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Procedia Engineering 00 (2017) 000–000

Procedia Engineering

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Producing alternative concept for the trans-Sumatera toll road project development using location quotient method

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Abstract

The Trans-Sumatera Toll Road (TSTR) is one of Indonesia's mega project infrastructures and is planned to stretch along Northern Sumatera provinces from Aceh to North Sumatera for about 800 km. Currently, the project development is only feasible in particular routes due to high investment costs and limited demand for revenue. This paper will investigate the best alternative route by considering related aspects to improve its viability. The research method used a combination of quantitative and qualitative approaches through desk study and in-depth interviews. This research produced optimum route for the Northern Sumatera area and also revealed dominant sectors for both provinces.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: Highway Infrastructure; Indonesia; Location Quotient; Regional Development; Route Selection; Toll Roads.

1. Introduction

Infrastructure plays significant role in increasing national economic growth and creating economic mobility for civilians. The quantity and quality of infrastructure in a country also determines investment attractiveness for private sectors and the nation's competitiveness in a global scale [1]. As one of the most significant sectors, road infrastructure in Indonesia has to be improved significantly in terms of quantity, quality and proper government management. According to the Global Competitiveness Report in 2012, the quality of road infrastructure in

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

Indonesia placed at 78 from 148 countries. This report shows Indonesia's infrastructure condition still behind neighboring countries such as Singapore, Malaysia and Thailand. Improving Indonesia's position will then require mutual collaboration among the government, academics, private sectors and also the society.

Indonesia's government has attempted to minimize the infrastructure gap, particularly in the road sector, by initiating the development of Trans Sumatera Toll Road in recent years. This mega project infrastructure required huge investments of about 340 trillion rupiah to construct ± 2,788 kilometers, which connects Bandar Lampung in Southern Sumatera to Aceh in Northern Sumatera [2]. The development of this project was expected to create equality of welfare by connecting a road network system in Sumatera Island.

Many researchers have been shown the benefits of toll road construction for various aspects of life in their respective findings. Toll road contribution ranging from reducing transportation and logistics costs, accelerating economic mobility [3], opening new job opportunities in a greater scale [4], creating industrial areas such as cement, steel and construction services [5], improving investment attractiveness [6], as well as generating economic activities around the region [7,8].

However, despite its huge positive impact to accelerate nation's economic growth, the Trans Sumatera Toll Road is only feasible in a selected part of the route. In contrast, as the second contributor for national GDP, Sumatera Island has many potential areas that can be developed for greater purpose. Therefore, the regional development has to be considered as the main aspect in determining Sumatera potential sectors. It requires identification of featured sectors in every city and district that can be used as an input for the government to formulate the best policy regarding this mega project development.

This research will create alternatives concept for Trans Sumatera Toll Road project particularly in Nanggroe Aceh Darussalam and North Sumatera provinces by producing new route selections. It will consider Gross Regional Domestic Product (GRDP) and population in both provinces. It will be obtained from related sources from books, journals, public records and published reports. The research findings expected can be used by the government to increase the feasibility of the project by considering its added value and potential economic growth.

2. Research Methodology

This research will use two approaches by using Location Quotient (LQ) method and the investigation of secondary data. Data collection will be extracted from GRDP and population from statistic of Indonesia to produce targeted outcomes. LQ analysis argued as one of efficient method to analyze and determine the diversity of local economic basis. It also provides the overview about economic stability and flexibility in the region through the investigation of industrial degree. Many scholars have used this method in various degrees of research. It can be used as an estimator of industrial concentration [9], to investigate marine sector policy [10], and also analyze carbon emission [11]. It is also used for food, forestry and tourism sector [12–14].

LQ is an indirect measurement method that determines basis and non-basis sectors by using secondary data from economic indicators in the region particularly from GRDP, population and workforce per sector. The secondary data will be retrieved from books, public records such as The Annual Statistic Report, policies, and government reports. LQ means ratio between two proportions. It compares the relative function of value from the GRDP of production commodity sector in a region to the relative function from the whole value of GRDP. In mathematical equation, LQ can be formulated as follows.

$$LQ_i = \frac{e_i/e}{E_i/E}$$

Where:

LQi	= LQ value for i sector in a district
ei	= GRDP for i sector in a district
e	= GRDP whole sector in a district
Ei	= GRDP sector i in province of the district
E	= GRDP whole sector in province of the district

LQ will produce a coefficient from 0 to unlimited value. LQ < 1 means the commodity sector in that region has no comparative industrial cluster. LQ = 1 indicates no distinguishing feature from one region to the others. LQ > 1 shows the investigated sector has a comparative industrial sector.

This research also conducted in-depth interviews with related stakeholders with a transportation background, including operators, academics and government bodies with more than 10 years of experience. The instruments will be use a semi-structured questionnaire which expected as a validation regarding research output. The interview takes 15 – 30 minutes to collect sufficient data for analysis. The questions in interviews will correlate to the result of LQ analysis, therefore both results from the in-depth interview and LQ analysis can be cross checked and increases the validity and reliability of the research outcomes.

3. Result and Discussion

3.1. Nanggroe Aceh Darussalam Province

From 23 cities and districts in Nanggroe Aceh Darussalam (NAD) province, four cities/districts were selected as having the highest of GRDP and population. In term of GRDP, there are the cities of Lhoksuemawe, Aceh Utara District, City of Banda Aceh, and Bireun District. While in terms of population, there are Aceh Utara District, Bireun District, Pidie District, and Aceh Timur District. It can be seen that some of cities/districts in top ranking of GRDP such as City of Lhoksuemawe and City of Banda Aceh have a low population. Considering this evidence, the number of population is not the only variable that determines the GRDP of a city. The detail ranking from both GRDP and population can be seen in Table 1.

Table 1: Table of GRDP and Population for Nanggroe Aceh Darussalam Province

Rank	Cities / Districts	Capital	GRDP (Rp.)	Number of Population
Ranking of GRDP				
1	City of Lhoksuemawe	Lhoksuemawe	5,495,875,473,600	
2	Aceh Utara District	Lhoksukon	4,775,787,735,000	
3	City of Banda Aceh	Banda Aceh	3,651,734,500,000	
4	Bireun District	Bireun	3,066,934,950,000	
Ranking of Population				
1	Aceh Utara District	Lhoksukon		556,556
2	Bireun District	Bireun		413,817
3	Pidie District	Sigli		401,082
4	Aceh Timur District	Idirayeuk		393,135

The route sketching of Trans Sumatera Toll Road in Nanggroe Aceh Darussalam province is determined by the ranking from Table 1. It will connect the cities of Lhokseumawe, Lhoksukon, Banda Aceh, Bireun, Sigli and Idirayeuk. Besides the 6 capital cities, the Langkat Milang sub-district at the border of NAD and North Sumatera provinces are also included to connect the whole route of Northern Sumatera.

Moreover, the GRDP value was also identified from the constant price of NAD province [15]. The data shows 9 economic sectors in selected six cities and districts of NAD province. The economic sector is mostly gained from statistics of Indonesia ranging from agriculture, mining and excavation, processing industry, to services. The comparison of the cities/districts in term of economic sectors is shown in Table 2.

Table 2: GRDP in NAD Province for various economic sector

No	Economic Sectors	City of Lhoksuemawe	Aceh Utara District	City of Banda Aceh	Bireun District	Pidie District	Aceh Timur District	GRDP TOTAL of Aceh Province
1	Agriculture	297,846	1,159,762	122,669	934,452	834,185	994,305	9,893,292
2	Mining and Excavation	10,100	1,014,828	0	48,853	21,225	736,060	2,164,400
3	Processing Industry	2.962,870	240,131	79,844	38,614	100,919	211,340	4,458,629
4	Electricity, Gas and Water	4,227	8,098	20,581	11,381	10,637	15,840	144,951
5	Buildings	193,014	918,319	228,199	221,312	87,055	71,587	3,447,851
6	Trade, Hotel and Restaurant	1,350,327	473,356	890,748	987,666	123,797	250,450	7,339,229
7	Transportation and Comm.	242,816	336,668	575,427	338,579	139,855	158,854	2,692,299
8	Finance, Real Estate and Business	60,110	89,683	87,562	45,833	33,610	69,120	703,296
9	Services	374,556	534,943	1.646.705	440.244	608,097	69,320	6,929,023
	TOTAL	2,532,996	4,775,788	2,005,030	2,627,130	1,959,380	2,576,876	37,772,970

* In 000,000

Based on Table 2, LQ value for selected cities/districts in Nanggroe Aceh Darussalam then calculated. For instance, city of Lhoksuemawe has a value of agriculture sector of about 297,846,000 (ei), a GRDP value around 5,495,875,473,600 (e), total GRDP of agriculture sector about 9,893,292,000,000 (Ei) and Total GRDP from overall economic sectors about 37,772,970,000,000 (E). Using the LQ formula as the basis, city of Lhoksuemawe has LQ = 0.207. Since the value is below 1, it can be concluded that agriculture is not the main potential sector to be further developed in this city. A similar calculation approach then also conducted for every economic sector and selected cities/districts. LQ value calculation is summarized in Table 3.

Table 3: LQ value in Nanggroe Aceh Darussalam Province

No	Economic Sectors	City of Lhokseumawe	Aceh Utara District	City of Banda Aceh	Bireuen District	Pidie District	Aceh Timur District
1	Agriculture	0,207	0,927	0,128	**1,163**	**1,625**	**1,473**
2	Mining and Excavation	0,032	**3,708**	0,000	0,278	0,189	**4,985**
3	Processing Industry	**4,567**	0,426	0,185	0,107	0,436	0,695
4	Electricity, Gas and Water	0,200	0,442	**1,469**	0,967	**1,415**	**1,602**
5	Buildings	0,385	**2,107**	0,685	0,791	0,487	0,304
6	Trade, Hotel and Restaurant	**1,265**	0,510	**1,255**	**1,657**	0,325	0,500
7	Transportation and Communication	0,620	0,989	**2,211**	**1,549**	**1,001**	0,865
8	Finance, Real Estate and Business	0,587	**1,009**	**1,288**	0,803	0,924	**1,441**
9	Services	0,372	0,611	2,458*	0,783	**1,692**	0,147

Furthermore, using a route sketching technique through google earth software, the total of Trans Sumatera Toll Road in NAD province is estimated to be about 393.79 km. A route visualization can be seen in Fig. 1.

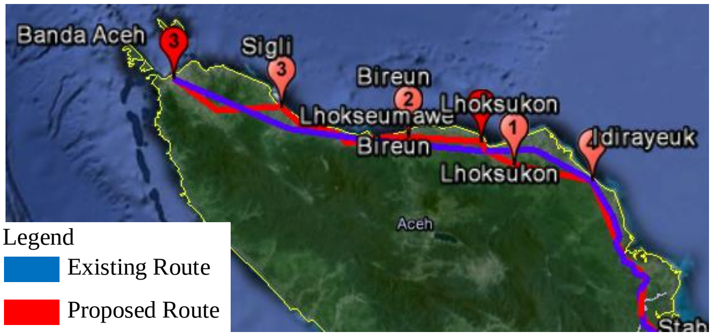

Fig. 1. Route Sketch of Nanggroe Aceh Darussalam Province

This research produces an alternative route compared to the existing route as shown in Fig. 1. The proposed route determines Lhoksukon as the capital city of North Aceh district to be included in Trans Sumatera Toll Road. The reason behind this selection is derived from its potential that shows a great number of population and GRDP. According to statistics, it has the highest population in the NAD province of about 556,556 inhabitants with Rp 4.775.787.735.000 of GRDP and placed second highest from other districts.

Moreover, LQ analysis has produced economic sectors that potentially generate regional income. Based on Table 3, the highest value with 4.985 is Aceh Timur district for mining and excavation, followed by the city of Lhokseumawe with 4.567 for its processing industry and Aceh Utara district with 3.708 for its mining and excavation.

Furthermore, six cities/districts in NAD province have at least two potential economic sectors that can be developed to increase local competitiveness. The city of Banda Aceh has five potential sectors from electricity, gas and water; Trade, Hotel and Restaurant; Transportation and Communication; Finance, Real Estate and Business and services. Meanwhile, the city of Lhokseumawe has the lowest potential with only processing industry and Trade, Hotel and Restaurant. The other four cities/districts have two up to four potential economic sectors.

3.2. North Sumatera Province

Meanwhile, from 33 cities/districts in North Sumatera province, four of them were selected as the highest in terms of GRDP and population. In terms of GRDP, there are the City of Medan, Deli Serdang District, Langkat District and Batubara District. While the City of Medan, Deli Serdang District, Langkat District and Simalungun District become major contributors in terms of population. The detail ranking from both GRDP and population can be seen in Table 4.

Table 4: Table of GRDP and Population for North Sumatera Province

Rank	Cities / Districts	Capital	GRDP (Rp.)	Number of Population
Ranking of GRDP				
1	City of Medan	Medan	43,303,956,380,000	
2	Deli Serdang District	Lubukpakam	18,409,790,000,000	
3	Langkat District	Stabat	8,527,344,220,000	
4	Batubara District	Limapuluh	8,437,600,000,000	
Ranking of Population				
1	City of Medan	Medan		2,135,516
2	Deli Serdang District	Lubukpakam		1,886,388
3	Langkat District	Stabat		978,734
4	Simalungun District	Raya		833,251

Based on the table above, the route sketching of Trans Sumatera Toll Road in North Sumatera province will connect city of Medan, Lubukpakam, Stabat, Lima Puluh and Raya. This route excludes Medan – Sibolga as stated in existing route. City of Sibolga has a low GRDP (< 1 trillion rupiah) and low population (< 100,000 inhabitants). The route also includes Langko - Bangkoang sub-district at the border of North Sumatera and Riau to connect Northern Sumatera to Central Sumatera.

From the Table 4, GRDP value also has been identified from constant price of NAD province [16]. Details can be seen in Table 5.

Table 5: GRDP in North Sumatera Province for various economic sector

No	Economic Sectors	City of Medan	Deli Serdang District	Langkat District	Batubara District	Simalungun District	GRDP TOTAL of N. Sumatera Province
1	Agriculture	834,424	2,731,160	4,608,281	1,335,487	3,699	29,540,225
2	Mining and Excavation	535	231,330	452,977	10,194	25	1,291,539
3	Processing Industry	5,332,919	6,442,210	918,649	4,426,056	953	28,369,936
4	Electricity, Gas and Water	555,266	40,860	29,985	57,619	36	998,683
5	Buildings	4,952,401	545,940	252,326	162,734	123	9,343,738
6	Trade, Hotel and Restaurant	12,384,754	3,655,450	1,371,969	1,968,365	552	29,326,781
7	Transportation and Comm.	7,847,892	1,577,840	194,857	200,146	171	12,792,795
8	Finance, Real Estate and Business	6,642,544	655,160	180,625	127,229	153	9,923,333
9	Services	4,753,220	2,529,840	517,676	149,771	814	14,521,624
	TOTAL	43,303,955	18,409,790	8,527,345	8,437,601	6,526	136,108,654

* In 000,000

Based on Table 5, LQ values for each city and district in North Sumatera can be calculated using the LQ formula. More detail information can be seen in Table 6.

Table 6: LQ value in North Sumatera Province

No	Economic Sectors	City of Medan	Deli Serdang District	Langkat District	Batubara District	Simalungun District
1	Agriculture	0,089	0,684	**2,490**	0,729	**2,612**
2	Mining and Excavation	0,001	**1,324**	**5,598**	0,127	0,398
3	Processing Industry	0,591	**1,679**	0,517	**2,517**	0,700
4	Electricity, Gas and Water	**1,748**	0,302	0,479	0,931	0,743
5	Buildings	**1,666**	0,432	0,431	0,281	0,275
6	Trade, Hotel and Restaurant	**1,327**	0,922	0,747	**1,083**	0,393
7	Transportation and Communication	**1,928**	0,912	0,243	0,252	0,279
8	Finance, Real Estate and Business	**2,104**	0,488	0,291	0,207	0,321
9	Services	**1,029**	**1,288**	0,569	0,166	**1,169**

Based on Table 6, the highest value with 5.598 is Langkat district for mining and excavation, followed by Simalungun district with 2.612 for its agriculture, Batubara district with 2.517 for its processing industry, Langkat district with 2.490 for its agriculture and city of Medan with 2.104 for its Finance, Real Estate and Business sector.

Using the above analysis as the basis, total length of the Trans Sumatera Toll Road in North Sumatera province will be about 491.41 km. Route visualization can be seen in Fig. 2.

For North Sumatera province, this research produces a new route from Lima Puluh – Tebing Tinggi and Raya – Pematang Siantar. The consideration in selecting this route is because Batubara district that is located between Lima Puluh and Tebing Tinggi has the fourth highest GRDP in the North Sumatera province for about Rp 8.437.600.000.000. While, Raya – Pematang Siantar was selected by considering Simalungun district which ranks as the fourth highest population for about 833.251 inhabitants.

Districts in North Sumatera province that are excluded for the Trans Sumatera Toll Road are Kisaran, Tanjung Balai, Kabanjahe, Balige and Sibolga. Kisaran as the Asahan district capital only has a population of about 681.794 inhabitants and GRDRP around Rp6.345.250.900.000. Tanjungbalai has GRDP around Rp 1.607.030.000.000 with population of about 158.599 inhabitants, ranked 18th and 25th respectively. Kabanjahe as the Karo district capital has 363.755 inhabitants (ranked 10th) with GRDP around Rp 3.996.714.250.000 (placed 7th). Meanwhile, Balige as the Toba Samosir district capital has GRDP around Rp2.057.483.390.000 with 175.069 inhabitants, ranked 16th and 24th respectively. Lastly, Sibolga has only 85.981 inhabitants with GRDP about Rp 866.829.150.000.

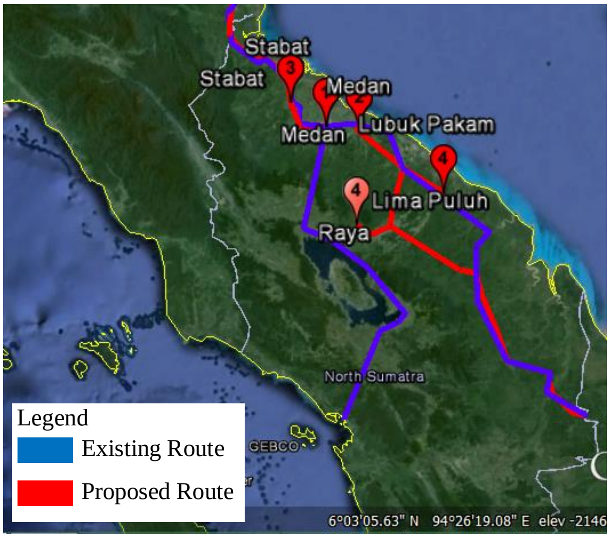

Fig. 2. Route Sketch of North Sumatera Province

The LQ value shows economic activities in North Sumatera are still concentrated in the city of Medan. It holds 7 out of 9 sectors ranging from Electricity, Gas and Water; Buildings; Trade, Hotel and Restaurant; Transportation and Communication; Finance, Real Estate and Business; and Services. The result shows a great gap between the city of Medan and other neighboring districts which only have two to three potential sectors. It is suggested that the government provides more concern in creating more economic activities by increasing public infrastructure in potential areas. The findings are also supported by the director of operational and maintenance in Toll Road Project that other economic activities will play significant role in the project’s long-term sustainability, while the financial manager of SOE in Toll road project argues that strategic development in this concept may include the connectivity of Kuala Tanjung Port in Batubara District and Sei Mangkei Industrial area development to improve the project’s feasibility. Fig. 3 shows the comparison of existing route with the alternative route produced from this research for Northern part of Sumatera.

