). The remaining 40% of the selected articles were published in the other nine journals. The number of selected articles by journal and year is shown in Figure 3. The selected articles were published over the period from 1990 to 2017; among these, 109 articles (73.84%) were published between the years 2005 and 2017. The number of selected articles published in the span of 2010–2014 is considerably greater than any other publication period.

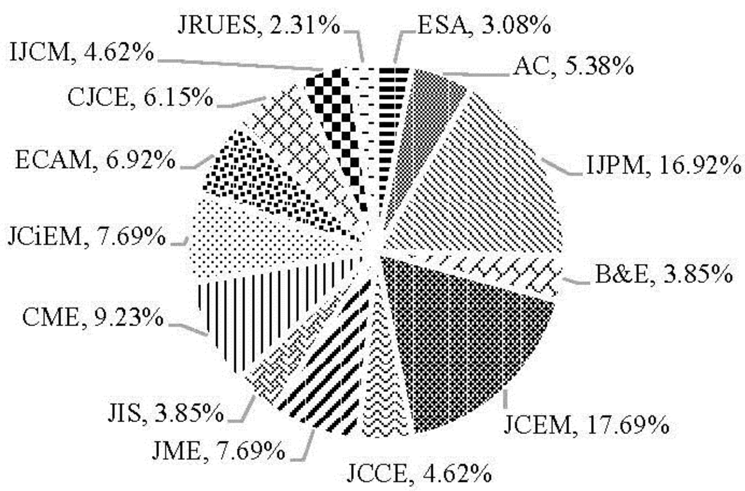

Fig. 2. Percentage of the selected articles published in each journal.

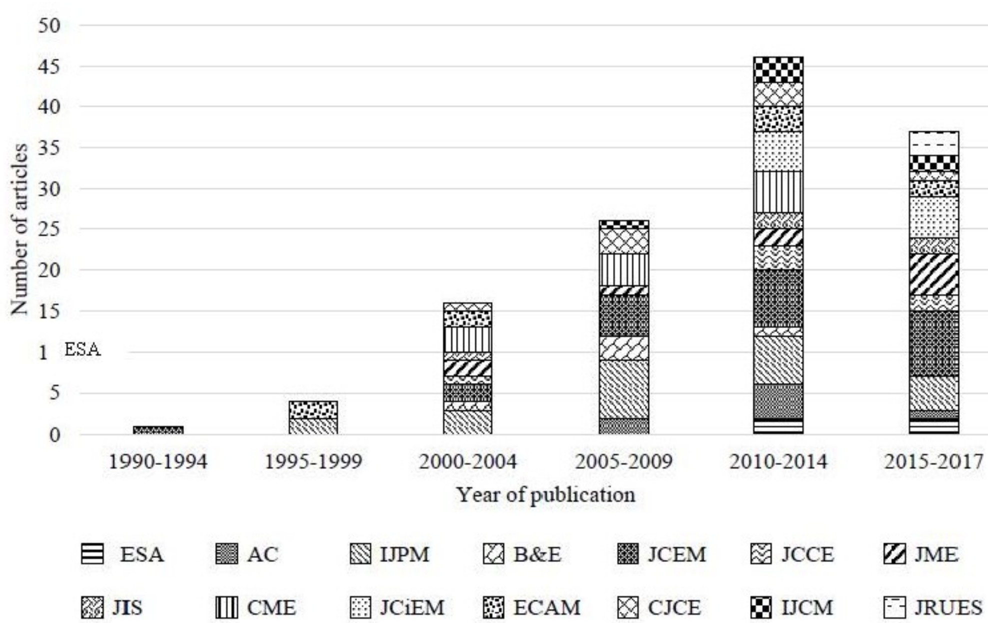

Fig. 3. Number of selected articles by journals and year.

