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Overview of analytical hierarchy process decision making method for construction risk management

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Overview of analytical hierarchy process decision making method for construction risk management

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Abstract. The construction industry is one of the industries that currently gave an overwhelming effect to the booster of the developing country. Construction field is one of the areas that need immediate decision during the planning, design or construction stage. A construction project in a broader context is the involvement of multiple construction practitioners with an aim to ensure that the project complete within the time frame and budget with assured quality. In ensuring smoothness of the construction project, a multi-criteria decision making (MCDM) technique as a systematic tool has been used widely, namely Analytical Hierarchy Process (AHP). Based on the 40 journal articles, questions of which civil engineering field does AHP mostly employed as decision making tools in any of risk occurrence may be answered. Results revealed that thirteen (13) various civil engineering field was discovered adopting AHP as decision making assessment method and company and managerial, road highway project and building construction remarked the core field attracted much interest.

1. Introduction

The construction industry is one of the industries that currently gave an overwhelming effect to the economic booster of any developing country. In Malaysia, construction is one of the industry sectors that spurred good economic growth. The construction industry is the most dynamic and responsive sectors [1] has been seen to benefit most countries regarding generating state revenues, the formation of federal and state capital and also indirectly helping to create career opportunities which would certainly increase the gross domestic product and drive a positive socio-economic growth [2]. A construction project in a broader context is the involvement of multiple construction practitioners with an aim to ensure that the project complete within the time frame and budget with assured quality. Most construction projects are exceptional and have their risks. With the involvement of multiple parties in delivering the construction project, including the owner or client, contractor, technical designer, suppliers, and others. All parties involved in a project certainly carry enormous risks [3]. Also, the construction projects are also certifying for manageable and deliver a promised quality. There are several of others prevalent construction fields built; including building construction, infrastructure construction that typically consist of road construction, railway construction, and construction of utility facilities such as sewerage treatment plant, water treatment plant and also the construction of water tank. As a result of the involvement of multiple construction practitioners, encompassing of several stages before completion of the construction project in the various construction field, thus leading to inherent risks either implicit or explicit. The risk in construction ever since has attracted interest since risk management in construction was initially published in 1985 [4]. Risk management is a formal and orderly process of systematically identifying, analysing, and responding to risks throughout the life-cycle of a project to obtain the optimum degree of risk elimination, mitigation and control [5]. The systematic approach of risk management procedure as suggested by [6] inclusive of three (3) significant stages including risk identification, risk assessment, and risk response. Under

those circumstances, a systematic approach, namely analytical hierarchy process (AHP) as a multi-criteria decision method will assist construction practitioners in identifying, analysing and response to the risk across project feasibility.

Analytical Hierarchy Process which was first introduced by Prof. Saaty [7] offer a flexible and simply implicit approach of analysing complex dispute. It is a multi-criteria decision method that permits subjective as well as objective factors to be deliberated in the decision-making process. The AHP permits the vigorous involvement of decision-makers in getting reconciliation, and helps to decide on a rational basis. For this reason, AHP was considered one of the great tools since introduced in 1988, still practical until this millennium era. The main strength of AHP is its ability to consider the subjective opinions of decision-makers. This feature has made it especially attractive for combining with other methodologies that are usually developed to deal with objective data [8]. In recent years, it reported that the decision makers in most construction project commonly the project managers, the client or stakeholders has accepted AHP more extensively as a tool for their decision making process. As a result, a systematic risk management program adopts AHP widely applied in the construction project life-cycle. Many previous studies including [9-11] adopting AHP as decision methods in their construction case study. However there has been little emphasis on prior studies giving any insights on the trend of how are AHP are being in developing countries' construction industry. Whereas [12] develop a systematic review of the literature on how was the criteria are being defined and measured in the AHP technique. However, the study is quite erroneous as the writer mixed up AHP and fuzzy-AHP as the calculation of both methods is thoroughly contrasted. While [13] studies on AHP methodological including problem modelling, pair-wise comparisons, judgment scales, derivation methods, consistency indices, incomplete matrix, synthesis of the weights, sensitivity analysis and group decisions rather than the application. This paper seeks to address the following question (1) in which civil engineering field does AHP mostly employed as decision making tools in any of risk occurrence.

2. Research Methodology

An extensive literature review is an important research methodology, proficient in synthesising the existing body of knowledge, creating new understanding in a broader sense, and resulting new recommendation for future studies. In order to fully review and analyse the findings of previous research studies of a particular topic or research area, methodical analysis of publications in academic journals is consist of planning the review and computer search, visual examination and content analysis is carried out.