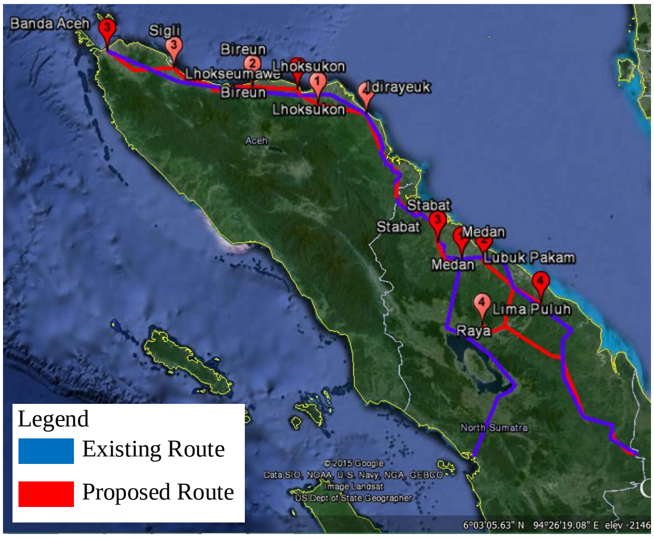

Fig. 3. Comparison of existing and alternative route

4. Conclusion

Route selection plays a significant role in generating demand and creating connectivity between raw material sources to processing centers. This research has produced alternatives routes for the northern part of Trans – Sumatera Toll Road by considering Product Domestic Brute Regional (PDRB) and population density. It comprises of Banda Aceh, Sigli, Bireuen, Lhokseumawe, Lhoksukon, Idirayeuk, Stabat, Medan, Lubukpakam, Limapuluh and Raya. Compared to the existing route that is published in public records for about 866 km, this alternative route has successfully produces a more efficient route of 797.29 km.

The route has been considered featured sectors in both provinces. Nanggroe Aceh Darussalam consists of mining in Aceh Utara and Aceh Timur as well as processing industry in Lhoksumawe. Meanwhile, North Sumatera province consists of mining and agriculture in Langkat and processing industry in Batubara. The result expected can be used as input for the government in formulating policies and producing decisions that increase people mobility and connectivity of goods. This research is also expected to be used as an alternative concept for development not only in other parts of the nation but also in developing countries related to infrastructure development particularly road sector.

Acknowledgements

This research has been supported by research grants from the Ministry of Research, Technology and Higher Education and Universitas Indonesia.

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Procedia Engineering 00 (2017) 000–000

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Developing a self-assessment model of risk management maturity for client organizations of public construction projects: Indonesian context

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Abstract

This paper presents a self-assessment model to measure the risk management (RM) maturity level of construction public client organizations within the Indonesian context. It used a mixture of the Delphi method to select and validate the most relevant attributes and the Analytical Hierarchy Process (AHP) to assign the weights of the selected attributes. A total of 34 attributes, categorized under four dimensions (organizational culture, RM processes, RM resources, and RM implementation) were used. It has been shown that top management commitment, integrity and ethics, and change management capabilities were found to be the most important attributes, suggesting that the RM maturity level is more than formal and standardized systems. The RM maturity score was computed by summing the products of AHP-based weights and ratings which were expressed in a 0–3 scale with 0 representing an immature and 3 denoting a mature level. Given this score, the maturity level of a client organization under evaluation will be classified into one of the following four levels: naïve (0–24), novice (25–49), normalized (50–74), and managed (75–100). This model was pilot tested on a governmental unit under the Ministry of Public Works with a satisfactory result.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: Construction; risk; maturity model; self-assessment; client organization; Indonesia.

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

1. Introduction

Risk is inherent to any construction project and may result in substantial cost and time overruns that are detrimental to the project objectives. Clients (i.e. project owners), construction contractors and even the community at large could suffer from losses arising from delays and additional costs, in particular with regards to public construction projects. While contractors are ultimately held responsible for the on-time completion of projects and keeping to quality specifications at the costs specified in contracts, it does not imply that clients may simply blame contractors for any project failures. Many studies have confirmed the critical client's role to the success of construction projects [1-3].

It is essential to have risk management (RM) as an integral part of a construction organization's management practice [4]. This argument should be valid for all project stakeholders. From an RM standpoint, clients are accordingly required to identify, assess, and allocate risks associated with their projects to ensure them meeting expectations. In this regard, there emerges a need for assessment of organizational risk maturity to describe the understanding of risks as well as to measure to what extent the organization under evaluation is competent on dealing with the risks, and how the processes are implemented [5].

There have been abundant articles directed toward the development of RM maturity for construction [4,6,7]. However, few studies on this domain were dedicated to client organizations, especially those of public construction projects. This paucity therefore provided an impetus for research in this area as reported in this paper. This paper may generate interest for at least two reasons.

First, government units often constitute the largest clients of construction works and the contribution of their capital expenditures to total national construction market is significant. This trend not only holds for developing countries but also for developed ones [8]. In the case of Indonesia, for instance, the spending of the Ministry of Public Works (MPW) alone in 2014 made up about 20% of the total amount. This figure will likely continue to grow overtime as the Government of Indonesia has put pressure on the MPW to boost massive infrastructure development in the country's least disadvantaged regions.

Second, while private and public construction works share a great number of commonalities, they also feature significant different characteristics in certain aspects. Too often the former has a very rigid and strict system, framed with mandatory acts and regulations, from initiation, procurement to completion, making them less flexible and versatile compared to private-owned construction projects.

This paper thus enriches the body of literatures by presenting a measurement model of RM maturity for public organizations. From a practical viewpoint, this paper would help these organizations assess their RM maturity level and take necessary actions for improvement. This paper is of high relevance as government officials often skew toward playing safe and avoiding risks when making decisions. Because the developed model is intended to be a self-assessment tool, the model is made as practical as possible.

2. Risk management maturity models

Hillson's work [5] can be regarded as one of the studies that paved the way for the development of RM maturity models [9]. Cienfuegos [10] developed a maturity model and tested it in 72 Dutch municipalities. He suggested that the maturity level greatly varied but was far below expectation and found that larger organizations tended to attain higher maturity levels.

Zou, Chen, and Chan [4] built a web-based RM maturity measurement tool for construction on five attributes: management, risk culture, ability to identify risk, ability to analyze risk, and application of standardized RM process. Sun, Vidalakis, and Oza [6] established a capability maturity model to provide a measurement framework for assessing the improvement of a project team's capability in dealing with construction contract changes. Based on previous RM maturity models, Öngel [7] proposed another tool that fitted into the characteristics of construction industry.

Zhao, Hwang, and Low [11] identified enterprise risk management (ERM) best practices and important ERM maturity criteria from Chinese construction firms (CCF) perspectives and developed a fuzzy-based ERM maturity model for CCFs. Next, using their model, Zhao et al. [12] measured the ERM maturity of CCFs and reported that these firms exhibited a low level of ERM maturity and there existed a positive association between ERM maturity and firm size. On the same vein, Salawu and Abdullah [13] also developed a fuzzy-based risk management capability model to assess the RM maturity level of contractors in Nigeria. They suggested that 80% of the evaluated contractor organizations were novice while the rest were naïve.

3. Research methodology

The initial step in developing a self-assessment model was to identify attributes pertinent to RM maturity for construction public client organizations. This paper first compiled ten RM maturity models for both construction and non-construction fields (see Table 1) and selected 45 preliminary attributes.

Table 1. Selected risk management maturity models.

Model	Maturity Level	Attribute
Calderon and Pero [14]	Very Immature Immature Evolving Mature Very Mature	Risk Appetite Characteristics Perception of Risk and Risk Assessment RM Alignment Leader of Risk Oversight Reporting of Risk and Satisfaction Integration and Maturity Adoption and Barriers of ERM
Cienfuegos [10]	Initial Repeatable Defined Managed Optimized	Content and Objectives Risk Identification Risk Analysis and Measurement Risk Decision and Control Implementation, Review, and Feedback Organizational Learning Characteristics Decision Theory Approach
Ciorciari and Blattner [15]	Very weak Poor Mid Good Optimized	Internal Environment Objective Setting Event Identification Risk Assessment Risk Response Control Activities Information and Communication Monitoring
Calderon and Pero [14]	Very Immature Immature Evolving Mature Very Mature	Risk Appetite Characteristics Perception of Risk and Risk Assessment RM Alignment Leader of Risk Oversight Reporting of Risk and Satisfaction Integration and Maturity Adoption and Barriers of ERM
Cienfuegos [10]	Initial Repeatable Defined	Content and Objectives Risk Identification Risk Analysis and Measurement

Model	Maturity Level	Attribute
	Managed	Risk Decision and Control
	Optimized	Implementation, Review, and Feedback
		Organizational Learning Characteristics
		Decision Theory Approach
Ciorciari and Blattner [15]	Very weak Poor Mid Good Optimized	Internal Environment Objective Setting Event Identification Risk Assessment Risk Response Control Activities Information and Communication Monitoring

This paper applied a mixture of the Delphi method and Analytical Hierarchy Process (AHP) to develop the RM maturity model. The Delphi method is a systematic and interactive research technique for obtaining the judgment of a panel of independent experts on a specific topic. These experts are selected according to predefined guidelines and are asked to participate in two or more rounds of structured surveys [16]. This method was used to determine as well as to validate the most relevant attributes.

The Delphi survey employed a dichotomous question that only asked for a "yes/no" response with respect to the importance of a given attribute. A small group of three selected experts was first set up to provide insights and comments on the preliminary version of the Delphi questionnaire. After some refinement, the final version was then distributed to 12 high-ranked (at least echelon II) and knowledgeable officials of the MPW. The survey took place in October 2014.

A total of nine officials responded the questionnaire, thereby reflecting a 75 % response rate. Six respondents had more than 20 years of experience, one had 10-20 years of experience and the remaining had 5-10 years of experience, thus securing the validity of their responses. The cut-off level to define consensus was 70 % of panelists [13] responding "yes" to a specific attribute. At round two, this cut-off level was lowered to 50 % + 1 to prevent lengthy Delphi processes.

The AHP was used to assign weights for each selected criterion [18]. For this purpose, another group of respondents comprising 20 experts was invited and all agreed to participate in this AHP survey. This survey was conducted from November to December 2014. Most respondents (90%) had a master's degree and about a half of these respondents had more than 10 years of experience.

The AHP requires respondents to complete pairwise comparisons of two attributes using a scale of 1-9 with 1 representing "equally important" and 9 denoting "extremely important." Individual ratings of respondents were aggregated to form a group decision using geometric mean, which has been proven consistent and upholds the axioms underlying the AHP process [19]:

$$a_{ij} = \left(\prod_{i=1}^{n} a_{ijk} \right)^{\frac{1}{n}} \qquad (1)$$

where a_{ij} = relative importance of attribute i over attribute j, a_{ijk} = relative importance of attribute i over attribute j given by respondent k, n = number of respondents (n = 20 in this paper). Relative weights of attributes are obtained by solving the following equation:

$$\mathbf{A}_{m\times m}\mathbf{w}_{m\times 1} = \lambda_{\max}\mathbf{w}_{m\times 1} \qquad (2)$$

where $\mathbf{A}$ = pair-wise comparison matrix containing a_{ij}, $\mathbf{w}$ = vector matrix of estimated weights, m = number of attributes, λ_{max} = largest eigenvalue of matrix **A**. The AHP also provides a measure of consistency, referred to as consistency index (*CI*) which is computed as follows:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (3)$$

Another measure, a consistency ratio (CR), is defined as:

$$CR = \frac{CI}{RI} \quad (4)$$

where *RI* = random consistency index which depends on the matrix size (*m*; see Table 2). The consistency level is acceptable when *CR* is less than 10 %.

Table 2. Random consistency index.

m	3	4	5	6	7	8	9	10
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

The final development stage was to define a scoring system. This paper used a score running from ‘0’ denoting an immature level (i.e. unaware to RM) to ‘3’ indicating a mature level (i.e. fully aware to RM). Of course, every attribute had its own definition with respect to maturity level. For instance, a score of ‘0’ for management commitment was assigned for “no commitment,” a score of ‘1’ for “partial and passive commitment,” a score of ‘2’ for “active commitment,” and a score of ‘3’ for “full commitment.” The overall score was then calculated using the following simple formula:

$$S = \frac{100}{3} \sum_{i} w_i R_i \quad (5)$$

where S = risk maturity score, w_i = weight of attribute i, R_i = rating for attribute i. Given Eq. 1, the score will range between 0 and 100 and determines the maturity level of the client organization under evaluation. The readers are encouraged to consult [20] for detailed information. Borrowing Hillson [5], the maturity level was classified into four levels: naïve, novice, normalized, and managed (see Table 3).

Table 3. Risk management maturity level (adapted from Hillson[5])

Score	Maturity Level	Definition
0 – 24	Naïve	Unaware, no structured approach dealing with uncertainty, repetitive and reactive management, no attempt to learn
25 – 49	Novice	Aware but no effective risk process, experimenting risk management through nominated individuals
50 – 74	Normalized	RM in routine business process, implementation on most project, formal and widespread risk process
75 – 100	Managed	Risk-aware culture, proactive RM in all aspects of business, risk information is actively used, RM used to manage opportunities

4. Results and discussion

Out of initially identified 45 attributes, 34 were selected from the Delphi survey and then grouped under four dimensions: “organizational culture”, “RM processes”, “RM resources”, and “RM implementation” (see Table 4). A total of 138 pairwise comparisons were presented to the invited respondents. For all levels, the AHP inconsistency ratios of responses were far below 10 % and hence acceptable.

4.1. Attributes and weights

At the parent level (i.e. dimension), the AHP analysis showed that "organizational culture" ranked the first (32.74%), followed by the three other attributes with almost equal weights. This finding is therefore consistent with those of earlier studies [5,21] that affirmed culture as being the first element to be rolled out for implementing RM in an organization. For risk culture to be changed, leadership must be the driver of that change [21]. Moreover, given that the construction industry heavily relies on human interactions, having a good cultural environment plays a significant role in the morale and productivity within the organization [4].

Table 4. Selected attributes for measuring risk management maturity.

Dimension*	Attribute*	Global Weight (%)
Organizational Culture (32.74 %; 1)	Risk perception (8.13 %; 7)	2.66 (17)
	Risk communication (9.66 %; 6)	3.16 (15)
	RM policy (10.00 %; 5)	3.27 (13)
	Top management commitment (16.36 %; 1)	5.36 (1)
	Corporate governance (10.18 %; 4)	3.33 (12)
	Responsibility and authority (6.85 %; 9)	2.24 (25)
	Integrity and ethics (15.48 %; 2)	5.07 (2)
	Competence (11.42 %; 3)	3.74 (8)
	Incentive system (7.10 %; 8)	2.32(24)
	Risk appetite (4.82 % ; 10)	1.58 (33)
RM Processes (22.92 %; 2)	Risk identification (16.70 %; 1)	3.83 (7)
	Risk database updating (8.58 % %; 8)	1.97 (28)
	Risk analysis (15.99 %; 2)	3.66 (10)
	Standardization (5.94 %; 9)	1.36 (34)
	Risk mitigation (13.94 %; 3)	3.20 (14)
	Monitoring and controlling (8.85 %; 7)	2.03 (27)
	Risk evaluation (10.70 %; 4)	2.45 (20)
	Risk information management (10.40 %; 5)	2.38 (21)
	RM audit (8.90 %; 6)	2.04 (26)
RM Resources (22.20 %; 3)	Budget (20.8 %; 2)	4.62 (4)
	Dedicated staff members (7.7 %; 6)	1.71 (31)
	Training (16.70 %; 4)	3.71 (9)
	Research and development (15.90 %; 5)	3.53 (11)
	Learning capability (17.8%; 3)	3.95 (6)
	Change management capability (21.1 %; 1)	4.68 (3)
RM Implementation (22.14 %; 4)	Formalization and routinity (8.48 %; 8)	1.88 (30)
	Scope (8.58 %; 7)	1.90 (29)
	Integration with other management tasks (13.28 %; 2)	2.94 (16)
	Stakeholder relationship (11.42 %; 3)	2.53 (18)
	RM dedicated function (10.64 %; 5)	2.36 (22)
	Barrier perception to adoption (7.22 %; 9)	1.60 (32)
	RM-linked performance measurement (10.58 %; 6)	2.34(23)
	Risk based decision making (18.69 %; 1)	4.14 (5)
	Risk based business process (11.11 %; 4)	2.46 (19)

*Numbers in parentheses indicate local weight and rank, respectively.

After "organizational culture", "top management commitment" becomes the most important attribute. This comes as a no surprise as a successful RM implementation requires a strong and sustained commitment from top management. Furthermore, this result confirmed Zhao et al. [11] that also ranked commitment of the board and senior management in the first place for ERM implementation, given that ERM was considered as a top-down approach. Interestingly, the finding of low rank of "risk appetite" is also in line with Zhao et al.

"Integrity and ethics" was globally ranked at the second place. One plausible argument to explain this result is that integrity and ethics are inherent in the organization and become the most important factor relating to organizational culture [22].

Risk identification ranks first under "RM processes." It is the first step of RM process in which potential risks associated with a construction project are identified and the foundation for setting up a risk register and risk assessment model [23,24]. "Risk analysis", "risk mitigation", and "risk evaluation"—subsequent key processes of RM—come next in rank. Again, this finding is compatible with Zhao et al. [11].

The first place under "RM resources" was occupied by "change management capability." Overall, this attribute ranked third after "top management commitment" and "integrity and ethics." Cienfuegos [10] stated that governmental units are urged to rapidly adapt to every change; accordingly, the organizational ability to deal with any change, supported by ability to learn, becomes essential for dynamic and active RM processes. It is worth noting here that although falling under the category of "RM resource" in this paper, "change management" might also be considered as stemming from culture and process, not from management change of committees and form [25].

The respondents put "risk-based decision making" bu top management as the first attribute on the list under "RM implementation." Its definition may vary from organization to organization but in essence it refers to a process to make an optimal trade-off decision by taking into account all possible outcomes in both positive and negative directions, based on available data and information. This attribute was viewed as crucial to a successful RM implementation.

4.2. Pilot testing

This model was pilot tested on an auditing unit under the General Inspectorate of the MPW with three senior staff members being the resource person to assist in risk maturity self-assessment. This pilot testing was also aimed to test the applicability of the model. The feedbacks were positive and encouraging in the sense that the users did not find any difficulty in completing this self-assessment and considered it to be a very useful tool.

Table 5 shows the self-assessment results. As shown, the unit under evaluation had a "novice" level for "organizational culture" and a "naïve" level for other three dimensions. Overall, its RM maturity level is only on the border of "naïve" and "novice." Although this result should not necessarily reflect the RM maturity level of the MPW given that the evaluation was run only on one sample unit, it has at the very least supported to some extent the findings of previous studies [10,13].