Profile of the Projects in the Selected Articles

The construction projects considered for risk identification in the selected articles were profiled based on type and geographical location. The construction projects were grouped into five categories according to the type of construction work being completed: building projects (residential, office, commercial, mixed development, hospitals, etc.), infrastructure projects (highways, mass transit systems, tunnels, bridges, drainage systems, sewage treatment plants, etc.), power and energy projects (hydroelectric plants, solar energy, wind power, nuclear energy, etc.), heavy industrial projects (chemical, refineries, oil sands installations, etc.), and multiple combinations thereof. As shown in Table 1, most of the construction project types considered for risk identification in the selected articles were infrastructure projects (41.54%), followed by a combination of two or more project types (37.69%), and building projects (11.54%). A majority of the selected articles dealt with risk identification of construction projects located in Asian countries (56.92%), of which 39.19 % were in China, followed by European countries (16.92%), of which Turkey and the United Kingdom took the largest shares, 50.00% and 27.27%, respectively.

Table 1. Profile of the projects in the selected articles.

Feature	Category	Number of articles	Percentage of articles
Project type	Building projects	15	11.54
	Infrastructure projects	54	41.54
	Power and energy projects	9	6.92
	Heavy industrial projects	3	2.31
	Combination of two or more project types	49	37.69
	Total	130	100.00
Geographical location of projects	Africa	4	3.08
	Asia	74	56.92
	Australia	6	4.62
	Europe	22	16.92
	North and Central America	9	6.92
	South America	1	0.77

General*	14	10.77
Total	130	100.00

*The geographical locations of the projects are not stated in the selected articles or the projects are located in more than one geographical location

Risk Identification Tools and Techniques Used in the Selected Articles

A wide variety of tools and techniques were used for risk identification in the selected articles (Table 2). In the selected articles, the use of combinations of two risk identification tools and techniques (53.08%) was more popular than the use of a single tool or technique (26.92%) and a combination of three or more tools and techniques (20.00%). The three most frequently used risk identification tools and techniques, regardless of whether they were used alone or in combination, were literature reviews (66.92%), questionnaire surveys (46.92%), and expert interviews (29.23%). Detailed analysis of the selected articles that used a combination of two or more tools and techniques indicated that the use of a literature review combined with a questionnaire survey was the most prevalent (29.47%), followed by a combination of literature review, expert interview, and questionnaire survey (15.79%), and a combination of literature review and expert interview (9.47%).

Table 2. Risk identification tools and techniques used in the selected articles.

Category	Number of articles	Percentage of articles	Rank
Combination of tools and techniques			
Single tool or technique	35	26.92	2
Two tools and techniques	69	53.08	1
Three or more tools and techniques	26	20.00	3
Total	130	100.00	
Tools and techniques regardless of being used alone or in combination			
Checklist	3	2.31	10
Documentation review	13	10.00	6
Brainstorming	5	3.85	7
Delphi technique	5	3.85	7
Expert interview	38	29.23	3
Questionnaire survey	61	46.92	2

Risk workshop	4	3.08	9
Literature review	87	66.92	1
Influence diagram	1	0.77	11
Expert judgment/panel	21	16.15	4
Past projects/ historical project data	21	16.15	4
Combination of two or more tools and techniques (top 3)			
Literature review and questionnaire survey	28	29.47	1
Literature review, expert interview, and questionnaire survey	15	15.79	2
Literature review and expert interview	9	9.47	3

Risk Classification Methods used in the Selected Articles

Table 3 presents the risk classification (categorization) methods adopted in the selected articles. A majority of the selected articles (38.46%) classified risks based on their nature. Classification based on the initial source of the risk (internal or external) was the second most favored classification method and was used in 15.38% of the articles. Classification based on the occurrence of the risk at different stages of the project (6.15%) and three-level meta-classification (6.15%) were considerably less common in the selected articles. Classification based on the impact of risks on project objectives (2.31%) and classification based on the project party who might be the originator of the risk (1.54%) were very rarely used in the selected articles. A considerable proportion of the selected articles (30.00%) did not use any of the classification methods; rather, the risks were simply listed. A large proportion of the selected articles (48.46%) used a three-level RBS comprised of main category, sub-category, and risks at the lowest level. Another 21.54% of the articles used a two-level RBS (i.e., main category and list of risks), and 30.00% of the articles just listed the risks without categorizing them. Further analysis carried out on the categories (main and sub) indicated that numerous category names have been adopted in the selected articles for classifying risks based on their nature. The top 20 risk category names used in the selected articles for classifying risks based on their nature are shown in Table 4. The most popular category names used in the selected articles were economic (24.62%), political (24.62%), construction (22.31%), financial (21.54%), and management (20.00%).