2.1. Stage 1 (Planning the review and computer search)

The first stage contains review planning and searching for relevant journal articles by using electronic databases. The purpose of this literature review was clearly defined earlier in the Introduction section, and to certify the searching process in a right track, authors ensure to rely back on the research questions that have been defined earlier and guided with the research design framework as illustrated in Figure 1 below. Research articles in English searched in two databases namely, Scopus and Science Direct provided that both databases have good coverage of all areas of the innovation sciences (engineering, energy and materials and transport) [14]. The expert search rule employed in the title/abstract/keyword (T/A/K) field of the selected databases was "(Analytical Hierarchy Process" OR "AHP) AND ("Construction Project" OR "Infrastructure Project" OR "Civil Engineering Project") AND ("Risk Management"). The limitation of searching set from 2008-2018 (Before 2018/5/17) and ("Engineering") selected as the sources.

On the other hand, to facilitate the searching process only "open-access" research articles were considered while books, editorial and conference proceedings eliminated. This is due to recent evidence by [15,16] that the open-access articles (freely available articles) do have a greater citation advantage and greater research impact. Similarly the effort of "open-access" article underpinning the European Union (EU) announcement in 2016 that to ensure all scientific publications will be freely

accessible by 2020 [17]. For this reason, a total of 138 "open-access" research articles retrieved for further analysis.