Table 5. Risk maturity self-assessment result.

Dimension	Average Score		Maturity Level
	Local	Global	
Organizational Culture	33.8	11.3	Novice
RM Processes	15.0	5.0	Naïve
RM Resources	4.8	1.6	Naïve
RM Implementation	21.7	7.2	Naïve

5. Conclusions

A self-assessment tool to measure the RM maturity level of a construction public client organization was presented. It consisted of four dimensions and 34 attributes. This paper highlights that the RM maturity level is not merely about formal and standardized systems but rather about organizational culture and human factors. Top management commitment, integrity and ethics, and change management capability are found to be fundamental attributes for RM maturity, later followed by allocated budget and risk-based decision making.

The development of this tool should lead to a better understanding of key attributes with respect to RM maturity for public client organizations, at least for the context of Indonesia, and allow decision makers to identify critical areas needing urgent improvement. The applicability and usefulness of the tool has been reported; however, to draw a meaningful conclusion, it must be tested with a greater number of respondents. Once it has been validated, it can be used for large-scale applications. At time of writing this paper, research in this direction is still on-going.

Acknowledgements

The authors wish to thank all the respondents who participated in this study.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Neural network for the standard unit price of the building area

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Abstract

The standard unit price in guidance book, which has been used to set allocation the government budget especially in Aceh, need to be reviewed in regularly. Review will be performed by comparing the standard unit price of building area toward the contractual unit price. The aim of research is to develop model of the standard unit price of the building area using Artificial Neural Network (ANN), and review the standard based on the variables that influence it, namely inflation, interest rates, construction cost index. The variables are not completely free but mutually interact between one against another, so that the regression model is not accurate enough to estimate the standard unit price. ANN, which have ability to find the unique pattern through learning process and visualize in learning curve, will be anticipated to solve the case. Data of 161 contractual of the state buildings were have collected. Result of review the standard unit price of the building area in the guidance book showed 57.69% of the data is not normal. The standard needs to be amended with average correction of -23.74%. The model estimating the standard unit price has been generated at MSE learning 0.000336 and MSE validation at 0.008974.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: Standard unit price; HSBGN guidance; building area; inflation; exchange rate; CCI; neural network; Indonesia; Aceh

1. Introduction

Budget is one aspect of planning in management functions, both in business and public sector organizations, including the government. Budget is an important part of the activities that should be done regularly, which was prepared to follow principles, namely accuracy, accountability, transparency, efficiency, and effectiveness. All of these principles must be compiled with the project performance approach.

The Budgeting mechanism for the development in every district in Aceh province is set in the guidance book for the standard unit price of building the state, which is also known as HSBGN. Budgetary costs for each building will

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

vary, which is formulated as a multiplication of building area (in m2), the standard unit price (in IDR) and index of the building. The method is also known as a parametric method. Index of the building is a set value based on the number of levels, location (classified according to districts), classification, and type of building.

The standard unit price (in IDR) needs to be reviewed regularly on every year to adjust on contractual data that ever undertaken. The review will be done due to there is some variables that influence the contract price, of course will vary depending on the index of inflation, currency exchange rates (exchange rate), CCI (Construction cost index) which is geographical characteristics.

Breakdown of the research aims are developing the model of standard unit price based on floor area of the building using Artificial Neural Network (ANN); and making the review to the ANN outputs which are outputs of the model.

The traditional method of cost estimation the parametric which uses regression analysis would not provide an accurate solution to the expected results, this could be caused by the independent variables used which are not fully independent, these variables affect each other (the interaction of independent variables), such as between inflation and the exchange rate, as well as CCI index. Disadvantage of the techniques is that the mathematical model should be defined before any analysis can be performed [1]. Use of Artificial Neural Network to estimate costs on a number of highway projects, it may provide greater accuracy and stability [2]. The project also has become one of the object of study the estimated costs of Artificial Neural Network model, which estimates reported results also show the tendency of high accuracy [3].

An Eligible Model to estimate the standard unit price of the building area has successfully formulated at MSE learning 0.000336 and MSE validation at 0.008974. Result of review the standard unit price of the building area in the guidance book showed 57.69% of the data is not normal. The standard needs to be amended with average correction of -23.74%. The detailed as shown in table 1 in column 16.

2. Literature Review

2.1. The Standard Unit Price and Construction Cost Index (CCI)

The standard unit price of the building area is the standard rate per unit area of the building used as a variable to estimate the cost of construction of the building at the conceptual stage. The calculation of the cost estimation of construction for the buildings is calculated by multiplying of the building area and the standard unit price that is generated base on the only driver variable of CCI [4].

These estimations are based on a prorated from previous projects that have a similarity in terms of the scope and number, and also still without the availability of data detail engineering complete, with the accuracy of the cost estimate is $\pm$ 15%. The accuracy of the estimation is largely determined by the availability of information in the form of a pattern of relationships estimated costs or the cost model the cost-quantity relationship (cost-quantity) as the learning curve [5].

Construction Cost Index (CCI) is the index that describes the rate of the construction cost that is compared between districts to level of the national average. The CCI is as a proxy to illustrate level of the difficulty to the geographical region, thus the more difficult to the geographical project area will be higher the CCI value [4].

2.2. Principles of Neural Network

Principles of neural network are network principle raised from the series of inputs multiplied by a factor of weights for each the analog synapses, and then summed all of these inputs to determine the level of activation of neurons [6, 7, 8]. By taking the idea from the neural of human, the components of the artificial neural networks are:

1. *Artificial Neurons* are composed by basic units processing, which are the processing elements in the network and all the calculations are done here.
2. *Layers* are composed by a collection of neurons related and grouped in layers. There are three layers, namely: the input layers, hidden layers, and output layers.

3. *Input* can only process data input of numeric data. Therefore, when the problem involves qualitative data such as graphics, image, or voice signals, the data must be transformed first into the equivalent numeric data before they can be processed by ANN.
4. *Outputs are* the solution to the problem. Output data are numeric data.
5. *Weights* are stating the level of intelligence of the system. Although actual weights are just the series of numbers only, weights are very important for ANN, where the optimal weights will allow the system translates the input data correctly and produce the desired output.

3. Method

Problem solving estimate the standard unit price is done in stages as follows:

1. Examining the standard unit price of building area, and will be compared to the contractual. The standard unit price is considered normal if it is still in the range of -15% to +15% of the contractual value [5]. Examining the difference in this research will refer to the research conducted by FACHRURRAZI (2016) [4].
2. Designing ANN model is using *MATLAB* for the settlement of these problems, as shown in Fig 3 and Fig 4.
3. Perform the learning process of the ANN model against actual data 156, success is measured by MSE.
4. Testing the model validation based on simulation models to 15 set data.
5. Reviewing the standard unit price of the building area, and will compared to the output ANN models.

Based on the conditions an analysis of the standard unit price (Y) that will be model based on three variables, namely the inflation (*x1*), exchange rates (*x2*), and Construction cost index (*x3*). The variables are not completely free but they are interacted each other, such as between the inflation (*x1*) and exchange rate (*x2*), as well as for variable CCI (*x3*). With regard to the variable conditions, it will be very suitable for the ANN.

3.1. Framework of Artificial Neural Network (ANN)

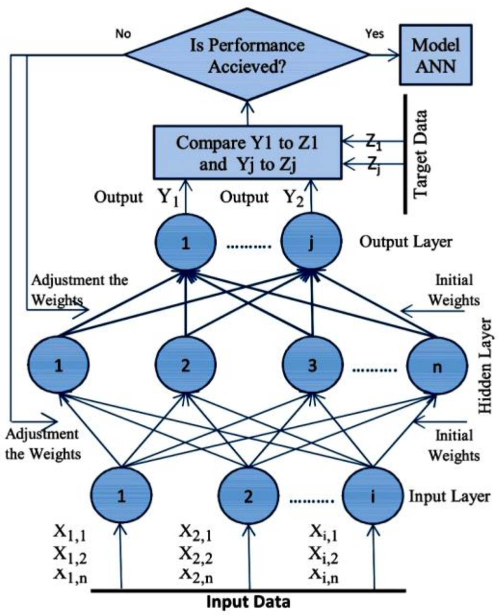

Fig 1 Framework ANN Algorithm with the supervised learning

Artificial Neural Network (ANN) algorithm has ability to solve a problem with the dynamic characteristics of the variables, and it is able to find the patterns through a learning process, which can be visualized in the form of a learning curve. Here is presented the framework of ANN for the model building process of the standard unit price, as shown in Fig 3.

The accuracy of ANN in analyzing problems estimations has been conducted by Li (1996) which concluded two things, "*comparing the performance of ANNs is better than the regression method and to identify the effects of difference configurations of neural networks on the accuracy of the estimation*" [9].

Input data are inflation index (*x1*), exchange rate (*x2*), and CCI (*x3*), the examples data as shown in table 1 in column (9). Output result is the standard unit price of the building area as the independent variable (*Y*) , that produce by ANN model, the output result as shown in table 1 column (12). Target data are the contractual unit price from the actual implementation project in province of Aceh, as shown in table 1 on column 3. The performance of the model is measured by Mean square error (MSE) which consists of MSE learning and MSE validation of results.

4. Result

4.1. Examine the existing standard unit price in the guidance

FACHRURRAZI (2016) that state "*the difference between the standard unit price and the contractual unit price is a normal distribution and has average value of 373,500 (in IDR) or 16.4% (in excess of the tolerance accuracy of ± 15%)*," [4], as shown in Fig 2. The average is outside the interval for the accuracy of cost estimates to ± 15% [5]. Based on the assessment, so it is necessary to review the standard unit price for the guidance book known as HSBGN, it also can be seen that 57.69% of the total data is not normal. On the contrary, a number of 42.31% data are summarized in normal, as shown in table 1, column (6), (7), (8). The formula is used to the assessment the standard unit price:

$$The\ differences\ of\ standard\ to\ the\ contract\ data = \frac{the\ contract\ data - the\ standard}{the\ standard} * 100\% \qquad (1)$$

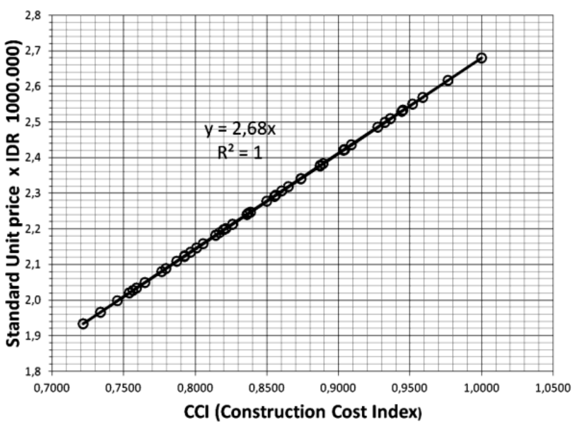

Fig 2 Correlation of the standard unit price (in guidance) and CCI [5]

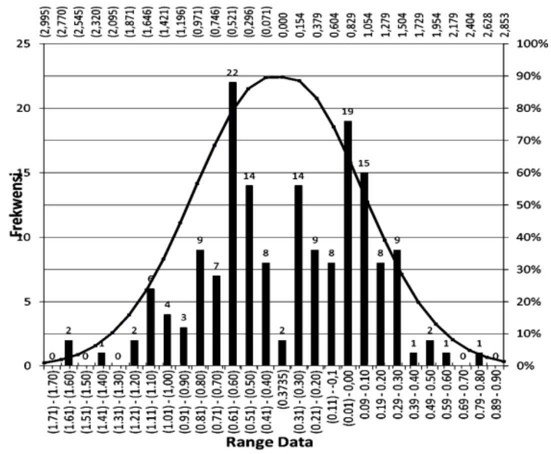

Fig 3 Normal Curve for the difference between the contractual unit price and the standard unit price (in guidance) [5]

In addition, CCI is the only driver variable to calculate the standard unit price for state building [4], as shown in Fig 1. On the certainly conditions do not fit anymore due to the inflation index (*x1*) and exchange rate (*x2*) that have also triggered the value of the contracts which were executed by the contractor.

4.2. Designing of the ANN Architecture

The architecture of the ANN will greatly affect the outcome of the research. In the last decades, the design of the architecture of ANN is directed to the acceleration in resolving problems [10, 11, 12]. Solving problems of cases the standard unit price are done by using a neural network approach to supervised learning mechanism. The algorithm used to apply the neural network is a back propagation algorithm with feed forward, where this model is suitable to solve the problems of the construction cost estimation [13, 14].

Constructing a model of ANN will be started by defining their objects using software of MATLAB [7], which consists of one input layer with three input size, two hidden layers and one output layer. The sizes of the nodes in each layer respectively are 3, 20, 1, and 1 node. Detail the object of layers and nodes of ANN as shown in Fig 4.

The description of Neural Network object:

architecture:	
Number Inputs:	1
Number Inputs size:	3
Number Layers:	2
Number Layer size:	20
Biases Connect:	[1; 1]
Input Connect:	[1; 0]
Layer Connect:	[0 0; 1 0]
Output Connect:	[0 1]
Target Connect:	[0 1]
Number Outputs:	1 (read-only)
Number Targets:	1 (read-only)
Number Input Delays:	0 (read-only)
Number Layer Delays:	0 (read-only)
Sub object structures:	
Inputs:	{1x1 cell} of inputs
Layers:	{2x1 cell} of layers
Outputs:	{1x2 cell} containing 1 output
Targets:	{1x2 cell} containing 1 target
Biases:	{2x1 cell} containing 2 biases
Input Weights:	{2x1 cell}
Layer Weights:	{2x2 cell}
functions:	
Adapt Function:	'trains'
Init Function:	'initlay' (Initial weights, biases)
Performance Function:	'mse' (mean square error)
Train Function:	'trainlm' (back propagation Algorithm Levenberg-Marquardt)
parameters:	
Adapt Parameter:	.passes
Init Parameter:	(none)
Perform Parameter:	(none)
Train Parameter:	.epochs:6000, .goal:1e^{-4}, .max_fail:1, .mem_reduc:1, .min_grad:1e-10, .mu:0.001, .mu_dec:0.1, .mu_inc:10, .mu_max:1e^{+10}, .show, .time: inf.
weight and bias	**values:**
IW (Input Weights):	{2x1 cell} 1 input weight matrix
LW (Layer Weights):	{2x2 cell} 1 layer weight matrix
B (Biases Weights):	{2x1 cell} 2 biases vectors
other: User data	(user stuff)

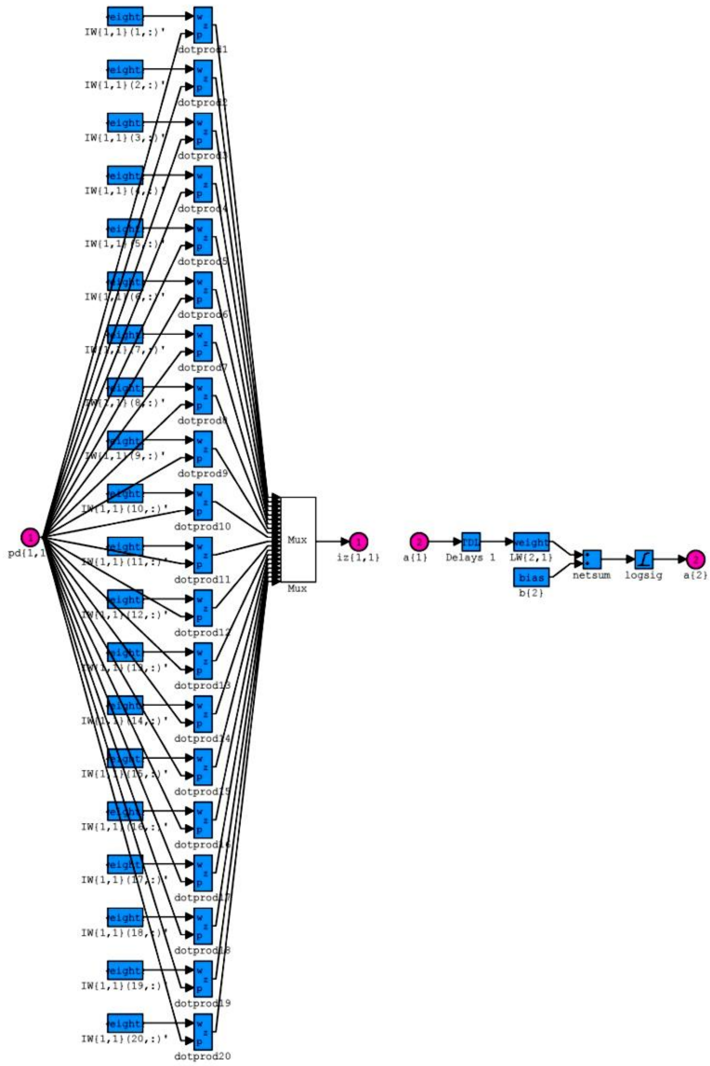

Fig 4 Architecture of Artificial Neural Network (ANN)

4.3. Learning Process of the ANN

4.3.1 The learning output of ANN

The steps of constructing of the ANN model have been completed, the next step is the learning of ANN model with the purpose in order the model can be applied on the real case of the standard unit price estimate of the building area. The data used for learning ANN are Inflation index (*x1*), Exchange rate (*x2*), and CCI (*x3*), where learning will be supervised using data from the contractual unit price as the target (*T*). The results of the learning on the ANN model are shown in Table 1 in column (13) and the errors of the model are shown in columns (14), (15).