Table 3. Risk classification methods and level of RBS used in the selected articles.

Category	Number of articles	Percentage of articles	Rank
Risk classification methods			
Classification based on initial source of risks (internal and external)	20	15.38	3
Classification based on nature of risks	50	38.46	1
Classification based on occurrence of risks at different stages of the project	8	6.15	4
Classification based on impact of risks on project objectives	3	2.31	6
Classification based on the project party who might be the originator of the risk	2	1.54	7
Three-level meta-classification	8	6.15	4
No classification (just listing of risks)	39	30.00	2
Total	130	100.00	
Level of risk breakdown structure (RBS)			
Three levels	28	21.54	3
Two levels	63	48.46	1
Single level (just listing)	39	30.00	2
Total	130	100.00	

Table 4. Top 20 risk category names used in the selected articles for classifying risks based on their nature.

Category name	Number of articles	Percentage of articles	Category name	Number of articles	Percentage of articles
Economic	32	24.62	Legal	15	11.54
Political	32	24.62	Site conditions	13	10.00
Construction	29	22.31	Market	10	7.69
Financial	28	21.54	Natural	9	6.92
Management	26	20.00	Health and safety	8	6.15
Environmental	23	17.69	Labor	8	6.15
Design	23	17.69	Equipment	7	5.38
Contractual	22	16.92	Resources	7	5.38
Technical	19	14.62	Acts of God	7	5.38
Social	18	13.85	Geological	7	5.38

Identification, Classification, and Ranking of Common Risks from the Selected Articles

In this paper, the risks identified from the selected articles were categorized based on their nature, as it is the most widely used classification approach in the selected articles. The identified risks were grouped into eleven categories: management, technical, construction, resource-related, site conditions, contractual and legal, economic and financial, social, political, environmental, and health and safety. These category names were chosen from the top 20 category names identified from the selected articles (Table 4). Some of the category names had to be combined to avoid redundancy in risk identification and categorization (e.g., economic and financial, contractual and legal). In the case of category names that were commonly used interchangeably, the one that was more general and inclusive of the other was used (e.g., the category name "technical" was chosen over "design" and "engineering," and the category name "resource-related" was chosen as it incorporates "material," "labor," "equipment," and "subcontractor"). Such classification is intended to illustrate the diversity of risks and thereby assist in examining the full breadth of exposure to possible risks so that project parties do not focus on specific risks and overlook others (Bu-Qammaz et al. 2009; Al-Bahar and Crandall 1990).

Because of the categorization method adopted in this paper, identified risks may fall under a different category than their original category from the selected articles. Each of the identified risks were categorized in a unique category. A total of 571 risks were identified after conducting an extensive review and content analysis on the selected articles. Table 5 shows the number of risks identified under each category.

Table 5. Number of identified risks in each category from the selected articles.

Risk category	Number of identified risks
Management	72
Technical	63
Construction	59

Resource-related	68
Site conditions	38
Contractual and legal	65
Economic and financial	67
Social	38
Political	46
Environmental	24
Health and safety	31
Total	571

The risks in each category were ranked solely based on their frequencies, that is, the total number of references (hits) each risk had (Table 6). The ranking does not show the probability of occurrence, impact, or severity of the identified risks on project objectives. The top 10 risks in each category are shown in Table 6.

Management risks are those risks related to the management skills and experience of the project team and project parties, the availability of project management professionals, and the relationships and coordination among project parties (Ling and Hoi 2006). As shown in Table 6, the most frequently mentioned management risks in the selected articles were poor coordination among various parties involved in the project (22.31%), lack of experience and project management skills of the project team (20.00%), inadequate or poor project planning and budgeting (18.46%), unavailability of sufficient professionals and managers (17.69%), and poor communication among various parties involved in the project (17.69%). Technical risks are risks associated with the technical aspects of the project, such as design, specifications, engineering, and technology (El-Sayegh and Mansour 2015). Among the technical risks identified from the selected articles, design errors and poor engineering (46.92%) and unanticipated engineering and design changes (36.92%) were the most prevalent, followed by unclear and inadequate details in design drawings and specifications (16.92%) and inadequate study and insufficient data before design (16.92%). Construction risks involve issues or concerns associated with construction methods, work tasks, delays and interruptions in construction, cost overruns, and quality of construction (Shrestha et al. 2017). The three most common construction risks identified from the selected articles were poor workmanship and construction errors leading to rework (38.46%), delays and interruptions causing a cost increase to the work package/project (27.69%), and an unreasonably tight project schedule causing a cost increase to the work package/project (11.54%).