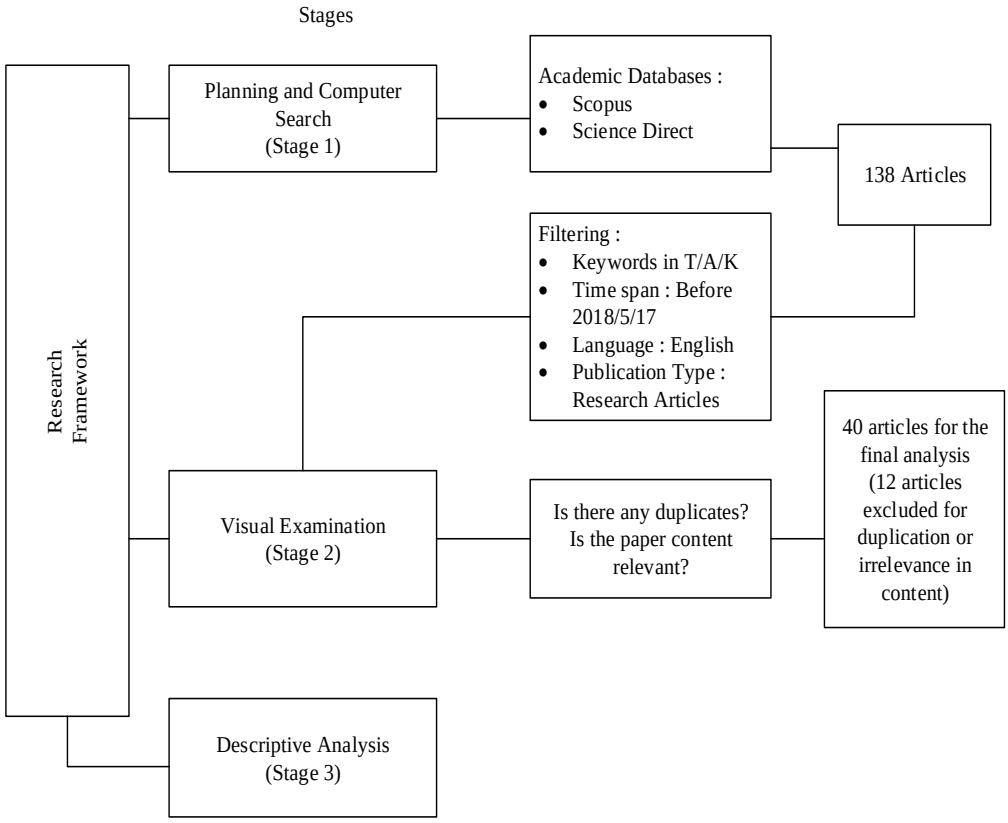

Figure 1. Research Stages for Literature Review

2.2. Stage 2 (Visual Examination)

In visual examination stages, out of 138 articles retrieved, only 40 articles considered for final analysis. In this stage, all duplicates in the titles and author removed and irrelevant application of AHP excluded. The searching made for one decade (2008-2018) of AHP application in various civil engineering fields, figure 2 depicts the annual distribution of the finalised paper. From the figure, we can see that the trends increases from 2013 with seven papers published, slightly decreases in 2014 with six papers published and the maximum published in 2015 with eight numbers. The trends however slowly decrease in 2016, 2017 that might arise due to the inherent of others multi-criteria decision methods application in the civil engineering field. The critical year observed in 2017, yielded two numbers of papers published compared to the previous year. During initial search it was found that in 2017, a number of thirteen papers of risk related in construction project published, however none of the paper adopting AHP as their method. On the contrary, in 2018 it turns out that only one article reported adopting an AHP method. A possible explanation for this might be that the searching for 2018 restricted on 17/5/2018 and there are likely that more papers to get published in the following months in 2018.

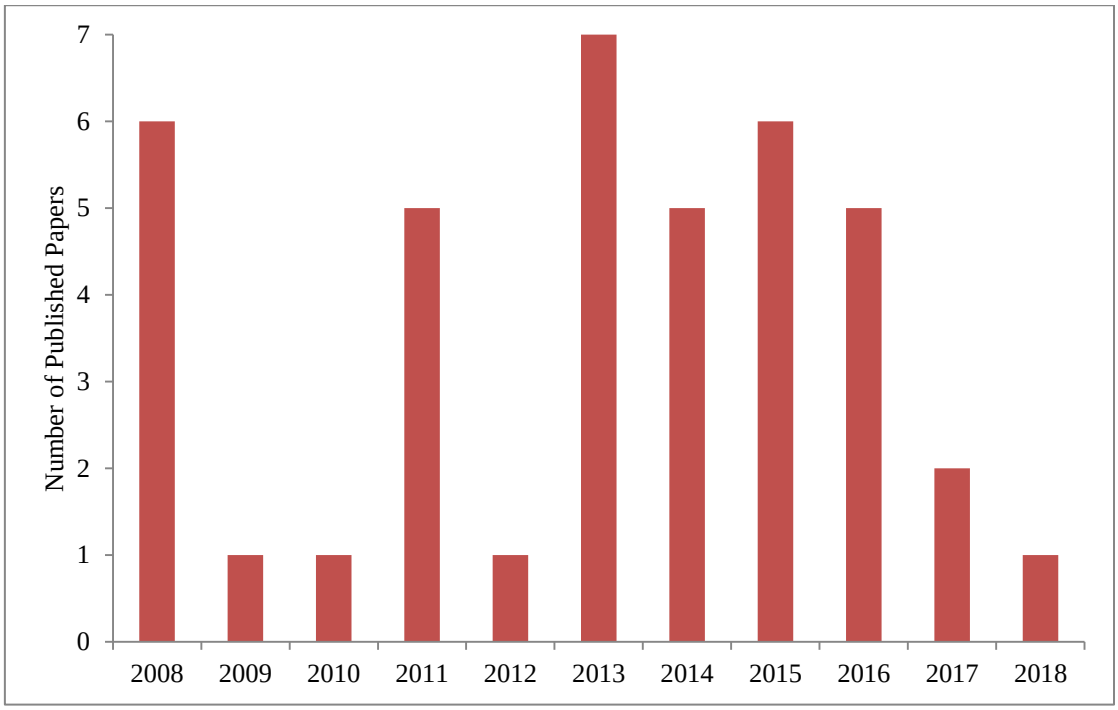

Figure 2. Numbers of Relevant Paper published from 2008-2018

2.3. Stage 3 (Descriptive Analysis)

In the analysis stage, the finalised forty (40) articles were prudently read and assess. In order to analyse the articles, the technique of descriptive analysis employed. From stage 2, numbers of articles rejected due to most of the paper being published adopting AHP method not in civil engineering fields or construction project. During the analysis stage, articles were systematically studied and each of the research articles categorised into various civil engineering field according to a given case study in the articles. The field selected was based on the theme highlighted by the Author upon rigorous read of the articles. The next section will discuss further on the overview of the selected publications.

3. Overview of the selected publication

Figure 3 below depicts number of published papers clustered to thirteen (13) various civil engineering fields categorize into bridge construction, building construction, company/managerial based, deep-water port construction, hydrological, infrastructure, pipeline, power plant, railway, road or highway construction, safety and health, underground rock engineering and some categorize under "not define" by the Author. Whereas Table 1 presents the overview of specific case study area based to the the author.