The outputs of the ANN model are 136 data that are considered normal (the result is among -15% until + 15% of the target data), and 20 data is considered to be out of normal (the result have less than -15% and more than 15%). Overall, the outputs of the learning are done successfully. The success rate is 87.18% of the total data (i.e. 136/165), as shown in table 1 on the column 15. The formula is used to the assessment the output of the ANN model:

$$The\ differences\ of\ ANN\ output\ to\ the\ target = \frac{the\ target\ data - the\ ANN\ output}{the\ target\ data} * 100\% \qquad (2)$$

$$Review\ the\ ANN\ output\ as\ the\ standard\ unit\ price = \frac{the\ ANN\ output - the\ standard}{the\ ANN\ output} * 100\% \qquad (3)$$

Table 1: The Learning assessment of the ANN model for the standard unit price

MUNICIPAL	PROJECT CODE	YEAR	ASSESSEMENT OF THE STANDARD UNIT PRICE						LEARNING OF ANN MODEL							REVIEW
			UNIT PRICE						VARIABLE - X			VARIABLE - Y		THE DIFFERENCE OF ANN OUTPUT AND TARGET (CONTRACTUAL) (ERROR OF MODELS)		THE ANN OUTPUTS AS THE STANDARD UNIT PRICE
			CONTRACT DATA	STANDARD	DIFFER ENCES	THE ASSESSMENTS OF THE STANDARD UNIT PRICE TO THE CONTRACTUAL			INFLA TION INDEX	EXCHANGE RATE	CCI After Normalized	TARGET OF ANN	OUTPUT OF ANN			
			(IDR/m2)	(IDR/m2)	%	< -15%	-15%≤Y, Y<+15%	> +15%	*X1* (%)	*X2* (IDR)	*X3*	(IDR/m2)	(IDR/m2)	(IDR/m2)	PERCENT	PERCENT
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Sabang	P1	I	1602.98	2240	-28.44%	UNDER			9.54	10295	0.8358	1602.98	1879	-275.68	-17.20%	-19.23%
	P2	I	2033.00	2240	-9.24%		NORMAL		9.54	10295	0.8358	2033.00	1879	154.34	7.59%	-19.23%
	P3	I	2000.00	2240	-10.71%		NORMAL		9.54	10295	0.8358	2000.00	1879	121.34	6.07%	-19.23%
	P4	II	2430.70	2243	8.37%		NORMAL		11.00	9979	0.8369	2430.70	2368	63.00	2.59%	5.28%
	P5	II	2236.36	2243	-0.30%		NORMAL		11.00	9979	0.8369	2236.36	2368	-132.00	-5.90%	5.28%
	P6	II	2437.01	2243	8.65%		NORMAL		11.00	9979	0.8369	2437.01	2368	69.00	2.83%	5.28%
	P7	III	2695.76	2422	20.19%			OVER	10.27	12900	0.9037	2695.76	2535	161.33	5.98%	4.45%
	P8	III	2284.69	2422	1.86%		NORMAL		10.27	12900	0.9037	2284.69	2535	-249.67	-10.93%	4.45%
	P9	III	2622.54	2422	16.92%			OVER	10.27	12900	0.9037	2622.54	2535	88.33	3.37%	4.45%
…	P156	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
TOTAL ASSESSMENT BEFORE LEARNING						72	66	18	TOTAL ASSESSMENT AFTER LEARNING				NORMAL	**136 (87.18%)**		Average:
						46.15%	**42.31%**	**11.54%**					OUT OF NORMAL	**20 (12.82%)**		**-23.74%**

4.3.2 The performance of the ANN learning

The process of progress in learning by the ANN can be followed by observing the learning curve in Fig 1. The learning process showed a significant decrease on the charts in the early stages of learning process. This happens due to the setting of initial weights and transfer function (activation function) is suitable, furthermore the learning process gradually achieve a good performance (MSE decreased variance may be closed to zero), or in other words that the charts were flattened horizontally and stable in the epoch to 3000 up to 6000.

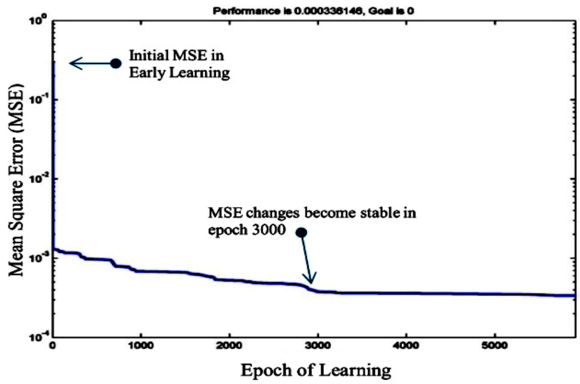

Fig 5. Learning curve of ANN

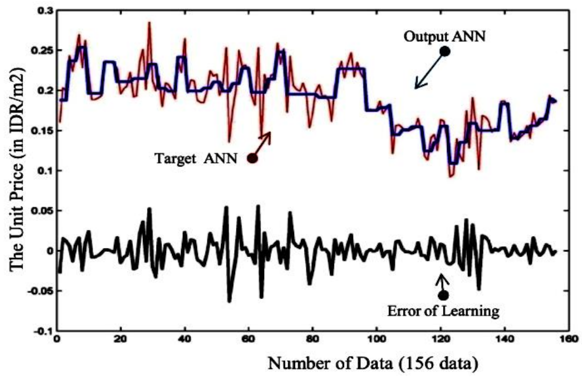

Fig 6. Plotting data of learning for Target–Output-Error

Performance of the ANN learning is achieved at the MSE learning 0.000336, as shown in Fig 5. The ability to perform tracking the target based on the input, which is known as the ability ANN to recognize the patterns, is done well. The result of plot the target is shown on the chart pattern that it is in line on the track, as shown in Fig 6. It can be concluded that, the ANN can estimate the standard unit price that is based on the contractual unit price is better. The results in the form of a simulation the ANN model on the tool of MATLAB can be used by agents of the government in projects to predict the standard unit price of the building area is based on changes of the three variables in the time series. The use of that tool will also contribute to the improved performance of the model [8].

These conditions are conformity with the opinion of PEWDUM (2009) which states that "*the forecasting results obtained from the ANN is more accurate and stable than the conventional method, in which the study presents a useful tools for construction project manager to predict the project budget end and duration*" [2]. KIM (2004), which also states that from "*the analysis of three approaches made to construction cost estimation, the best ANN gave the models more accurate estimation results than the CBR or MRA models*" [15].

4.4. The performance of the ANN Validation

The success of the learning process can also be measured by performing validation of the neural network models [6]. Based 15 sets of data to test the validation, obtained the validation MSE is equal to 0.008974, as shown in Fig 7. The overall results of the validation test are still within the error tolerance, or it can be said that the error is still in the range of ± 15%, as shown in table 2.

Table 2: The validation assessment of the ANN model for the standard unit price

DESCRIPTION		**DATA VALIDATION OF ANN MODEL**														
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**	**S13**	**S14**	**S15**
INFLATION INDEX	*X1*	0.09540	0.09540	0.09540	0.11000	0.11000	0.11000	0.11000	0.11000	0.10270	0.10270	0.10270	0.10270	0.10270	0.10270	0.10270
EXCHANGE RATE	*X2*	0.10295	0.10295	0.10295	0.09979	0.09979	0.09979	0.09979	0.09979	0.12900	0.12900	0.12900	0.12900	0.12900	0.12900	0.12900
CCI	*X3*	1.00000	1.00000	1.00000	0.73358	0.73358	0.73358	0.73358	0.73358	0.79216	0.79216	0.79216	0.79216	0.85522	0.85522	0.85522
OUTPUT OF ANN	*Y*	0.00864	0.00864	0.00864	0.19814	0.19814	0.19814	0.19814	0.19814	0.24792	0.24792	0.24792	0.24792	0.20659	0.20659	0.20659
TARGET	*T*	0.14411	0.14471	0.15299	0.14410	0.18095	0.34470	0.15622	0.27710	0.32690	0.35590	0.12599	0.34272	0.18838	0.16408	0.18836
ERROR	*E*	0.13547	0.13607	0.14435	-0.05404	-0.01719	0.14656	-0.04192	0.07896	0.07898	0.10798	-0.12193	0.09480	-0.01821	-0.04251	-0.01823
% ERROR		13.55%	13.61%	14.44%	-5.40%	-1.72%	14.66%	-4.19%	7.90%	7.90%	10.80%	-12.19%	9.48%	-1.82%	-4.25%	-1.82%
ASSESSMENT		Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
MSE validation		**0.00897**														

The pattern shows the uniform shape between the output and the target data. The visible gap (distance) between the new standard unit price (output of ANN) and contractual unit price (target of ANN) is visualization of the MSE validation. Based on the validation results, we can conclude that the neural network has been able to demonstrate the formation of the pattern of the standard unit price. Regarding to the estimated costs analysis and economic overview by using ANN have been also well done by other research, and showed excellent results [16, 17, 18].

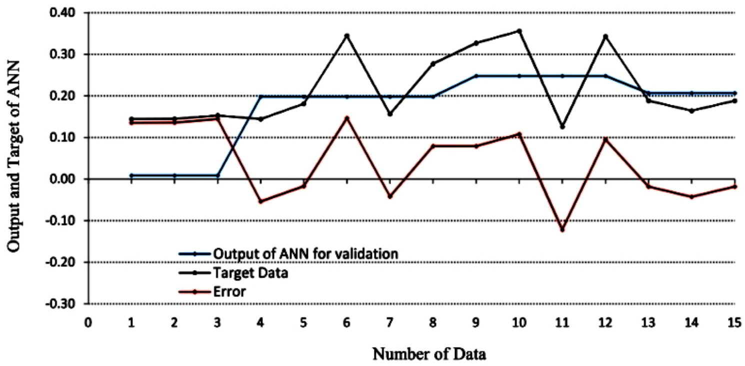

Fig 7. Plotting data of validation of ANN model

4.5. The Review the Standard Unit Price toward the ANN result

Reviewing the standard unit price in the guidance book is done by comparing the standard toward the output of ANN (the result of learning). The comparison results show some data of the standard unit price that need to be increased, and the other need to be reduced from the output of ANN (the result of learning). The overall result of review the standard unit price needs to be decreased at average -23.74%, as shown in Table 1 on the column 16.

5. Conclusion

The result of review the standard unit price of the building area in the guidance book showed 57.69% of the data is out of normal. The standard needs to be amended with average correction of -23.74%. An eligible model to estimate the standard unit price of the building area, which has been generated based on the contracts actual target (y) and three variables namely inflation index (x1), exchange rate (x2), and CCI (x3), has successfully built at MSE learning 0.000336 and MSE validation at 0.008974.

Acknowledgements

This study can be completed smoothly, due to the help and support from various parties. For that, the authors would like to thank and appreciation, in particular to: 1.) Prof. Dr. Ir. Hasanuddin M.S. Chairman of the Research Institute of the University of Syiah Kuala as funders of research with contract number 427 / UN11 / S / LK-PNBP / 2014; 2.) Staff Management Laboratory Construction Management in Civil Engineering., University of Syiah Kuala.

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Table Appendix

Table 1: The Learning assessment of the ANN model for the standard unit price

MUNICIPAL	PROJECT CODE	YEAR	ASSESSEMENT OF THE STANDARD UNIT PRICE						LEARNING OF ANN MODEL							REVIEW
			UNIT PRICE						VARIABLE - X			VARIABLE - Y		THE DIFFERENCE OF ANN OUTPUT AND TARGET (CONTRACTUAL) (ERROR OF MODELS)		THE ANN OUTPUTS AS THE STANDARD UNIT PRICE
			CONTRACT DATA	STANDARD	DIFFER ENCE	THE ASSESSMENT OF THE STANDARD UNIT PRICE TO THE CONTRACTUAL			INFLA TION INDEX	EXCHANGE RATE	CCI After Normalized	TARGET OF ANN	OUTPUT OF ANN			
			(IDR/m2)	(IDR/m2)	%	< -15%	-15%≤Y, Y<+15%	> +15%	*X1* (%)	*X2* (IDR)	*X3*	(IDR/m2)	(IDR/m2)	(IDR/m2)	%	%
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Sabang	P1	I	1602.98	2240	-28.44%	UNDER			9.54	10295	0.8358	1602.98	1879	-275.68	-17.20%	-19.23%
	P2	I	2033.00	2240	-9.24%		NORMAL		9.54	10295	0.8358	2033.00	1879	154.34	7.59%	-19.23%
	P3	I	2000.00	2240	-10.71%		NORMAL		9.54	10295	0.8358	2000.00	1879	121.34	6.07%	-19.23%
	P4	II	2430.70	2243	8.37%		NORMAL		11.00	9979	0.8369	2430.70	2368	63.00	2.59%	5.28%
	P5	II	2236.36	2243	-0.30%		NORMAL		11.00	9979	0.8369	2236.36	2368	-132.00	-5.90%	5.28%
	P6	II	2437.01	2243	8.65%		NORMAL		11.00	9979	0.8369	2437.01	2368	69.00	2.83%	5.28%
	P7	III	2695.76	2422	20.19%			OVER	10.27	12900	0.9037	2695.76	2535	161.33	5.98%	4.45%
	P8	III	2284.69	2422	1.86%		NORMAL		10.27	12900	0.9037	2284.69	2535	-249.67	-10.93%	4.45%
	P9	III	2622.54	2422	16.92%			OVER	10.27	12900	0.9037	2622.54	2535	88.33	3.37%	4.45%
Banda Aceh	P10	II	2206.06	1966	12.21%		NORMAL		11.00	9979	0.7336	2206.06	1963	242.80	11.01%	-0.14%
	P11	II	1883.83	1966	-4.18%		NORMAL		11.00	9979	0.7336	1883.83	1963	-79.20	-4.20%	-0.14%
	P12	II	1887.01	1966	-4.02%		NORMAL		11.00	9979	0.7336	1887.01	1963	-76.20	-4.04%	-0.14%
	P13	II	1903.52	1966	-3.18%		NORMAL		11.00	9979	0.7336	1903.52	1963	-59.20	-3.11%	-0.14%
	P14	II	1935.48	1966	-1.55%		NORMAL		11.00	9979	0.7336	1935.48	1963	-28.20	-1.46%	-0.14%
	P15	III	2364.33	2123	20.26%			OVER	10.27	12900	0.7922	2364.33	2352	12.00	0.51%	9.74%
	P16	III	2362.89	2123	20.19%			OVER	10.27	12900	0.7922	2362.89	2352	11.00	0.47%	9.74%
	P17	III	2352.12	2123	19.64%			OVER	10.27	12900	0.7922	2352.12	2352	0.00	0.00%	9.74%
	P18	III	2328.54	2123	18.44%			OVER	10.27	12900	0.7922	2328.54	2352	-23.00	-0.99%	9.74%
Aceh Besar	P19	I	2272.87	2292	-0.83%		NORMAL		9.54	10295	0.8552	2272.87	2106	167.00	7.35%	-8.83%
	P20	I	1956.35	2292	-14.64%		NORMAL		9.54	10295	0.8552	1956.35	2106	-150.00	-7.67%	-8.83%
	P21	I	2025.40	2292	-11.63%		NORMAL		9.54	10295	0.8552	2025.40	2106	-81.00	-4.00%	-8.83%
	P22	I	2051.03	2292	-10.51%		NORMAL		9.54	10295	0.8552	2051.03	2106	-55.00	-2.68%	-8.83%
	P23	I	2225.17	2292	-2.92%		NORMAL		9.54	10295	0.8552	2225.17	2106	119.00	5.35%	-8.83%
	P24	II	1920.42	1934	-0.70%		NORMAL		11.00	9979	0.7216	1920.42	2148	-227.60	-11.85%	9.95%
	P25	II	1933.06	1934	-0.05%		NORMAL		11.00	9979	0.7216	1933.06	2148	-214.60	-11.10%	9.95%
	P26	II	2360.11	1934	22.03%			OVER	11.00	9979	0.7216	2360.11	2148	212.40	9.00%	9.95%
	P27	II	2509.66	1934	29.77%			OVER	11.00	9979	0.7216	2509.66	2148	362.40	14.44%	9.95%
	P28	II	2015.40	1934	4.21%		NORMAL		11.00	9979	0.7216	2015.40	2148	-132.60	-6.58%	9.95%
	P29	III	2850.00	2089	47.36%			OVER	10.27	12900	0.7795	2850.00	2324	525.67	18.44%	10.12%
	P30	III	2127.25	2089	9.99%		NORMAL		10.27	12900	0.7795	2127.25	2324	-197.33	-9.28%	10.12%
	P31	III	1996.19	2089	3.22%		NORMAL		10.27	12900	0.7795	1996.19	2324	-328.33	-16.45%	10.12%