Table 6. Top ten risks in each category identified from the selected articles.

Description of risks	Number of articles	Percentage of articles	Rank
Management			
Poor coordination among various parties involved in the project	29	22.31	1
Lack of experience and project management skills of the project team	26	20.00	2
Inadequate or poor project planning and budgeting	24	18.46	3
Unavailability of sufficient professionals and managers	23	17.69	4
Poor communication among various parties involved in the project	23	17.69	4
Poor site management and supervision by the contractor	16	12.31	6
Poor relationships among various parties involved in the project	16	12.31	6
Inadequate project organization structure	15	11.54	8
Poor project quality management, including inadequate quality planning, quality assurance, and quality control	14	10.77	9
Poor capability of owner in project management	12	9.23	10
Technical			
Design errors and poor engineering	61	46.92	1
Unanticipated engineering and design changes	48	36.92	2
Unclear and inadequate details in design drawings and specifications	22	16.92	3
Inadequate study and insufficient data before design (errors in feasibility studies)	22	16.92	3
Unproven or immature engineering techniques	16	12.31	5
Delay in design (design process takes longer than anticipated)	14	10.77	6
Incomplete design	10	7.69	7
Technology changes	8	6.15	8
Complexity of design	7	5.38	9
Poor constructability	7	4.62	9
Construction			
Poor workmanship and construction errors leading to rework	50	38.46	1
Delays and interruptions causing a cost increase to the work package/project	36	27.69	2
Unreasonably tight project schedule causing a cost increase to the work package/project	15	11.54	3

Description of risks	Number of articles	Percentage of articles	Rank
Complexity of proposed construction methods/techniques	12	9.23	4
Contractors' incompetence in executing the work package/project	12	9.23	4
Changes in construction methods/techniques	11	8.46	6
Adoption of improper, poor, or unproven construction methods/techniques	11	8.46	6
Contractor's lack of experience in similar projects	8	6.15	8
Conflicting interfaces of work items	6	4.62	9
Pressure to deliver project on accelerated schedule (pressure to crash project duration)	6	4.62	9
Resource-related			
Unavailability of a sufficient amount of skilled labor in the project region	53	40.77	1
Unavailability or shortage of expected materials	48	36.92	2
Unavailability or shortage of expected equipment	31	23.85	3
Delay in materials delivery	27	20.77	4
Defective or non-conforming materials that do not meet the standard	22	16.92	5
Low labor productivity of local workforce	22	16.92	5
Subcontractors' failure; default of subcontractors	15	11.54	7
Unavailability of qualified subcontractors	15	11.54	7
Low productivity and efficiency of equipment	14	10.77	9
Equipment breakdown	13	10.00	10
Site conditions			
Unpredicted adverse engineering geology (subsurface conditions)	54	41.54	1
Differing and unforeseen site conditions	35	26.92	2
Lack of readily available utilities on site (e.g., water, electricity, etc.) and unavailability of supporting infrastructure	20	15.38	3
Inadequate site investigations (soil tests and site survey)	17	13.08	4
Difficulties of access and work on site due to specific geographical constraints of the region	15	11.54	5
Late construction site possession	13	10.00	6
Unexpected underground utilities encounters	10	7.69	7
Delays in the right-of-way process	8	6.15	8
Ineffective control and management of traffic	8	6.15	8
Improper selection of project location	7	5.38	10
Contractual and legal			
Contradictions and vagueness in contract documents	41	31.54	1
Changes in project scope	22	16.92	2
Immaturity and/or unreliability of the legal system	21	16.15	3
Delays in resolving contractual disputes and litigations	20	15.38	4
Possibility of contractual disputes and claims	17	13.08	5
Frequent change orders	12	9.23	6
Change in codes and regulations	12	9.23	6
Excessive contract variation	10	7.69	8
Intense competition at the tender stage	8	6.15	9