The highest interest published was company and managerial of construction based at 21% followed by road and highway project at 15% and sharing the same statistic was building construction at 15% as well. The following civil engineering fields remarked the lowest being published being persistent at 3% which are deep-water port construction, pipeline construction, power plant construction, safety and health and underground rock engineering. The highest field recorded was the company and managerial based at 21% which normally both belonged to organisational matters. Generally, the main issue associated with decision making in construction industry field is the organisation or company field. A primary concern in decision making in construction field organisation is that project managers are requested to make a complex decision under tighter timelines, high pressure and fewer errors encountered in their judgment. Road highway project and building construction is the core of development in the field of civil engineering. To demonstrate how important construction of road

infrastructure, the affordability of any country is typically reckoned based on the density and the quality of the road infrastructure [18]. Whereas an indicator for the development of any country is counted based on the number of roads, highways and skyscrapers buildings.

The other civil engineering fields including deep-water port construction, pipeline construction, power plant construction, safety and health and underground rock engineering remarked the lowest published might be due to the reason that the field is yet to be explored, specifically for undeveloped countries. Also, in the event of lack of expertise in the technical field, the country's financial status likewise acts as a significant role in developing the field that has not widely explored and discovered. One of the issues that emerge from these findings is that AHP method even introduced by Saaty back in 1988, after three decades, the utilisation is still relevance specifically in civil engineering field where decision making is crucial. On the other hand, recent several papers have also compiled the AHP success stories in very different fields including [19] in the supply chain risks, while [20] employed AHP in developing a landslide susceptibility map of the Lish river basin of Eastern Darjiling Himalaya, [21] adopt AHP in determining the relative importance of different constraints upon fisheries diversification. Similarly, by using AHP, [22] identify the barriers to develop renewable energy from the context of Nepal. Also, [23] determine factors in evaluating the techno-entrepreneurship projects by using the AHP method. Despite its popularity, AHP is also having the drawback including its incapability to satisfactorily solve the ambiguity and vagueness associated with presenting the decision-maker's sensitivity and the decision to precise ratios or numbers [24]. Similarly, AHP requires decision makers remain consistent in making a pair-wise comparison and the difficulty to express accurate expression due to the limitation of the nine (9) value scale of Saaty [25]. In order to overcome the uncertainty and vagueness issue is that the consistency ratio obtained ascertained within the range of 1% [26].