MUNICIPAL	PROJECT CODE	YEAR	ASSESSEMENT OF THE STANDARD UNIT PRICE						LEARNING OF ANN MODEL							REVIEW
			UNIT PRICE						VARIABLE - X			VARIABLE - Y		THE DIFFERENCE OF ANN OUTPUT AND TARGET (CONTRACTUAL) (ERROR OF MODELS)		THE ANN OUTPUTS AS THE STANDARD UNIT PRICE
			CONTRACT DATA	STANDARD	DIFFER ENCE	THE ASSESSMENT OF THE STANDARD UNIT PRICE TO THE CONTRACTUAL			INFLA TION INDEX	EXCHANGE RATE	CCI After Normalized	TARGET OF ANN	OUTPUT OF ANN			
			(IDR/m2)	(IDR/m2)	%	< -15%	-15%≤Y, Y<+15%	> +15%	*X1* (%)	*X2* (IDR)	*X3*	(IDR/m2)	(IDR/m2)	(IDR/m2)	%	%
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Pidie	P32	I	2176.67	2421	-10.09%		NORMAL		9.54	10295	0.9034	2176.67	2024	152.67	7.01%	-19.60%
	P33	I	1800.00	2421	-25.65%	UNDER			9.54	10295	0.9034	1800.00	2024	-224.33	-12.46%	-19.60%
	P34	I	2096.12	2421	-13.42%		NORMAL		9.54	10295	0.9034	2096.12	2024	71.67	3.42%	-19.60%
	P35	II	2075.19	2034	2.02%		NORMAL		11.00	9979	0.7590	2075.19	1990	84.67	4.08%	-2.20%
	P36	II	2002.83	2034	-1.53%		NORMAL		11.00	9979	0.7590	2002.83	1990	12.67	0.63%	-2.20%
	P37	II	1892.96	2034	-6.93%		NORMAL		11.00	9979	0.7590	1892.96	1990	-97.33	-5.14%	-2.20%
	P38	III	2373.05	2197	16.67%			OVER	10.27	12900	0.8198	2373.05	2414	-41.33	-1.74%	9.00%
	P39	III	2224.56	2197	9.37%		NORMAL		10.27	12900	0.8198	2224.56	2414	-189.33	-8.51%	9.00%
	P40	III	2645.35	2197	30.06%			OVER	10.27	12900	0.8198	2645.35	2414	230.67	8.72%	9.00%
Bireuen	P41	I	1972.42	2499	-21.07%	UNDER			9.54	10295	0.9325	1972.42	1991	-19.20	-0.97%	-25.50%
	P42	I	2131.64	2499	-14.70%		NORMAL		9.54	10295	0.9325	2131.64	1991	140.80	6.61%	-25.50%
	P43	I	2119.06	2499	-15.20%	UNDER			9.54	10295	0.9325	2119.06	1991	127.80	6.03%	-25.50%
	P44	I	1881.22	2499	-24.72%	UNDER			9.54	10295	0.9325	1881.22	1991	-110.20	-5.86%	-25.50%
	P45	I	1851.67	2499	-25.90%	UNDER			9.54	10295	0.9325	1851.67	1991	-139.20	-7.52%	-25.50%
	P46	II	1846.25	2124	-13.08%		NORMAL		11.00	9979	0.7925	1846.25	2029	-182.67	-9.89%	-4.70%
	P47	II	1993.92	2124	-6.12%		NORMAL		11.00	9979	0.7925	1993.92	2029	-34.67	-1.74%	-4.70%
	P48	II	2245.93	2124	5.74%		NORMAL		11.00	9979	0.7925	2245.93	2029	217.33	9.68%	-4.70%
	P49	III	2177.43	2294	2.52%		NORMAL		10.27	12900	0.8560	2177.43	2105	71.67	3.29%	-8.96%
	P50	III	2202.00	2294	3.67%		NORMAL		10.27	12900	0.8560	2202.00	2105	96.67	4.39%	-8.96%
	P51	III	1936.77	2294	-8.81%		NORMAL		10.27	12900	0.8560	1936.77	2105	-168.33	-8.69%	-8.96%
Lhokseumawe	P52	I	2078.32	2530	-17.85%	UNDER			9.54	10295	0.9440	2078.32	1989	89.33	4.30%	-27.22%
	P53	I	2533.33	2530	0.13%		NORMAL		9.54	10295	0.9440	2533.33	1989	544.33	21.49%	-27.22%
	P54	I	1355.08	2530	-46.44%	UNDER			9.54	10295	0.9440	1355.08	1989	-633.67	-46.76%	-27.22%
	P55	II	1748.91	2135	-18.08%	UNDER			11.00	9979	0.7966	1748.91	2086	-336.67	-19.25%	-2.36%
	P56	II	2008.20	2135	-5.94%		NORMAL		11.00	9979	0.7966	2008.20	2086	-77.67	-3.87%	-2.36%
	P57	II	2500.00	2135	17.10%			OVER	11.00	9979	0.7966	2500.00	2086	414.33	16.57%	-2.36%
	P58	III	2291.66	2306	7.34%		NORMAL		10.27	12900	0.8604	2291.66	2276	16.00	0.70%	-1.32%
	P59	III	2319.17	2306	8.63%		NORMAL		10.27	12900	0.8604	2319.17	2276	43.00	1.85%	-1.32%
	P60	III	2216.97	2306	3.84%		NORMAL		10.27	12900	0.8604	2216.97	2276	-59.00	-2.66%	-1.32%
Aceh Utara	P61	I	1931.79	2533	-23.74%	UNDER			9.54	10295	0.9451	1931.79	1975	-42.80	-2.22%	-28.27%
	P62	I	1815.00	2533	-28.35%	UNDER			9.54	10295	0.9451	1815.00	1975	-159.80	-8.80%	-28.27%
	P63	I	2533.19	2533	0.01%		NORMAL		9.54	10295	0.9451	2533.19	1975	558.20	22.04%	-28.27%
	P64	I	1394.88	2533	-44.93%	UNDER			9.54	10295	0.9451	1394.88	1975	-579.80	-41.57%	-28.27%
	P65	I	2199.11	2533	-13.18%		NORMAL		9.54	10295	0.9451	2199.11	1975	224.20	10.20%	-28.27%
	P66	II	2024.88	2146	-5.64%		NORMAL		11.00	9979	0.8007	2024.88	2139	-114.00	-5.63%	-0.33%
	P67	II	2185.37	2146	1.83%		NORMAL		11.00	9979	0.8007	2185.37	2139	46.00	2.10%	-0.33%
	P68	II	2207.25	2146	2.85%		NORMAL		11.00	9979	0.8007	2207.25	2139	68.00	3.08%	-0.33%
	P69	III	2591.30	2318	20.75%			OVER	10.27	12900	0.8649	2591.30	2477	114.00	4.40%	6.42%
	P70	III	2323.90	2318	8.29%		NORMAL		10.27	12900	0.8649	2323.90	2477	-153.00	-6.58%	6.42%
	P71	III	2516.14	2318	17.25%			OVER	10.27	12900	0.8649	2516.14	2477	39.00	1.55%	6.42%
Aceh Timur	P72	I	1728.99	2341	-26.14%	UNDER			9.54	10295	0.8735	1728.99	1953	-223.50	-12.93%	-19.90%
	P73	I	2429.38	2341	3.78%		NORMAL		9.54	10295	0.8735	2429.38	1953	476.50	19.61%	-19.90%
	P74	I	2061.08	2341	-11.96%		NORMAL		9.54	10295	0.8735	2061.08	1953	108.50	5.26%	-19.90%
	P75	I	2013.64	2341	-13.98%		NORMAL		9.54	10295	0.8735	2013.64	1953	61.50	3.05%	-19.90%
	P76	I	1990.01	2341	-14.99%		NORMAL		9.54	10295	0.8735	1990.01	1953	37.50	1.88%	-19.90%
	P77	I	2090.60	2341	-10.70%		NORMAL		9.54	10295	0.8735	2090.60	1953	138.50	6.62%	-19.90%
	P78	I	1981.57	2341	-15.35%	UNDER			9.54	10295	0.8735	1981.57	1953	29.50	1.49%	-19.90%
	P79	I	1536.04	2341	-34.39%	UNDER			9.54	10295	0.8735	1536.04	1953	-416.50	-27.12%	-19.90%
	P80	I	1710.00	2341	-26.95%	UNDER			9.54	10295	0.8735	1710.00	1953	-242.50	-14.18%	-19.90%
	P81	I	1982.64	2341	-15.31%	UNDER			9.54	10295	0.8735	1982.64	1953	30.50	1.54%	-19.90%
	P82	II	2071.16	2020	2.53%		NORMAL		11.00	10295	0.7537	2071.16	1912	159.00	7.68%	-5.65%
	P83	II	1924.42	2020	-4.73%		NORMAL		11.00	10295	0.7537	1924.42	1912	12.00	0.62%	-5.65%
	P84	II	1934.43	2020	-4.24%		NORMAL		11.00	10295	0.7537	1934.43	1912	22.00	1.14%	-5.65%
	P85	II	1876.97	2020	-7.08%		NORMAL		11.00	10295	0.7537	1876.97	1912	-35.00	-1.86%	-5.65%
	P86	II	1613.87	2020	-20.11%	UNDER			11.00	10295	0.7537	1613.87	1912	-298.00	-18.46%	-5.65%
	P87	III	2052.46	2020	1.61%		NORMAL		11.00	10295	0.7537	2052.46	1912	140.00	6.82%	-5.65%
	P88	III	2226.28	2182	10.21%		NORMAL		10.27	12900	0.8142	2226.28	2269	-42.56	-1.91%	3.82%
	P89	III	2361.69	2182	16.92%			OVER	10.27	12900	0.8142	2361.69	2269	93.44	3.96%	3.82%
	P90	III	2157.03	2182	6.78%		NORMAL		10.27	12900	0.8142	2157.03	2269	-111.56	-5.17%	3.82%
	P91	III	2326.94	2182	15.20%			OVER	10.27	12900	0.8142	2326.94	2269	58.44	2.51%	3.82%
	P92	III	2470.00	2182	22.28%			OVER	10.27	12900	0.8142	2470.00	2269	201.44	8.16%	3.82%
	P93	III	2169.23	2182	7.39%		NORMAL		10.27	12900	0.8142	2169.23	2269	-99.56	-4.59%	3.82%
	P94	III	2351.30	2182	16.40%			OVER	10.27	12900	0.8142	2351.30	2269	82.44	3.51%	3.82%
	P95	III	2213.17	2182	9.56%		NORMAL		10.27	12900	0.8142	2213.17	2269	-55.56	-2.51%	3.82%
	P96	III	2141.67	2182	6.02%		NORMAL		10.27	12900	0.8142	2141.67	2269	-126.56	-5.91%	3.82%
Aceh Jaya	P97	I	1739.02	2378	-26.87%	UNDER			9.54	10295	0.8873	1739.02	1750	-11.25	-0.65%	-35.86%
	P98	I	1766.25	2378	-25.73%	UNDER			9.54	10295	0.8873	1766.25	1750	15.75	0.89%	-35.86%
	P99	I	1741.16	2378	-26.78%	UNDER			9.54	10295	0.8873	1741.16	1750	-9.25	-0.53%	-35.86%
	P100	I	1755.44	2378	-26.18%	UNDER			9.54	10295	0.8873	1755.44	1750	4.75	0.27%	-35.86%
	P101	II	1866.77	2027	-7.90%		NORMAL		11.00	9979	0.7563	1866.77	1782	85.33	4.57%	-13.77%
	P102	II	1707.94	2027	-15.74%	UNDER			11.00	9979	0.7563	1707.94	1782	-73.67	-4.31%	-13.77%
	P103	II	1769.88	2027	-12.68%		NORMAL		11.00	9979	0.7563	1769.88	1782	-11.67	-0.66%	-13.77%
	P104	III	1816.98	2189	-10.36%		NORMAL		10.27	12900	0.8168	1816.98	1817	0.00	0.00%	-20.47%

MUNICIPAL	PROJECT CODE	YEAR	ASSESSEMENT OF THE STANDARD UNIT PRICE						LEARNING OF ANN MODEL							REVIEW
			UNIT PRICE						VARIABLE - X			VARIABLE - Y				
			CONTRACT DATA	STANDARD	DIFFER ENCE	THE ASSESSMENT OF THE STANDARD UNIT PRICE TO THE CONTRACTUAL			INFLA TION INDEX	EXCHANGE RATE	CCI After Normalized	TARGET OF ANN	OUTPUT OF ANN	THE DIFFERENCE OF ANN OUTPUT AND TARGET (CONTRACTUAL) (ERROR OF MODELS)		THE ANN OUTPUTS AS THE STANDARD UNIT PRICE
			(IDR/m2)	(IDR/m2)	%	< -15%	-15%≤Y, Y<+15%	> +15%	*X1* (%)	*X2* (IDR)	*X3*	(IDR/m2)	(IDR/m2)	(IDR/m2)	%	%
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
Aceh Barat	P105	I	1212.79	2436	-50.21%	UNDER			9.54	10295	0.9090	1212.79	1448	-234.67	-19.35%	-68.27%
	P106	I	1558.06	2436	-36.04%	UNDER			9.54	10295	0.9090	1558.06	1448	110.33	7.08%	-68.27%
	P107	I	1571.60	2436	-35.48%	UNDER			9.54	10295	0.9090	1571.60	1448	124.33	7.91%	-68.27%
	P108	II	1533.67	2049	-25.15%	UNDER			11.00	9979	0.7646	1533.67	1508	26.00	1.70%	-35.88%
	P109	II	1493.71	2049	-27.10%	UNDER			11.00	9979	0.7646	1493.71	1508	-14.00	-0.94%	-35.88%
	P110	II	1496.43	2049	-26.97%	UNDER			11.00	9979	0.7646	1496.43	1508	-12.00	-0.80%	-35.88%
	P111	III	1515.35	2213	-26.04%	UNDER			10.27	12900	0.8257	1515.35	1545	-29.75	-1.96%	-43.26%
	P112	III	1531.25	2213	-25.27%	UNDER			10.27	12900	0.8257	1531.25	1545	-13.75	-0.90%	-43.26%
	P113	III	1648.26	2213	-19.56%	UNDER			10.27	12900	0.8257	1648.26	1545	103.25	6.26%	-43.26%
	P114	III	1484.51	2213	-27.55%	UNDER			10.27	12900	0.8257	1484.51	1545	-59.75	-4.02%	-43.26%
Nagan Raya	P115	I	1183.59	2383	-50.33%	UNDER			9.54	10295	0.8892	1183.59	1242	-58.33	-4.93%	-91.82%
	P116	I	1131.47	2383	-52.52%	UNDER			9.54	10295	0.8892	1131.47	1242	-111.33	-9.84%	-91.82%
	P117	I	1412.49	2383	-40.73%	UNDER			9.54	10295	0.8892	1412.49	1242	169.67	12.01%	-91.82%
	P118	II	1451.10	1998	-27.37%	UNDER			11.00	9979	0.7455	1451.10	1352	99.50	6.86%	-47.84%
	P119	II	1251.51	1998	-37.36%	UNDER			11.00	9979	0.7455	1251.51	1352	-99.50	-7.95%	-47.84%
	P120	III	1637.91	2158	-18.02%	UNDER			10.27	12900	0.8052	1637.91	1552	85.67	5.23%	-39.02%
	P121	III	1616.92	2158	-19.07%	UNDER			10.27	12900	0.8052	1616.92	1552	64.67	4.00%	-39.02%
	P122	III	1402.13	2158	-29.82%	UNDER			10.27	12900	0.8052	1402.13	1552	-150.33	-10.72%	-39.02%
Aceh Barat Daya	P123	I	920.81	2570	-64.17%	UNDER			9.54	10295	0.9590	920.81	1090	-169.33	-18.39%	-135.71%
	P124	I	953.27	2570	-62.91%	UNDER			9.54	10295	0.9590	953.27	1090	-137.33	-14.41%	-135.71%
	P125	I	1396.89	2570	-45.65%	UNDER			9.54	10295	0.9590	1396.89	1090	306.67	21.95%	-135.71%
	P126	II	1196.57	2201	-45.64%	UNDER			11.00	9979	0.8213	1196.57	1352	-155.33	-12.98%	-62.76%
	P127	II	1114.30	2201	-49.37%	UNDER			11.00	9979	0.8213	1114.30	1352	-238.33	-21.39%	-62.76%
	P128	II	1746.03	2201	-20.67%	UNDER			11.00	9979	0.8213	1746.03	1352	393.67	22.55%	-62.76%
	P129	III	1281.42	2377	-41.78%	UNDER			10.27	12900	0.8869	1281.42	1588	-306.67	-23.93%	-49.71%
	P130	III	1911.29	2377	-13.16%		NORMAL		10.27	12900	0.8869	1911.29	1588	323.33	16.92%	-49.71%
	P131	III	1570.69	2377	-28.64%	UNDER			10.27	12900	0.8869	1570.69	1588	-16.67	-1.06%	-49.71%
Aceh Selatan	P132	I	1013.65	2509	-59.60%	UNDER			9.54	10295	0.9362	1013.65	1497	-482.50	-47.60%	-67.66%
	P133	I	1686.08	2509	-32.80%	UNDER			9.54	10295	0.9362	1686.08	1497	189.50	11.24%	-67.66%
	P134	I	1667.35	2509	-33.55%	UNDER			9.54	10295	0.9362	1667.35	1497	170.50	10.23%	-67.66%
	P135	I	1619.23	2509	-35.46%	UNDER			9.54	10295	0.9362	1619.23	1497	122.50	7.57%	-67.66%
	P136	II	1480.96	2109	-29.78%	UNDER			11.00	9979	0.7869	1480.96	1502	-20.67	-1.40%	-40.44%
	P137	II	1527.00	2109	-27.60%	UNDER			11.00	9979	0.7869	1527.00	1502	25.33	1.66%	-40.44%
	P138	II	1497.40	2109	-29.00%	UNDER			11.00	9979	0.7869	1497.40	1502	-4.67	-0.31%	-40.44%
	P139	III	1862.71	2278	-11.68%		NORMAL		10.27	12900	0.8500	1862.71	1831	31.67	1.70%	-24.39%
	P140	III	1868.92	2278	-11.38%		NORMAL		10.27	12900	0.8500	1868.92	1831	37.67	2.02%	-24.39%
	P141	III	1761.80	2278	-16.46%	UNDER			10.27	12900	0.8500	1761.80	1831	-69.33	-3.94%	-24.39%
Aceh Singkil	P142	I	1361.45	2485	-45.21%	UNDER			9.54	10295	0.9272	1361.45	1404	-43.00	-3.16%	-76.99%
	P143	I	1471.53	2485	-40.78%	UNDER			9.54	10295	0.9272	1471.53	1404	68.00	4.62%	-76.99%
	P144	I	1379.35	2485	-44.49%	UNDER			9.54	10295	0.9272	1379.35	1404	-25.00	-1.81%	-76.99%
	P145	II	1420.45	2081	-31.74%	UNDER			11.00	9979	0.7765	1420.45	1479	-58.67	-4.13%	-40.73%
	P146	II	1457.12	2081	-29.98%	UNDER			11.00	9979	0.7765	1457.12	1479	-21.67	-1.49%	-40.73%
	P147	II	1558.89	2081	-25.09%	UNDER			11.00	9979	0.7765	1558.89	1479	80.33	5.15%	-40.73%
	P148	III	1401.32	2247	-32.66%	UNDER			10.27	12900	0.8384	1401.32	1559	-158.33	-11.30%	-44.10%
	P149	III	1721.24	2247	-17.29%	UNDER			10.27	12900	0.8384	1721.24	1559	161.67	9.39%	-44.10%
	P150	III	1556.38	2247	-25.21%	UNDER			10.27	12900	0.8384	1556.38	1559	-3.33	-0.21%	-44.10%
Simeulue	P151	I	1583.19	2551	-37.94%	UNDER			9.54	10295	0.9519	1583.19	1640	-57.33	-3.62%	-55.52%
	P152	I	1620.86	2551	-36.46%	UNDER			9.54	10295	0.9519	1620.86	1640	-19.33	-1.19%	-55.52%
	P153	I	1716.99	2551	-32.69%	UNDER			9.54	10295	0.9519	1716.99	1640	76.67	4.47%	-55.52%
	P154	II	1941.94	2423	-19.85%	UNDER			11.00	9979	0.9041	1941.94	1891	51.00	2.63%	-28.13%
	P155	II	1839.82	2423	-24.07%	UNDER			11.00	9979	0.9041	1839.82	1891	-51.00	-2.77%	-28.13%
	P156	II	1858.27	2423	-23.31%	UNDER			11.00	9979	0.9041	1858.27	1891	0.00	0.00%	-30.39%
TOTAL ASSESSMENT BEFORE LEARNING						**72**	**66**	**18**	TOTAL ASSESSMENT AFTER LEARNING				NORMAL	**136 (87.18%)**		Average:
						46.15%	**42.31%**	**11.54%**					OUT OF NORMAL	**20 (12.82%)**		**-23.74%**

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Impact factors on the cost calculation for building services within the built environment

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Abstract

Different building epochs, materials and styles challenge planners and furthermore executing companies to define the required services upfront. The presumptions made, often differ from the real conditions on site (building substance), so that additional investigations in advance would be helpful, to gain more knowledge on the existing structure. These deviations then demand additional services on site, which are usually not listed in the bills of quantities and lead to budget overruns. Clients can cushion such overruns through reserves in the budget, but how do contractors deal with those uncertainties in their calculation? To investigate if and how these risks of differing construction and site conditions affect their bids of contractors, quantitative research has been applied and a survey has been conducted. The trend shows, that not the cost component of labour work increases, but is calculated into the prices for materials in order to hide those additional costs. Uncertainties in construction works on existing buildings will always be difficult to evaluate. To minimize the risks of running an unprofitable construction site, employers have the possibility to work with a flexible budget, but contractors can only act to uncertainties and additionally required services with claiming.

Keywords: building in existing; built environment; cost control; cost calculation of building services; building stock; building substance; refurbishment of existing buildings, retrofitting; built environment; cost calculation; building services in the built environment; building stock; impact factors on the construction cost calculation; uncertainties in the cost calculation

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1. Introduction

Building in existing plays an increasingly important role in the construction industry. Decisive for this development are demographic changes, the public awareness of sustainable development as well as the application of energy-efficient, resource-friendly materials [1]. These structural changes in social, economic and environmental spheres have led to a decline of the volume of new construction in recent decades. At the same time there has been a significant increase of building activities in projects in the built environment and refurbishment of existing buildings. In view of these developments, both, principals and agents, must meet new demands in legal, technical, economic, political, planning, creative, social, cultural and aesthetic areas, which deal with building in existing.

This contribution provides an overview of the major internal and external factors that must be taken into account due to the above-mentioned developments of clients and contractors. In addition, the formation and building of the construction price is explained, as well as significant factors of the construction industry are described, which have a major impact on it. Moreover, the principles of the construction calculation, according to the Austrian Standard ÖNORM B 2061 „Price calculation for construction works" are explained, in order to get a better theoretical understanding about the costing in Austria.