Description of risks	Number of articles	Percentage of articles	Rank
Unclear roles and responsibilities of project stakeholders	8	6.15	9
Economic and financial			
Unpredicted changes in the inflation rate	64	49.23	1
Project-funding problems	48	36.92	2
Fluctuations in currency exchange and/or difficulty of convertibility	43	33.08	3
Unpredicted changes in interest rates	33	25.38	4
Escalation of material prices	29	22.31	5
Delay in payments	29	22.31	5
Changes in tax regulation	25	19.23	7
Poor financial market or unavailability of financial instrument resulting in difficulty of financing	24	18.46	8
Unfavorable economic situations in the country (instability of economic conditions)	22	16.92	9
Market demand changes	16	12.31	10
Social			
Land acquisition and compensation problems (the cost and time for land acquisition exceeds the original plans)	28	21.54	1
Public opposition to the project (public objections, social grievances)	23	17.69	2
Differences in social, cultural, and religious backgrounds	21	16.15	3
Insecurity and crime (theft, vandalism, and fraudulent practices)	14	10.77	4
Strikes and labor disputes	14	10.77	4
Poor public relations with local contacts	10	7.69	6
Unfavorable social environment	8	6.15	7
Societal conflict and/or public unrest	8	6.15	7
Poor public decision-making process	7	5.38	9
Disturbances to public activities	5	3.85	10
Political			
Changes in government laws, regulations, and policies affecting the project	60	46.15	1
Political instability of the government (unfavorable political environment)	34	26.15	2
Delay or refusal of project approval and permit by government departments (excessive approval procedures)	32	24.62	3
Outbreak of hostilities (wars, revolution, riots, and terrorism)	26	20.00	4
Corrupt local government officials demand bribes or unjust rewards	24	18.46	5
High level of bureaucracy of the authority	16	12.31	6
Expropriation and nationalization of assets/facilities without reasonable compensation	16	12.31	6
Government's improper intervention during construction	15	11.54	8
Poor relations with related government departments	11	8.46	9
Government restrictions on foreign companies (e.g. import/export restrictions, mandatory technology transfer, differential taxation of foreign firms, etc.)	10	7.69	10

Description of risks	Number of articles	Percentage of articles	Rank
Environmental			
Adverse weather conditions (continuous rainfall, snow, temperature, wind)	60	46.15	1
Force majeure (natural and man-made disasters which are beyond the firm's control, e.g. floods, thunder and lightning, landslide, earthquake, hurricane, etc.)	52	40.00	2
Adverse environmental impacts of the project	30	23.08	3
Pollution associated with construction activities (dust, harmful gases, noise, solid and liquid wastes, etc.)	16	12.31	4
Strict environmental regulations and requirements	12	9.23	5
Poor environmental regulations and controls	7	5.38	6
Changes in environmental standards and permitting	6	4.62	7
Poor preliminary assessment and evaluation of environmental impacts of the project	5	3.85	8
Prosecution due to unlawful disposal of construction waste	5	3.85	8
Failure to obtain environmental approval	4	3.08	10
Health and Safety			
Accidents occurring during construction	36	27.69	1
Inadequate safety measures or unsafe operations	28	21.54	2
Poor construction safety management	16	12.31	3
Damage to persons or property or materials due to poor safety and health management of the project	9	6.92	4
Failure to comply with HS&E standards or security plan	9	6.92	4
Ineffective protection of surrounding environment (e.g., adjacent buildings and facilities)	7	5.38	6
Epidemic illness	7	5.38	6
Strict health and safety regulations	6	4.62	8
Changed labor safety laws or regulations	6	4.62	8
Fatalities	5	3.85	10

Resource-related risks are risks associated with the suitability, condition, availability, quality, and procurement of construction materials and equipment and the availability, skill level, and performance of labor and subcontractors. As shown in Table 6, unavailability of a sufficient amount of skilled labor in the project region (40.77%), unavailability or shortage of expected materials (36.92%), unavailability or shortage of expected equipment (23.85%), and delay in materials delivery (20.77%) are very common resource-related risks in the selected articles. The site conditions risk category includes those risks related to the construction project site, including uncertainty regarding subsurface conditions, underground utilities, archaeological finds, accessibility of the site, availability of supporting infrastructure, and security and traffic conditions at the site (El-Sayegh and Mansour, 2015). The top three site condition risks identified from the selected articles were unpredicted adverse engineering geology (41.54%), differing and unforeseen site conditions (26.92%), and lack of readily available utilities on site and unavailability of supporting infrastructure (15.38%).