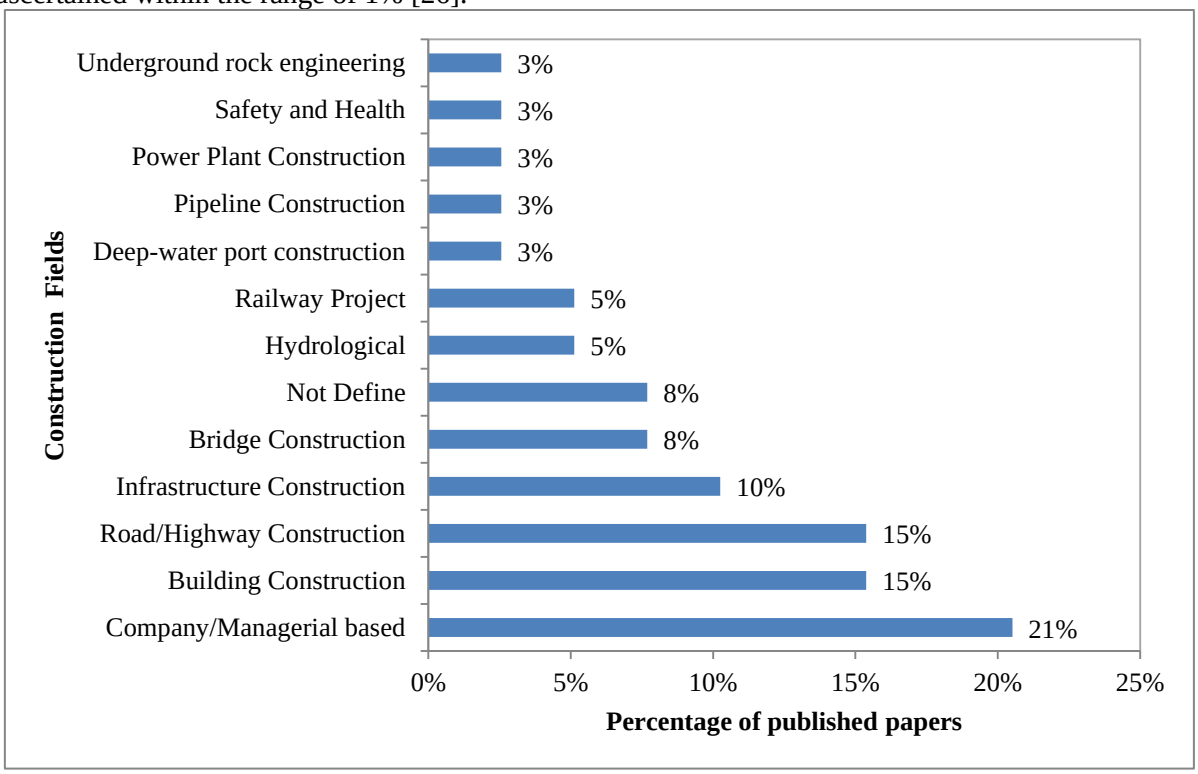

Figure 3. Statistic of Published papers according to Construction Fields

Table 1. Specific case study area

(Reference)	Case Study Area	Field Area

(Reference)	Case Study Area	Field Area
[27]	Indonesia South Highway Project International Construction Project Kuwait Acid Gas Removal Plant Singapore East-West Subway line	Road/Highway Construction
[28]	New bridge construction project of the National Taiwan Secondary Freeway Project	Bridge Construction
[29]	Building Construction Project Located in Central Taiwan	Building Construction
[25]	National Laboratory Animal Centre Construction Project	Building Construction
[30]	Chinese highway projects	Road/Highway Construction
[31]	300 historical pavement maintenance projects obtained from 13 divisions of the Taiwan Directorate General of Highways (TDGH).	Road/Highway Construction
[32]	Ruentex Construction & Engineering Company	Company/Managerial based
[33]	Pipeline construction project in the Indian oil industry.	Pipeline Construction
[34]	Construction Enterprises Management	Company/Managerial based
[35]	Dry Port Construction Project	Infrastructure Construction
[36]	PPP Expressway Project in China	Road/Highway Construction
[37]	Major Iranian Construction Company	Company/Managerial based
[38]	BT Engineering Construction in Chongqing, Nanjing and Shanghai.	Infrastructure Construction
[39]	No Case Study	Underground rock engineering
[40]	Construction Project	Safety and Health
[41]	4D Model Construction Project	Not Define
[42]	Bridges Construction in Iran	Bridge
[43]	Compassion House in Edmonton, Alberta, Canada.	Building Construction
[44]	66 projects in an operation centre	Building Construction
[45]	Bridges construction in Taiwan	Bridge Construction
[46]	Egyptian construction contractors	Company/Managerial based
[47]	Various construction field	Not Define
[48]	“Zhejiang-Fuzhou” UHV Power Transmission Construction Project	Infrastructure Construction
[49]	Construction projects at King Abdulaziz University (KAU)	Building Construction

(Reference)	Case Study Area	Field Area
[50]	Three dam projects, in the Prefecture of Trikala (Greece)	Hydrological
[51]	Five construction project	Not define
[52]	National Health Service (NHS), United Kingdom.	Building Construction
[53]	Klaipeda Port, Eastern Baltic Sea.	Deep-water port construction.
[54]	Semarang-Solo highway project	Road/Highway Construction.
[55]	Intercity railway project in Saudi Arabia.	Railway Project
[11]	Nuclear Power Plant in Korea.	Power Plant Construction
[56]	Seoul subway section 000 construction project One	Railway Project
[57]	Cross-sea route project that is expected to connect Guangdong Province and Hainan Island.	Road/Highway Construction
[58]	Not define	Company/Managerial based
[59]	Hydropower in Nepal	Hydrological
[60]	Energy service companies in Russia.	Company/Managerial based
[61]	Heavy Engineering Toll Roads between Two Cities	Infrastructure
[62]	Turkish construction project management	Company/Managerial based
[63]	Risk maturity level of public construction client in Indonesia.	Company/Managerial based

4. Conclusion

The overview of application for the Analytical Hierarchy Process (AHP) methods in decision making process in the various civil engineering field presented in this paper. AHP aids in capacity to consider subjective opinions of decision-makers particularly in the civil engineering construction field where the involvement of multiple parties in making a complex decision that entails under tighter timelines, high pressure and fewer errors. For a reason, thirteen (13) various civil engineering field was discovered adopting AHP as decision making assessment method and company and managerial, road highway project and building construction remarked the core field attracted much interest. In contrary, the findings presented reveal both that much has been achieved, and that much has yet to be done. Principally, the civil engineering fields that need to emphasise on in future including deep-water port construction, pipeline construction, power plant construction, safety and health and underground rock engineering.

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