As part of the contribution the influences of the identified factors on the calculation and pricing of contractors are investigated. Therefore, on the basis and the acknowledgements of the literature study, a questionnaire was developed and qualitative interviews with experts were carried out. The aim of the survey was to identify relationships between theory and practice and to survey how theoretical aspects are taken into account in the practical construction calculation and which cost units are most affected thereof.

The results show, that the identified factors from the literature analysis have a significant impact on the construction cost calculation. Especially the labour costs of building services in the existing increase due to many unpredictable events to large scales. The reason therefore is the fact that much of the work must be prevented by additional wage hours. Further affected cost units are the equipment costs or transport costs. The increased amount of cost plus services also often leads to additional costs in building in existing. In Summary, it can be stated that high savings potentials are possible by accurate qualitative planning and accurate tender documents.

2. Cost calculation

2.1. Basics and characteristics of cost calculation

Each cost calculation has peculiarities and has to be adapted for each project. Yet, there are several characteristics that can be applied in each calculation of a construction project and have significant impact on the result. In addition, there are different areas in which calculation principles can be distinguished and should be considered separately.

Regarding to Oberndorfer and Haring [2], the main characteristics that are common in every construction project are the following:

- Cost fairness vs. competition fairness
- The Pareto principle
- Time pressure
- Interest and chance of getting the contract

Additionally there are several factors and spheres that influence the calculation of the costs for building services in other ways. Those are:

- **External factors** : Including, Standards, laws, regulations, directives, collectively agreed conditions
- **Internal, operational factors** : Consisting of internal production factors, the internal cost accounting, personnel-, material-, machinery-, equipment costs, technical, organizational and economical Know-How and the post-calculation (determination of expense and service values) of finished projects [2].
- **Project-specific factors** : Those factors are exclusively depending of the building project. Major influences are the planning and tender documents, location of the site, supply for water, electricity, gas, the selected construction method, logistics and infrastructure, personnel-, material- and machinery effort [3]

2.2. Phases of cost calculation

Basis for the construction pricing is the calculation and the determination of the costs. Colloquially understood, the construction cost calculation for building services is much more the preliminary cost estimation than an exact calculation.

Depending on the project phase, different costing activities are carried out in order to determine the "right" costs. Therefore it is crucial to distinguish the construction cost calculation into different calculation types and stages before and after the awarding of a contract [4]. In addition, besides the different calculation types, external and internal project specific conditions must be considered.

The following Fig. 1 according to Drees and Paul [5] shows an overview about the different construction types as well as a precise time allocation to the different project phases:

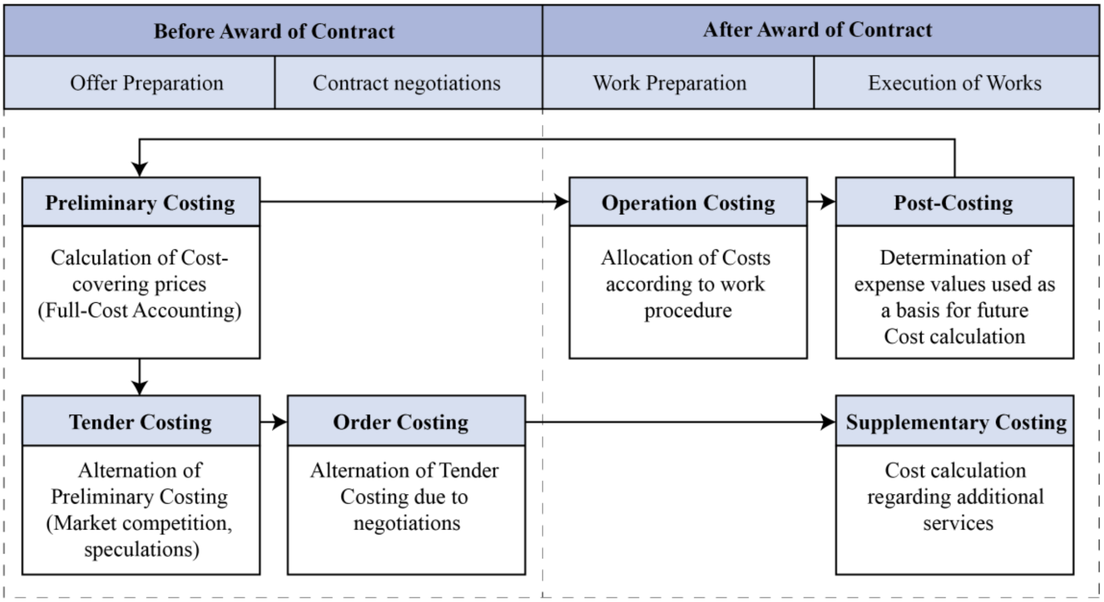

Fig. 1: Stages of cost calculation in different project stages [5]

2.3. Principles of cost calculation in Austria

Costing and the determination of prices for construction works in Austria are regulated in the Austrian Standard ÖNORM B 2061 „Determination of price in building construction - General principles" [6]. This standard is a directive for the estimation of prices as well as the correct presentation of the construction calculation of contractors. It defines important construction-cost terms and provides an overview of the calculation [7].

Regarding this standard, all calculational processes have to be uniform, clearly and comprehensibly described. Furthermore it demands that a common wording is used as well as that a clear presentation of the costs is applied, in order to serve as a basis for computerized calculation programs [6] and for the checking of the adequacy of the prices within the meanings of the Austrian Standards ÖNORM A 2050 [8] or ÖNORM A 2051 [9].

According to the ÖNORM B 2061 [6], the costs of construction sites are classified and determined in the following cost groups:

- **Personnel costs:** Including wages and salaries that result for collective and internal agreements and laws. Those costs also comprise direct, allocated costs and others like overhead costs and bonus payments.
- **Material costs:** Are all costs for material, auxiliary material and process materials like fuel. The costs for process materials are often added to the prices with allowances (especially in small building projects).
- **Equipment costs:** Are determined with the help of the Austrian national list of construction equipment (ÖBGL) [10] where the equipment costs are distinguished into "investment and depreciation" and "maintenance". The costs that are caused by the operation of the equipment have to be splitted up and considered in the wage and material costs.
- **Costs for third-party services:** Are e.g. prices and offers for services of third parties and professionists, freighters, disposal companies that are externally bought.
- **Interest costs:** Are caused by e.g. loans. Generally those include the costs for the operation and site management, costs for the execution of the construction works and the pre-financing, which depend on the liability and the payment conditions. They also include the return on assets and the capital, which is mandatory for the execution of construction works.
- **Other costs:** Are all costs that are not part of the mentioned cost groups but also influence the cost calculation. Those are taxes, license and other fees, rental costs.

2.4. Structure of cost calculation

The in section 2.3 mentioned cost groups serve as basis for the determination of the effective costs of specific construction services and are regulated in the Austrian Standard ÖNORM B 2061 [6]. The standard distinguishes the costs into:

- Direct costs
- On-site overhead costs
- General overhead costs
- Construction interest costs
- Costs for risk
- Profit

The **direct costs** consist of fixed and variable costs and contain the costs for wages, material and equipment. Also the total turnover of the project is added to the direct costs. The share for wages results from the production units multiplied with the calculated time effort of the service. The direct costs also take the costs for the operation of the equipment into account. The calculation for material costs result from the calculated requirements of construction-, auxiliary- and materials for the operation. Furthermore costs for wear and maintenance, but also costs for third-party services are considered. Equipment costs are also calculated with production units and the time effort and the costs for interest and depreciation. Time-based equipment, that is being considered in the overhead costs of the construction site.

Unlike the direct costs, the **on-site overhead costs** also consist of fixed and variable costs, but cannot be quantified and considered in single construction services. Depending on the construction process, they are being assigned to technical and time criteria or are being accounted as lump sum. Here, the ÖNORM B 2061 distinguishes between one-time costs like the development costs, the time-depending costs for the operations of services that are more or less the same over the a certain period. Those would be costs for the construction site manager, technicians, or the salaries for unproductive personnel like securities or cleaning staff. Also the costs for interest and depreciation of the equipment of the construction site have to be taken into account, if they were not considered in the direct costs.

Opposite than the on-site overhead costs the **general overhead costs** sum up all the costs that don't arise directly at a specific building project. Those for example are all the salaries that are not part of the construction site for office staff, costs for computer systems, marketing costs, insurance costs and so on. Generally, they are determined on an annual basis and a percentage of the annual turnover [4].

Direct costs for pre-financing, retentions and liabilities are called **construction interest costs**. Those depend on the agreements of the payments that are made in the contract. The financing of equipment is not taken into account [2].

Entrepreneurial **risks** are considered in a specific charge. The amount depends on the contract conditions, type, characteristics and size of the project, site and quality of the tendering documents. Besides the entrepreneurial risks, also those for the calculation and performance-based risks are calculated.

According to Oberndorfer and Haring [2], the reasonable charge for **profits** in Austria fluctuates between 3% and 5%. It strongly depends on the economical development and the market competition. Also uncovered risks that arise from uncertainties of construction works in the existing can be paid out of the profits.

2.5. Total add-on cost and attribute costing

To also get the costs that are not directly related to the construction, the **total add-on costs** are added to the specific performance costs. This charge consist of the general overhead costs, other overhead costs, equipment costs and third-party costs. Usually the overhead costs of the construction site are calculated separately, but can also (especially at smaller projects) be attributed to the costs of other services.

3. Research method

Based on the literature research, a questionnaire with 15 questions and the title "Impact Factors on the Cost Calculation for Building Services within the Built Environment" was developed in order to investigate how the uncertainties of construction works in the existing affect the cost calculation of contractors. After that, the essential query content was described in a related interview guidance document in order to interview experts of the construction industry [11].

The aim of the survey was, to see how risks for the calculation of construction works at existing buildings are taken into account and to compare the theory and practice through qualitative interviews. Furthermore to filter out commonalities, which are actually used in practice.

The expert interviews were conducted in November and December 2015 and took an average of 45 minutes. A total of eleven people of executing companies were questioned. All of them were whether managing directors or construction managers and experts in the field of construction cost calculation.

4. Results

4.1. Effects on the risks

Nine of the experts share the opinion that the risks of building in the existing are higher than in new building projects. All nine think that the main reason for the higher risks are the provided planning and tendering documents that are mostly very imprecise due to several reconstructions, renovations or extensions over the lifetime of a building. Furthermore, five of the nine experts state, that the risks are also highly dependent on the type of the contract and how the risks are shifted from the client's to the contractor's side.

Four of the interviewees are convinced that the required short construction time of most of the projects lead to an increasing of the risks. Moreover, it is difficult to assess the existing building substance, and to determine whether contaminated material was used for the construction, or if the static aspects still meet the requirements for the further usage and the technical standards.

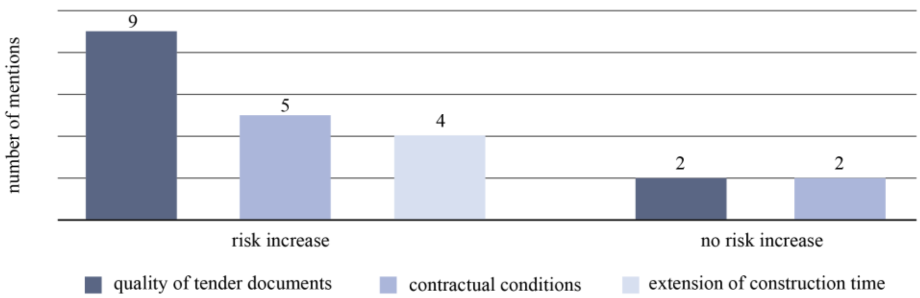

Fig. 2: Decisive risk factors in building in the existing

4.2. Effects on the construction time

Seven of the eleven experts agree that construction services of projects in the existing often take longer than in new building projects. These extensions are not due to legal restrictions, but in most cases are caused by the client or result out of the client's sphere. Mostly the reasons are technical factors like statics aspects, or the discovery of contaminated material where it was not expected. Also the necessity of renovating building parts e.g. like windows cause additional efforts and disrupt the construction works. All experts agree, that those unforeseen events and the extension of the construction time due to additional services are difficult to classify upfront in the calculation phases. Four interviewees furthermore stated, that scheduling is the client's duty and therefore he has to consider longer construction time for building services in the existing. If the client's approach appears to be false and the milestones cannot be met, then the client has to pay for the acceleration of the construction works in order to meet deadlines.

4.3. Effects on the documentation effort

Documentation in the construction industry plays a very important role [11] and will become even more important in the next years in order to preserve evidence. Six of the experts agree that the documentation effort for construction works in the existing is higher than in new building projects. Not only for the building itself, but for the surrounding buildings in order to monitor existing or occurring damages, settlements, cracks etc.

According to five experts the monitoring and documenting also affects personnel and time-sensitive costs.

4.4. Effects on the cost calculation

Nine, respectively six of the experts stated, that there is a significant increase of 15% up to 20% in the cost calculation concerning staff and transport costs. The stated reason for those increases is mostly the inaccessibility of the site or the working space with equipment. So more manual work hast to be done and therefore the labor costs for demolition or removal work must be greatly increased in the stage of preliminary costing.

Another statement from four experts was, that increasing the risk margin or surcharge in the cost calculation by more than 10% covers the unforeseen risks.

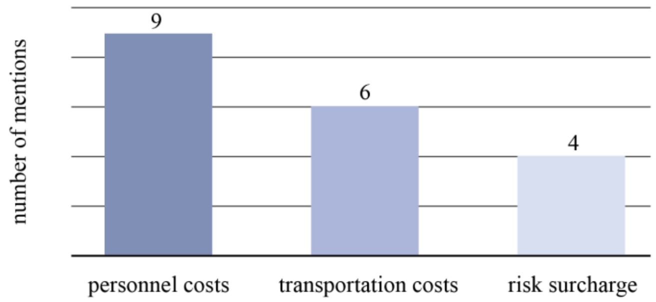

Fig. 3: Cost units that are calculated higher in building projects in the existing

All experts agree that the personnel and labor costs are subject to the greatest fluctuations. The reason is the lack of space on site, the limited use of equipment and unforeseeable events that need to be covered with additional work. Also that the expenditure values, service values and the composition of the team on site are those aspects, that cause the most costs on site and therefore comprise the greatest potential to save money.

Other cost units that were mentioned are the equipment costs, in which the costs for transportation have a significant impact on the costing according to eight experts. Those charges are mainly caused for disposal and demolition works and can be considered whether in separate service items or in the service items for the equipment.

In addition to the increased cost units, six of the interviewees stated that they would add a higher surcharge for risks and nine experts mentioned that they would consider a higher amount of additional works in their calculations for building services in the existing upfront.

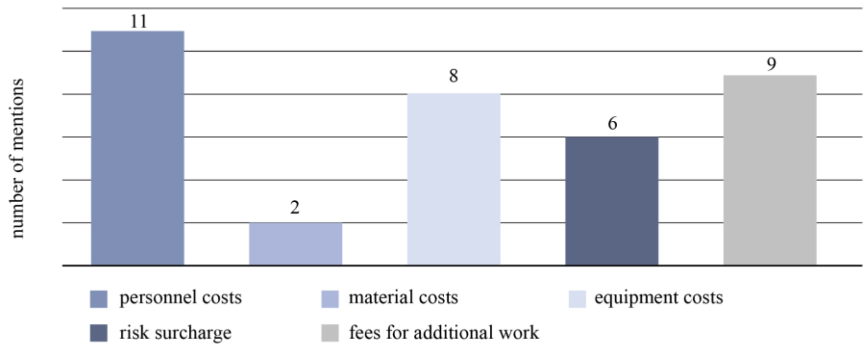

Fig. 4: Fluctuation of cost units in building projects in the existing

5. Discussion

The fact that every existing building project is one of a kind and mostly is not well documented makes it impossible to develop a standardized cost calculation for building services. To improve the quality of the cost calculation for construction services in the existing in the preliminary costing stage and to know how different cost units are and will be affected, examinations should be undertaken by the client in advance in order to be able to provide better plan material and tendering documents for the contractors. Because the more detail of the building substance is known, the more exact the contractor can estimate the costs for the building services.

This also means, that optimally, services like the documentation and monitoring of the surrounding buildings and the building process should be part of the bill of quantities, because if the client considers these costs as additional service items in his tendering documents, the contractor is able to calculate a price for those and will not claim the costs afterwards.

Another way to determine costs more exact is through the post calculation for specific building services of finished building projects. The more information is collected, the more exact the costs can be estimated in future projects.

6. Conclusion

For modifications, refurbishments or renovations, accurate planning and tendering documents are the basis for a clear cost calculation and essential if the building substance is not well known. The more accurate the client's work is done in advance and the better the required building services are described, the less unforeseen events occur on site [12]. This is especially crucial for construction works in the existing, because mainly the cost calculation for labor and wages is affected by additional services and wage hours that occur on site due to unforeseen events. The acknowledgements from former building projects in the existing cause contractors to increase their cost calculation for labor and wages, equipment and material in advance in order to consider these costs in their bids.

The findings of the paper show, that there is a need for further research. Not only to define a correct number for the surcharges of the risks and wages, but also because it is necessary to consider that there are additional risks that occur from different construction contracts and awarding types and how these affect the cost calculation of construction services in the existing. Given more interviews also with clients, it should be questioned if more planning effort leads to less additional costs on site.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Comparing Performance of Government and Private Clients in Construction Projects: Contractors' perspective

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Abstract

By nature, government and private projects may have different characteristics, which influence client performance. This research aims to compare performance of government and private clients in construction projects as perceived by contractors. Six client performance indicators were used, i.e. understanding of project requirements, financial, decision making, management skills, supports for contractor, and client's attitude. Data were collected through questionnaire surveys filled in by 117 respondents who have experience with government and private projects. The results show that there is a significant difference between the performance of both types of clients. Out of the six performance indicators, only the mean values of financial indicator are significantly different. All the three variables related to financial indicators, i.e. timely payment, suitability of owner value estimate, and ease of payment approval, rank in the bottom three of the government client performance, but in contrast rank in the top three of the private ones. These results suggest that in terms of financial indicators, the government clients' performance is perceived to be inferior than the private ones. Based on the research findings, the government should take strategic actions to enhance clients' capacities, one of which is by establishing a clients' forum for sharing knowledge and best practices.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: project performance, client performance, government client, private client, client forum

1. Introduction

It has been widely accepted that client performance plays important roles in a project's success. Together with contractors, clients interact and work during the construction phase to complete the project as agreed in the contract.

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

As early in 1994, Latham Report 'Constructing the Team' [1] points out the strategic roles of clients in the construction industry. Commissioned by the UK government, this report aims to examine the acute problems in the construction industry and recommend for solutions. This report reminded that “Government should commit itself to being a best practice client. It should provide its staff with the training necessary to achieve this and establish benchmarking arrangements to provide pressure for continuing improvements in performance”. …“Private clients have a leading role and should come together in a Construction Clients' Forum. Clients, and especially Government, continue to have a role in promoting excellence in design.”