Contractual and legal risks arise from poorly tailored contracts, inappropriate distribution of responsibilities, conflicts in contract documents, inadequate claim administration, disputes and litigations, third-party liabilities, immature laws, and complexity in the legal environment (Shrestha et al. 2017; El-Sayegh and Mansour 2015). The most frequently mentioned risks belonging to this category in the selected articles were contradictions and vagueness in contract documents (31.54%), changes in project scope (16.92%), immaturity and/or unreliability of the legal system (16.15%), and delays in resolving contractual disputes and litigations (15.38%). The economic and financial risk category includes risks related to inflation, fluctuations in exchange rates, changes in price, tax rates and economic policies, and also risks arising from financing structures and the financial market as well as challenges in financing the project (Shrestha et al. 2017; Iyer and Sagheer 2010). The most common economic and financial risks in the selected articles were unpredicted changes in the inflation rate (49.23%), project-funding problems (36.92%), fluctuations in currency exchange and/or difficulty of convertibility (33.08%), and unpredicted changes in interest rates (25.38%).

The social risks category involves risks associated with cultural and religious differences, crime and lack of security on project sites, issues or concerns related to social and cultural impacts of the project on the community, and public objections to projects (Nielsen 2006; El-Sayegh 2008). Among the identified risks belonging to this category, the most common were land acquisition and compensation problems (21.54%); public opposition to the project (17.69%); and differences in social, cultural, and religious backgrounds (16.15%). The political risks category includes risks that are dependent on political and regulatory situations as well as the stability of the country where the project is taking place (El-Sayegh and Mansour 2015). Changes in government laws, regulations, and policies affecting the project (46.15%) was the most frequently mentioned political risk in the selected articles, followed by political instability of the government (26.15%), delay or refusal of project approval and permit by government departments (24.62%), and outbreak of hostilities (i.e., wars, revolution, riots, and terrorism) (20.00%).

The environmental risk category includes risks created by nature, impact on the environment caused by the project, and changes in environmental policies and regulations (Shrestha et al. 2017; El-Sayegh and Mansour 2015). The most frequently mentioned environmental risks in the selected articles were adverse weather conditions (46.15%), force majeure (40.00%), and adverse environmental impacts of the project (23.08%). Risks belonging to the health and safety category relate to accidents and injuries due to poor safety conditions and measures on the construction site, health-related issues on the construction site, and health and safety regulations (El-Sayegh and Mansour 2015). The top three health and safety risks identified from the selected articles were accidents occurring during construction (27.69%), inadequate safety measures or unsafe operations (21.54%), and poor construction safety management (12.31%).

The overall top ten risks identified from the selected articles are presented in Table 7, along with their respective risk category, number of articles, percentage of articles, and overall rank. The results show that unpredicted changes in the inflation rate (49.23%); design errors and poor engineering (46.92%); changes in government laws, regulations, and policies affecting the project (46.15%); adverse weather conditions (46.15%); and unpredicted adverse engineering geology (41.54%) were the most common risks amongst all the risks identified from the selected articles.

Table 7. Overall top 10 risks identified from the selected articles.

Description of risks	Risk category	Number of articles	Percentage of articles	Overall rank
Unpredicted changes in the inflation rate	Economic and financial	64	49.23	1
Design errors and poor engineering	Technical	61	46.92	2
Changes in government laws, regulations, and policies affecting the project	Political	60	46.15	3
Adverse weather conditions (continuous rainfall, snow, temperature, wind)	Environmental	60	46.15	3
Unpredicted adverse engineering geology (subsurface conditions)	Site conditions	54	41.54	5
Unavailability of a sufficient amount of skilled labor in the project region	Resource-related	53	40.77	6
Force majeure (natural disasters that are beyond the firm's control, e.g. floods, thunder and lightning, landslide, earthquake, hurricane, etc.)	Environmental	52	40.00	7
Poor workmanship and construction errors leading to rework	Construction	50	38.46	8
Unanticipated engineering and design changes	Technical	48	36.92	9
Unavailability or shortage of expected materials	Resource-related	48	36.92	9
Project funding problems	Economic and financial	48	36.92	9