Later in 2008, Business and Enterprise Committee [2], emphasize that “success in construction projects is driven by the knowledge and skills of the client”. Other research also highlights the importance of client performance and its impact on project, e.g. Kometa et al [3] highlight the importance of attributes of clients' organizations which influence project performance, i.e. financial stability of client, feasibility of the project, past performance of client, project characteristics, and client's duties. Ryd [4] examined the clients’ perspective of the briefing process, and introduced construction client’s tools for facilitating strategic briefing as an important part of project success. Hwang et al [5] found that there is a significant contribution of clients to project rework which in turn impact on project cost, schedule and quality performance. These client related reworks increased project cost by 7.1% and caused project delay 3.3 weeks on the average. They also found “replacement of materials by the client” and “change of plans or scope by the client” as the most frequent factors to occur and have the highest impact on project.

This research aims to compare performance of government and private clients in construction projects as perceived by contractors. The objectives are: to identify performance variables of government and private clients in construction projects, and to examine the expected and the actual performance of clients.

2. Typical Clients in the Construction Industry

The client is described as construction client who develops a construction project from the inception to the commissioning and utilization [6]. There are different types of clients in construction project. They can be distinguished either by their experience in handling projects (experienced vs inexperience clients), or by types of institutions (government vs private clients). They can also be classified as one-off clients or repeat business/continuing clients, or sophisticated or naïve clients [6, 7]. Experienced clients, also known as frequent clients, in general are responsible for 60% of the value of construction work. However, almost 95% of construction clients are one-off or occasional clients. Therefore, they typically have little knowledge or experience with construction projects, making them are less likely to comprehend how the industry works and maximize their role for projects success. Risks of project failure may increase as such [2].

By nature, government and private projects may have different characteristics. Government projects, for example, may have more complex and longer bureaucracy than private projects, which in turn may impact on client performance. Government clients undertake government funded projects. They could be in local or central government undertaking public facilities, such as public buildings, roads, bridges, dams, etc. Government projects typically are traditional route of procurement, i.e. design-bid-build, while for private project are more flexible, e.g. design-bid-build (D/B/B), design-build (D/B), engineering-procurement-construction (EPC). BERR [8] reported that Government holds over 31% of construction output compare to private of 69%, meaning that the government is the largest single customer to the industry.

Private clients are institutions or companies which need assistance from contractors to build and maintain their private properties, such as building, roads, etc. They can use their own funding to build the project or obtain loan from financial institutions. As opposed to the government clients which are bound with certain regulation in project procurement, they may have more flexibility which may speed up and increase their performance. This argument is supported by Yunianto et.al. [9] who compared two building projects which were built by government and private clients. The government adopted traditional procurement route (design-bid-build), while the private client used design and build. They found that the private project has higher level of constructability in comparison to government funded project.

3. Measuring Client Performance

As client performance has significant impact on overall project performance, measuring client performance is very important. Some efforts have been made to measure client performance [e.g. 10, 11, 12]. Alinaitwe [10] assessed client performance based on their responsibilities related to project costs, quality, schedule and resources. Elforgani and Rahmat [11] relate clients' qualities with green building design performance. Soetanto et al [12] proposed 6 indicators for measuring client performance, i.e. client understanding of project requirements, financial, decisions making, management skill, support against contractor, and client's attitude.

Clients' understanding of project requirements and ability to explain them to other parties are required to ensure that the scope and technical specifications of the work to be done. In relation to finance, the client has to ensure sufficient funding for the project, as well as timely payment and ease of payment approvals. Decisions making should be quick and appropriate to accelerate project progress. As client organisations are often multifaceted, however, many problems may arise in the decision making process internally. Unity of opinion from client's team may significantly affect project performance. Good management skills, including comprehensive administration system are prerequisite as clients have to deal with and manage other parties under their coordination. Clients' support against contractors, such as timely information, adequacy of the project duration, readiness of site, etc, clearly has positive impact on timely project completion. Client's attitude includes integrity, discipline and effective coordination, commitment, empathy, respect and trust, all of which have a significant impact on project's success.

4. Research Method

To measure both the government and private clients' performance, 29 variables in 6 categories of performance indicators were used, i.e. understanding of project requirements, financial, decision making, management skills, supports for contractor and client's attitude. These variables are adapted and developed from Soetanto et al [12] and Hatmoko and Khasani [13], as shown in tables 2 and 3. The performance measured including the expected and actual performance. Data were collected through questionnaire surveys filled in by a total number of 117 respondents, consisting of 60 and 57 respondents which have experience with government and private projects, respectively. Their scope of projects includes buildings, waterworks, roads and bridges. The questionnaires basically ask the respondents on the expected and actual performance of government and private clients using a 1 to 5 Likert scale to indicate a range of very low to very high client performance. The expected performance reflects the ideal and level of importance of the client performance variables as perceived by contractors, while the actual performance reflects the actual conditions of clients' performance. Statistical independent t-test was performed to confirm any significant differences in perceptions of performance of both types of clients (at α=5%). The null hypothesis was that there was no significant difference between government and private clients. Table 1 shows general information of the profile of respondents and type of projects. Briefly, based on their positions, experience, education, as well as variety of project types involved, this profile of respondents provides some assurance related to the quality of data used for this research.

Tabel 1. General information of respondents and types of projects

Subject	Qualification	No of Respondents	
		Goverment	Private
Position	Top management	25	26
	Staff	33	20
	Site engineer	2	11
Experience	>15yr	18	20
	10-15yr	10	5
	5-10yr	21	18
	<5yr	11	14

Subject	Qualification	No of Respondents	
		Goverment	Private
Education	Vocational high school	3	5
	Diploma	20	14
	Undergraduate	35	37
	Postgraduate	2	1
Project Types	Building	49	46
	Waterworks	33	27
	Road	29	23
	Bridge	10	7

5. Results and Discussions

The results show that the average of mean values of actual performance of government and private clients are 3.436 and 3.566, respectively (Table 2). These values are below the average of mean values of expected performance of government and private clients of 4.312 and 4.140 (Table 3). This indicates that although the actual performance of both types of clients is perceived to be good, in general the contractors clearly wish a higher level of client performance.

The mean values of actual performance of private clients are higher than government clients (significantly different at α=1%), indicating that in general the private clients perform better than the government clients. This argument is also supported by the fact that the mean values of expected performance of government clients are higher than private clients (significantly different at α=1%), suggesting that the higher expectation of contractors on government client performance are due to inferior performance of government clients.

The mean values of actual performance of government and private clients are shown in table 2. It can be seen that out of 29 performance variables, 5 variables are significantly different (at α=5%). Three of them are related to financial indicators, i.e. suitability of owner value estimate, timely payment by the client in accordance with contract, ease of payment approval on projects. The other two are related to decision making (i.e. clients are able to make decisions/solutions quickly and appropriately according to problems), and support against contractor (sufficient and timely information support). For all these five indicators, the mean values of actual performance of private clients are higher than the government ones. This simply means that the actual performance of private clients for these 5 variables are perceived better than the government ones.

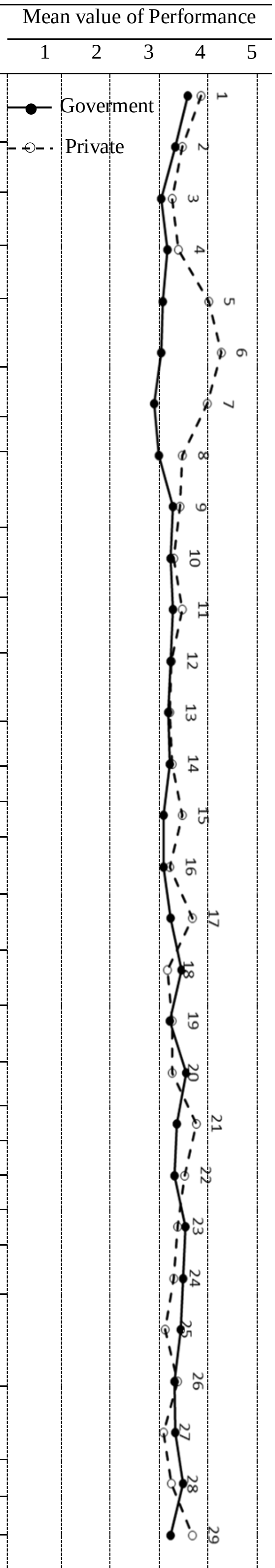
Table 3 compares the expected performance of government and private clients. It can be seen that the mean values of the expected performance generally are not significantly different (at α=5%). There are only 9 variables of which the mean values are significantly different (at α=5%), i.e. understand the construction process, sufficient and timely support of information, the adequacy of the project duration, readiness of site, support of addendum, commitment to quality, time and cost, empathy to the difficulties of contractors, proactive attitude, trust to the contractor. Interestingly, of these nine variables, all the mean values of expected performance of government clients are higher than the private ones. The higher mean values represent the higher expectation of contractors on the actual performance of government clients. This may also indicate that the actual performance of government clients is perceived insufficient, and the contractors wish more client performance improvement.

Table 4 shows the rank of actual performance variables for government and private clients based on the total weighted score of each variable. The top three actual performance variables of private clients are; suitability of owner value estimate, timely payment and ease of payment approval, all of which are related to financial indicator. Meanwhile the bottom three of the actual performance of private clients include routine monitoring client progress, empathy to contractors, client’s proactive attitude. The top three of actual performance variables of government clients include the clarity of contract documents and complete the scope of work, support for addendum, discipline of client in coordination. On the other hand the bottom three of the government client performance are; timely payment, ability to make decisions/solutions quickly and appropriately according to problems, and ease of payment approval. Interestingly, the three variables related to financial indicator which are in the top three of private client performance, are nearly in the bottom three of the government client performance (rank 26, 27, 29). It may suggest that the private clients are far better than the government ones in terms of financial indicators, i.e. the reasonable value of the project, timely payment and ease of payment approval. In other words, the financial indicator has been found as the weakest performance of the government clients. It is indeed in typical government projects, complex bureaucracy, slow administration process, unreliable staffs and other motives may cause difficulties for payment approval, hence delaying the project payment. In relation with the owner value estimate or the reasonableness of the price of the project, it may suggest that there could be problems with the capabilities of government clients in estimating the project values.

In relation to indicator level, the spider web diagram (Fig. 1) and Table 5 show the comparison of the mean values of performance indicators of government and private clients. It can be seen that out of six performance indicators, only the mean values of financial indicator are significantly different (at α = 1%), while the other indicators are not significantly different.

Tabel 2. Mean Value of Actual Performance for Goverment & Private Clients

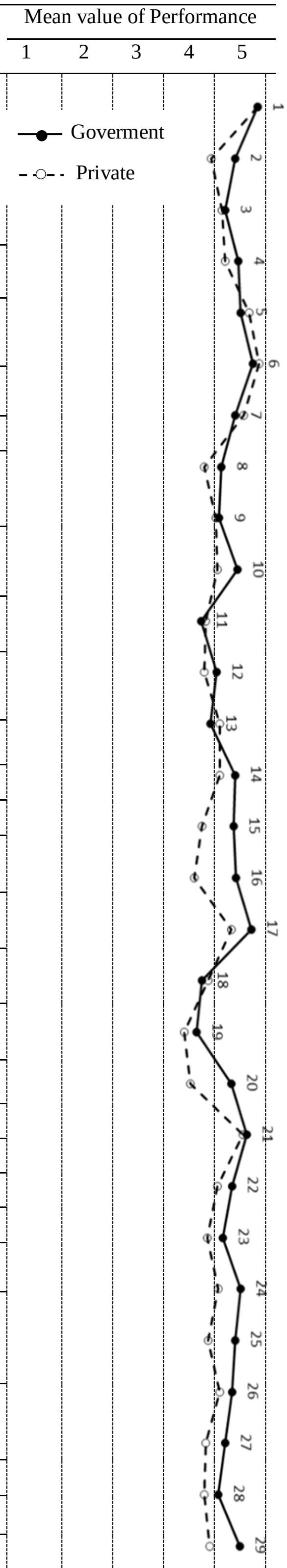
Indicator		Client's Actual Performance Variable	Goverment Mean	Private Mean	Sig.
Understand Project Requirements	1	Contract documents clearly explain and complete the scope of work/project	3.650	3.842	0.1896
	2	Clients understand the development process of the construction project	3.483	3.579	0.4788
	3	Clients has a clear idea embodied in the design so there is no change in development	3.283	3.439	0.2850
	4	Clients are able to explain the working limits, scope and specification well to avoid misunderstandings	3.367	3.526	0.1938
Financial	5	Suitability of owner value estimate (reasonableness of the price of the project)	3.300	3.947	0.00001**
	6	Timely payment by the client in accordance with contract	3.283	4.123	0.00001**
	7	Ease of payment approval on projects	3.183	3.930	0.00003**
Decisions Making	8	Clients are able to make decisions/solutions quickly and appropriately according to problems	3.250	3.579	0.0256*
	9	The decision is in line with between the client and contractors	3.450	3.544	0.4943
	10	Unity of opinion from client's team (owner, consultants, and management construction)	3.417	3.456	0.8182
Management Skill	11	Delegation (clients provide sufficient authority to contractor / consultant)	3.450	3.579	0.2552
	12	Quality of performance / competence of clients	3.417	3.421	0.9731
	13	Good ability of the client's internal organization	3.383	3.404	0.9020
	14	Good client's administration system	3.400	3.439	0.8080
Support Against Contractor	15	Support of information is sufficient and timely	3.317	3.579	0.0351*
	16	The adequacy of the implementation of the project duration	3.317	3.404	0.5665
	17	Readiness to begin the process of land development (eg, there is no dispute)	3.417	3.719	0.1002
	18	Routine monitoring client progress / performance (eg every week)	3.567	3.368	0.1957
	19	Clients are not too meddling in contractor's affairs	3.400	3.439	0.7484
	20	Client support if addendum is necessary	3.633	3.439	0.2204
Attitude	21	Integrity and client's honesty	3.500	3.772	0.0863
	22	Coordination (meetings) quality / effective	3.467	3.614	0.2493
	23	Discipline of client in coordination	3.617	3.509	0.4301
	24	The client is committed to the project in quality, time and cost	3.583	3.456	0.4192
	25	Clients empathize with the difficulties contractors by providing an alternative, suggestions / solutions to problems that arise	3.550	3.333	0.1234
	26	Clients implement the agreement that has been agreed with the contractor in case of problems during project implementation	3.467	3.509	0.8068
	27	The client is able to activate the proactive attitude	3.483	3.316	0.2172
	28	Clients respect the advice of the contractor	3.583	3.421	0.3024
	29	Clients trust the contractor	3.417	3.719	0.0761
		Average	3.436	3.456	0.004**



* Significant difference at α = 5%   ** Significant difference at α =1%

Tabel 3. Mean Value of Expected Performance for Goverment & Private Clients

Indicator		Client's Expected Performance Variable	Goverment Mean	Private Mean	Sig.
Understand Project Requirements	1	Contract documents clearly explain and complete the scope of work/project	4.700	4.702	0.9858
	2	Clients understand the development process of the construction project	4.383	4.053	0.00716**
	3	Clients has a clear idea embodied in the design so there is no change in development	4.250	4.211	0.7657
	4	Clients are able to explain the working limits, scope and specification well to avoid misunderstandings	4.433	4.246	0.1239
Financial	5	Suitability of owner value estimate (reasonableness of the price of the project)	4.467	4.579	0.3104
	6	Timely payment by the client in accordance with contract	4.633	4.719	0.4042
	7	Ease of payment approval on projects	4.383	4.509	0.3173
Decisions Making	8	Clients are able to make decisions/solutions quickly and appropriately according to problems	4.200	3.965	0.0699
	9	The decision is in line with between the client and contractors	4.167	4.123	0.7262
	10	Unity of opinion from client's team (owner, consultants, and management construction)	4.417	4.140	0.0570
Management Skill	11	Delegation (clients provide sufficient authority to contractor / consultant)	3.917	3.982	0.5731
	12	Quality of performance / competence of clients	4.133	3.965	0.2798
	13	Good ability of the client's internal organization	4.050	4.175	0.3967
	14	Good client's administration system	4.383	4.175	0.0731
Support Against Contractor	15	Support information is sufficient and timely client	4.367	3.930	0.0034**
	16	The adequacy of the implementation of the project duration	4.400	3.825	0.00003**
	17	Readiness to begin the process of land development (eg, there is no dispute)	4.617	4.333	0.04366*
	18	Routine monitoring client progress / performance (eg every week)	3.933	4.018	0.5627
	19	Clients are not too meddling in contractor's affairs	3.850	3.684	0.2461
	20	Client support if addendum is necessary	4.333	3.772	0.0002**
Attitude	21	Integrity and client's honesty	4.550	4.491	0.6471
	22	Coordination (meetings) quality / effective	4.350	4.140	0.0648
	23	Discipline of client in coordination	4.217	4.000	0.1309
	24	The client is committed to the project in quality, time and cost	4.467	4.158	0.0150*
	25	Clients empathize with the difficulties contractors by providing an alternative, suggestions / solutions to problems that arise	4.383	4.018	0.0044**
	26	Clients implement the agreement that has been agreed with the contractor in case of problems during project implementation	4.350	4.175	0.1546
	27	The client is able to activate the proactive attitude	4.250	3.982	0.0244*
	28	Clients respect the advice of the contractor	4.150	3.965	0.2429
	29	Clients trust the contractor	4. 450	4.035	0.0010**
		Average	4.312	4.140	0.006**



* Significant difference at α =5%

** Significant difference at α =1%

Tabel 4. Rank of Client's Actual Performanc

	Client's Actual Performance Indicator	Goverment		Private	
		T.Weight	Rank	T.Weight	Rank
6	Timely payment by the client in accordance with contract	197	27	235	1
5	Suitability of owner value estimate (reasonableness of the price of the project)	198	26	225	2
7	Ease of payment approval on projects	191	29	224	3
1	Contract documents clearly explain and complete the scope of work/project	219	1	219	4
21	Integrity and client's honesty	210	8	215	5
29	Clients trust the contractor	205	19	212	6
17	Readiness to begin the process of land development (e.g. there is no dispute)	205	18	212	7
22	Coordination (meetings) quality / effective	208	11	206	8
2	Clients understand the development process of the construction project	209	9	204	9
8	Clients are able to make decisions/solutions quickly and appropriately according to problems	195	28	204	10
11	Delegation (clients provide sufficient authority to contractor / consultant)	207	14	204	11
15	Support information is sufficient and timely client	199	24	204	12
9	The decision is in line with between the client and contractors	207	13	202	13
4	Clients are able to explain the working limits, scope and specification well to avoid misunderstandings	202	23	201	14
23	Discipline of client in coordination	217	3	200	15
26	Clients implement the agreement that has been agreed with the contractor in case of problems during project implementation	208	12	200	16
24	The client is committed to the project in quality, time and cost	215	4	197	17
10	Unity of opinion from client's team (owner, consultants, and management construction)	205	16	197	18
19	Clients are not too meddling in contractor's affairs	204	21	196	19
20	Client support if addendum is necessary	218	2	196	20
3	Clients has a clear idea embodied in the design so there is no change in development	206	15	196	21
14	Good client's administration system	204	20	196	22
28	Clients respect the advice of the contractor	215	5	195	23
12	Quality of performance / competence of clients	205	17	195	24
16	The adequacy of the implementation of the project duration	199	25	194	25
13	Good ability of the client's internal organization	203	22	194	26
18	Routine monitoring client progress / performance (e.g. every week)	214	6	192	27
25	Clients empathize with the difficulties contractors by providing an alternative, suggestions / solutions to problems that arise	213	7	190	28
27	The client is able to activate the proactive attitude	209	10	189	29

This research provides measures and comparisons of government and private client performance in Indonesian construction industry, which previously may not be available. The research findings are useful to identify areas for improvement of both types of client performance. Improving client performance will contribute positive impacts on the project performance to finish on time, on budget with excellent quality. For contractors, this research may raise awareness of areas of which both types of client performance are typically considered inferior, so that they can come up with anticipation in advance with precise strategies to maintain and improve project performance.