Conclusions and Recommendations for Future Work

This paper discussed a systematic review and detailed content analysis of 130 articles related to risk identification published in 14 well-known academic journals in construction management and engineering between 1990 and 2017. The selected articles encompassed risk identification on various types of construction projects located in different geographical locations. Common risk identification tools and techniques and risk classification methods used in the construction risk management process were investigated. Also, common potential risks that affect construction projects were identified from the selected articles, categorized based on the nature of the risks, and ranked. The conclusions drawn in this paper are based on the review and content analysis done on the selected papers.

The findings of the content analysis show that the use of a combination of two or more risk identification tools and techniques occurred more frequently than the use of a single tool or technique in the selected articles. A comparison between the individual tools and techniques, regardless of whether they are used alone or in combination, indicated that literature reviews, questionnaire surveys, and expert interviews were the most frequently used tools and techniques. Risk classification based on the nature and source of risks was the most common method in the selected articles. A three-level RBS was used in a large proportion of the selected articles, and the top five common category names used for classifying risks based on their nature were economic, political, construction, financial, and management. In this paper, the risks identified from the selected articles were categorized into eleven categories: management, technical, construction, resource-related, site conditions, contractual and legal, economic and financial, social, political, environmental, and health and safety. Categorizing risks in such a manner helps to avoid redundancy and ambiguity and contributes to the effectiveness and quality of the risk identification process because the categories are detailed and comprehensive. In order to rank the risks belonging in each category, the percentage of articles in which a particular risk is mentioned was used, and the top ten risks in each category were presented in this paper. The top five most frequently mentioned risks in the selected articles based on the overall rank of the risks were unpredicted change of inflation rate; design errors and poor engineering; changes in government laws, regulations, and policies affecting the project; adverse weather conditions (continuous rainfall, snow, temperature, wind); and unpredicted adverse engineering geology.

The main contributions of this paper can be grouped into three areas. First, the paper addressed the lack of a systematic review and content analysis of published articles related to risk identification in construction by providing a comprehensive review and content analysis of 130 articles published in 14 different journals. Second, the paper identified the most common risk identification tools and techniques and risk classification methods used in construction projects. Third, the paper identified, categorized, and ranked the most common risks affecting construction projects. The findings of this study are of value to researchers and industry practitioners seeking a useful reference on common potential risks affecting construction projects for future risk identification, analysis, and modeling purposes.

Using the research methodology adopted in this paper, future research should focus on the identification of common risks, risk identification tools and techniques, and risk classification methods for different contexts based on project type, project location, project stakeholders, and project delivery type; for example, the identification of common risks for public-private partnership infrastructure projects in a given country or region from the contractors' perspective. The findings of this paper show that there are a vast number of risk management tools and techniques and risk classification methods in the literature. Therefore, it has become increasingly challenging to select an appropriate tool and technique and classification method for risk identification on construction projects. Future research is required to develop a framework to assist with the selection of an appropriate risk identification tool and technique and risk classification method. In order to develop such a framework, important criteria that will be considered for the selection of risk identification tools and techniques and risk classification methods (e.g., complexity of the project, risk maturity of the organization, simplicity of use, completeness of the tools and techniques, etc.) will be identified, and a multi-criteria decision-making model will be developed. In most construction risk assessment and analysis methods, risks are treated independently, and the dynamic nature of risks and causal interactions between risks are not considered. The causal interactions and dependencies between risks have considerable effect on risk assessment and analysis, and neglecting to account for this effect can lead to overestimation or underestimation of the risk (contingency) allowance. Therefore, future work is also required to develop a dynamic risk analysis model that is capable of accounting for the dynamic behavior, causal interactions, and dependencies between the most common risks identified in this paper in order to determine the concurrent and cumulative impact of risks on work package and project cost.

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Supplemental Data

Table S1 is available online in the ASCE Library (www.ascelibrary.org).

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