Particularly for government clients, Latham report recommends that "Government should commit itself to being a best practice client…". Government has a strategic role in the construction industry, as it can act as client, regulator, as well as funding provider. It has also the powerful purchasing power as procurer equals to almost a third of construction output. With this strategic position, it can influence the construction sector in many aspects [2].

Although Latham report is in the context of The UK, this recommendation is also relevant for Indonesia context. Strengthening client performance should be one of strategic agendas in Indonesia construction industry, for both types of client. The government should take a strategic action to enhance capacities of clients for the success of the project. This can done by establishing a construction clients' forum as a media to share knowledge and best practice, benchmarking with peers, etc. In the UK, such clients' forum called The Client Commitments was established focusing on six areas where clients can make positive contributions, i.e. client leadership, procurement and integration, health and safety, design quality, sustainability, commitment to people. In Indonesia context, this forum will help defining and empowering of what so-called good clients.

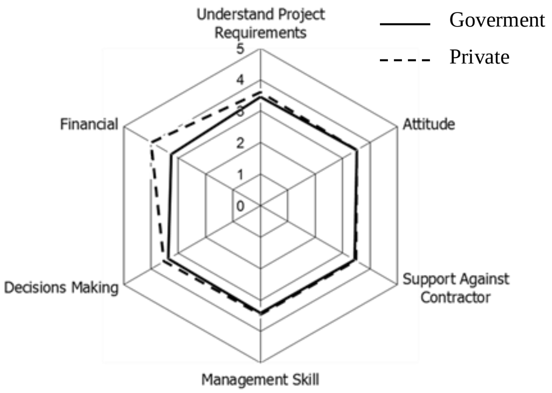


Fig. 1. Comparison of clients' actual performance

Tabel 5. Mean Value Indicator of Actual Performance

Indicator	Mean Performance		Sig.
	Goverment	Private	
Understand Project Req.	3.45	3.6	0.247
Financial	3.26	4.00	0.000*
Decisions Making	3.37	3.53	0.099
Management Skill	3.41	3.46	0.300
Support Against Contractor	3.44	3.49	0.530
Attitude	3.52	3.52	0.973

* Significant difference at α = 1%

6. Conclusions and Recommendations

This research compares performance of government and private clients utilizing 29 variables in 6 performance indicators, i.e. understanding of project requirements, financial, decision making, management skills, supports for contractor and client's attitude. The results show that there is a significant difference (at α=5%) between the actual performance of both types of clients, as well as for their expected performance, which indicates that in general the private clients perform better than the government clients.

Out of the six performance indicators, only the mean values of financial indicator of government and private clients are significantly different (at α = 1%), while the others are not significantly different. All the three variables related to financial indicators, i.e. timely payment, suitability of owner value estimate, and ease of payment approval, are in the bottom three of the government client performance (rank 26, 27, 29). However, these three variables are in the top three of private client performance (rank 1, 2, 3). These results suggest that in terms of financial indicators, the private clients perform way much better in comparison with government clients. The government clients' performance is perceived to be inferior in these financial indicators.

This research provides measures and comparisons of government and private client performance in Indonesian construction industry, which are likely not available beforehand. The research findings are very vital in terms of identifying key variables for improvement of both types of client performance. As a project's success is also largely dependent on the client's knowledge and skills, improving client performance will obviously support the acceleration of the delivery of the project, and in turn will improve the project performance. Following this research, further topic can be done by developing national strategic framework for enhancing construction client capacity.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Use of life cycle assessments in the construction sector: critical review

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Abstract

A life cycle assessment (LCA) is an internationally accepted and useful tool to assess the environmental impact of products. In this paper, the use of LCA in the construction sector has been critically analyzed. The analysis is based on specific literature cases and different standards and frameworks. As an example, a detailed comparison of four LCA studies for structural concrete is presented. LCA is one of the most promising techniques for an ecological design of products. However, in order to appeal to the benefits of LCA, it is important to know how to use LCA properly. From the review in this article it becomes clear that the LCA research is still in a fragmented state, due to the existence of various unspecific guidelines and different interpretations of those guidelines. Since for example the international standards on LCA, ISO 14040/44, only provide a global framework, and no exact technique to calculate environmental impacts, it is possible to create an LCA with different boundary conditions. Hence, a valuable comparison between distinct LCAs is difficult. Comparisons should thus thoughtfully be performed, taking into account all information about the LCAs under study. When this background information is communicated transparently, LCAs can be interpreted correctly.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: Construction sector; life cycle assessment; ecology; sustainability; EPD; review.

1. Introduction

According to the United Nations Environment Programme (UNEP) three planets will be necessary by 2050 to bear the world consumption and our way of life. This will be the case if the current consumption and production is

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

continued, taking into consideration the growing population [1]. Hence, in several fields, there is an increasing focus on sustainability in general and on the environmental impact of different processes in various sectors. In the European Union, approximately three billion tonnes of waste are generated each year. About one-third of this waste (i.e. one billion tonnes) has its origin in construction and demolition activities [2]. Moreover, the building industry is responsible for the consumption of more than 40 percent of the world energy and for approximately one-third of the emitted greenhouse gasses worldwide [3]. This "sector" consumes about 25 percent of the global wood harvest and approximately 40 percent of the materials entering the global economy. Every year, the construction sector uses three billion raw materials [4]. These facts reveal that the building industry has a large, negative impact on the environment. It is necessary to identify how this consumption, pollution and waste processing is caused, in order to address the causality of these issues.

To thoroughly analyze these causalities, a frequently used and generally accepted method is the life cycle assessment (LCA). This system is used to evaluate the possible environmental impacts and used resources throughout the whole life cycle of a product: starting from the extraction of resources, to the production and use phases up to the waste processing [5]. The introduction of LCAs in the construction industry is highly important since this system can systematically and objectively evaluate and quantify each ecological impact [6]. As such, LCA is one of the most promising techniques for an ecological design of a product.

Since the beginning of the 21st century, the interest in LCAs has increased strongly. This is reflected in the wider application of this methodology. Moreover, the use of LCA is further encouraged by incorporation in recommendations of authorities and the increased use of LCA on policy level [7,8]. For example, the Integrated Product Policy (IPP) has in this context been developed by the European Commission [9]. In 2002, the United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC) launched an International Life Cycle Partnership, known as the Life Cycle Initiative (LCI). This partnership enables users from all over the world to put life cycle thinking into effective practice [10].

Despite the different advantages of LCA causing this increased interest in the topic, various drawbacks still exist. To be able to clarify the use of LCA in the building industry, an extensive literature review has been carried out for this paper. Based on this review, a general background of LCA in the building industry is presented in this paper, together with a focus on advantages, recurrent drawbacks and possibilities to solve problems.

2. General regulatory context

The general standards in the context of LCA, ISO 14040:2006 and ISO 14044:2006, describe and specify respectively the principles and framework, and the requirements and guidelines for LCA [5,11]. These standards describe the four main phases (**Error! Reference source not found.**) of an LCA, of which the first is the definition of the goal and scope. In this first phase the purpose of the study, the system boundaries and the definition of the functional unit (FU) have to be determined. The FU should be defined very accurately, since all of the inputs and outputs are calculated per functional unit. To enable fair and equivalent comparison of two products, each system should thus be composed according to the exact same functional unit. In this context of comparability, attention should also be paid to other requirements, such as a closer look at the system boundaries and allocation principles. [12].

The second phase of an LCA is the life cycle inventory (LCI). This is the data collection process of all relevant inputs and outputs of a product life cycle. In this phase, it is important to work with very accurate data, since the accuracy of the final results of the life cycle assessment strongly depends on the life cycle inventory data [13].

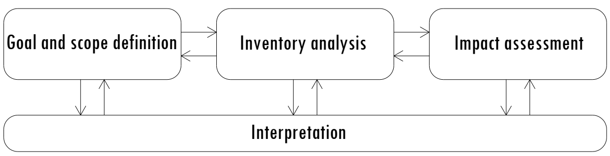

Fig. 1: Stages of an LCA according to NBN EN ISO 14040.[

Thirdly, the life cycle impact assessment (LCIA) will evaluate potential environmental impacts and used resources, based on the data of the LCI phase and depending on which impact assessment method is used. Basically, there are two types of methods in conducting an impact assessment: the problem-oriented (or midpoint) methods and the damage-oriented (or endpoint) methods. Midpoints are considered as a point in the cause-effect chain (environmental mechanism) of a particular impact category, prior to the endpoint. To nuance the midpoint results, characterization factors can be calculated to reflect the relative importance of various specific emissions or extractions in the LCI. However, LCA studies that require a combination of impact categories will often acquire endpoint methods [14].

The fourth and final step in an LCA is the interpretation which identifies significant issues, evaluates results in order to draw conclusions and provides recommendations [6]. The three last phases all refer to the goal and scope definition. This complete procedure should be applied as an iterative technique, in which collected data and information may imply a modification of the scope in order to meet the original goal of the study [5].

This abstract summary of these four stages in LCA reveals that the international LCA standards are precise in some points, but leave room for interpretation in others. In this context, it is important to know that ISO never aimed at defining the exact methods for creating an LCA, by stating in ISO 14040 as one of the key features of an LCA that ‘there is no single method for conducting LCA’ [5,15].

3. Drawbacks in LCA

Being one of the most functional assessment tools, LCA is used regularly in the architectural and construction industries to assess sustainability. However, presently there are still some shortcomings of LCA in general and for building-specific LCAs. Some of these overall complications with LCA are discussed in the following section of the paper, after which a closer look will be taken to issues with the use of EPDs and building rating systems.

3.1. Obstacles and problems

A first obstacle is the existence of several different databases with which LCAs can be performed. These databases contain inventory data for complete supply chains, i.e. specific information about the inputs and outputs related to the processes in the LCA [16]. The databases are owned by different companies which maintain their own data. Hence, the absence of a reference database results in gaps and overlaps between the databases. These gaps and overlaps create issues of quality and comparability of the LCA results [17].

Recently, a study has been published in this context, which reviews LCA databases that focus on construction materials [16]. The authors analyzed the methodology, documentation, data quality and comprehensiveness of the databases. According to this study, only a few of the existing LCA databases contain information about construction materials. Further results of the study [16] show clearly that Ecoinvent [18] and Gabi Database [19] surpass other databases through their integrity, usability and dedicated resources. However, when comparing Ecoinvent and Gabi, based on a case study performed in 2014, it becomes clear that the mutually numerical results can still differ significantly between these two generic databases [20].

A second obstacle occurs in the LCIA, the third stage of life cycle assessment. In the LCIA, the results of the LCA can be defined using an endpoint method, as mentioned above. To calculate the results using the endpoint method, “weighting” must be applied to combine separate impact categories. This weighting is a value-based process that represents the scientific interpretation of the importance of each separate impact category. The structure of this scientific interpretation goes along with ideological, political and ethical principles. As a matter of fact, the weighting makes the results of an LCA subjective, since the weights are often defined by a group of professionals who only rely on their general knowledge.

Despite the subjectivity, weighting provides also a great benefit, since it is helpful in decision making. By means of the weighting, endpoint methods show a single-value result which helps decision makers to better understand the differences between the environmental impact of various options [21]. A similar consensus was reached at an international workshop in Brighton in 2000: “Both endpoint and midpoint methodologies have complimentary merits and limitations, they both provide useful information to the decision maker. Midpoint indicators are more certain but can have a lower relevance for decision support in some cases. Endpoint indicators were argued to often have a higher relevance but lower certainty" [14]. In any case, researchers should take into account the fact that the weighting factors vary depending on economic, cultural and social conditions [22], and when choosing the weighting factors, some criteria should be taken into account, as described by Johnsen and Løkke [23]. Because of these restrictions, some researchers still prefer to work with alternatives for weighting factors, such as indicators based on laws of physics [24].

The third and fourth obstacles concern respectively the end of life phase, and the lack of benchmarks in the construction sector. During the life cycle of a building product many types of waste are produced, depending on the product under review and the life cycle stage in which the waste is produced. Taking into account the recycling of this waste in the LCA may result in negative values for impacts, which can reduce the overall impact of a building. However, the methods to account for recycling activities are not yet well integrated in LCA tools [21]. This is important, since the way in which the recycling activities are accounted for, can greatly affect the LCA results. The other, fourth, issue is the absence of well-defined benchmarks in the LCA analysis of buildings in many parts of the world. This is unfortunate, since benchmarks can be very useful in providing a basis for comparison of existing products, and in evaluating the performance of new ecological alternatives [21].

3.2. The use of EPDs

In Journal of Industrial Ecology, Bo Weidema raises the question whether ISO 14040/44 has failed its role as a standard for LCA [25]. This questioning is based on the fact that there exist different guidelines that aim to define more explicit rules to perform an LCA of specific product groups. These types of guidelines are called Product Category Rules (PCRs). Unfortunately, different PCRs sometimes cover the same product categories, but include different interpretations of ISO 14040/44. In this way, the standard does not fulfill its role to minimize or eliminate unnecessary variation, and failed in this respect according to Weidema.

PCRs are used to compose Environmental Product Declarations (EPDs). These declarations are, according to ISO 14025, Type III environmental declarations [26] and are widely used by product manufacturers in the construction sector to report the environmental impact of their products. In this context, EN 15804 has been developed by the European Committee for Standardization (CEN/TC350) to define more specific rules for EPDs of construction products [27,28]. These specific rules are necessary, since the number of "Type III environmental programs" —"the bodies supervising and administrating the development of PCRs and verifying EPDs under a Type III Environmental Declaration Programme (also known as EPD schemes or EPD operators)" [29] — has grown steadily in recent years. While until 2002 only seven operators were active, a fivefold increase by the end of 2013 has been observed in a study by Minkov et al. [29]. The PCRs associated with these programs cause an increasing overlap and duplication among each other. This does not only confirm what Weidema points out, but this causes also a risk to the legitimacy of environmental claims.

According to the previous paragraph, it can be seen that EPDs are being used frequently. Minkov et al. analyzed 39 EPD schemes and show that 56% of these have a European origin (followed by North America (28%) and Asia (8%)). Of the analyzed EPD schemes, 44% is generic, and next to this, the "building and construction" related programs hold a large share of the total amount (36%). EPDs are not only a useful instrument in this sector, but this large share originates also in newly introduced requirements for green building certification. For instance, LEED, the rating system of the US Green Building Council, awards additional points to projects that use products verified with EPDs that meet predefined criteria [30].

Moreover, Subramanian et al. developed a comparison template to compare PCRs from different global program operators, and a broad selection of product categories [31]. Based on this comparison, Subramanian et al. conclude that there is indeed a lack of consistency, as mentioned before in this current paper. The disparity between PCRs of the same product category range from broad differences in system definition (scope, system boundaries, impact assessment) to specific variation of technical elements. These differences can be due to contrasting purposes of the PCR, the application of different standards, the use of other product categorization systems, or simply methods being developed independently. From this angle, it is interesting to perform a comparison of two versions of an EPD considering the same product. Such a study was published in 2012 by Modahl et al. This study highlights the importance of precise definitions regarding data quality in EPDs. The paper shows that there are substantial variations arising from using two datasets with different degrees of specificity: generic and specific data [32]. Furthermore, when comparing the Ecoinvent generic database with an EPD database developed in France for construction materials, Lasvaux et al. indicate deviations of different magnitudes at the database level, depending on the LCIA indicators and the building materials [33]. The results of these studies illuminate the fact that it is necessary to avoid comparisons of products based on different assumptions.

3.3. LCA building rating systems

Since the early 1990s the construction sector has seen an emergence of tools that aim to develop environmental certifications of whole buildings. This induced an acceleration of changes in construction practices [34,35]. Fowler and Rauch give the following definition of these rating systems: "tools that examine the performance or expected performance of a 'whole building' and translate that examination into an overall assessment that allows for comparison against other buildings" [36]. These rating methods have become a popular research field, but an international tool which allows the assessment of buildings in different regions of the world, taking into account differences in climates, topographies and cultures has not yet been developed [35]. Banani et al. indicate that the most popular and globally used schemes are BREEAM (Building Research Establishment's Environmental Assessment Method), LEED (Leadership in Energy and Environmental Design), Green Star, CASBEE (Comprehensive Assessment System for Building Environmental Efficiency) and Estidama [37]. Each system defines its own categories that have to be analyzed and evaluates these categories according to different assessment methods (and thus weighting factors). In this way the results of an evaluated building by one rating system is not comparable to the evaluation based on another rating system [38].

4. Evaluation and comparison of four case studies

4.1. Background information

Life cycle assessments in the construction sector are a complicated issue. Evaluating the drawbacks listed earlier in this paper, it becomes clear that these problems are the result of the complexity of LCA. When trying to compare distinct LCAs performed by different researchers, it is important to consider the background information of each study carefully. To illustrate this, the following section presents a comparison of four different LCA studies [39–42] which all concern the material concrete. Summarizing elements of these studies are shown in Table 1.

The first study [39] regards cradle-to-gate LCAs by Tait and Cheung of three concrete mix designs containing different cementitious blends. A part of the article is subdivided into the four phases of LCA as prescribed by ISO 14040/44. Furthermore, the system boundaries are clearly defined in a separate section. The goal of the mentioned study is to make a comparison between the three concrete mixtures and thus to help industry make key decisions in mix designs. In this way, a further objective is to achieve lower CO_2 emissions.

In the second study [40], Knoeri et al. analyze a cradle-to-gate LCA of 12 recycled concrete mixtures with two different cement types, and compare this with corresponding conventional concretes for three structural applications. Here, the sequence of the four different LCA phases is also respected. This study's objective is to perform a comparative LCA of conventional concrete (CC) and recycled concrete (RC) to analyze the effect of cement content and transport distances. In this way the researchers can provide policy recommendations for construction waste management and support construction stakeholders' decisions.

The third study [41] consists of an LCA by Sjunnesson which concerns two types of concrete: an ordinary mixture and a frost-resistant mixture. An extra focus has been put on the effect of superplasticizers. The LCA is a cradle-to-grave LCA in which the use phase has been neglected. Since this study has been executed in 2005, the study is based on the older version of the standards, ISO 14040-14043. Moreover, no databases or software have been used: a literature study was the source for LCI data and conversion indicators.

For the fourth study [42], previous research of the authors of the current paper has been taken into account. The LCI for this analysis is based on specific information of a Belgian producer of prefabricated, prestressed concrete elements, and on the Ecoinvent database. The study has been performed according to the four LCA stages, and aims to analyze an ecological alternative for the traditional production of prefabricated, prestressed concrete elements.

4.2. Attempt at comparison

Although all four studies consider LCAs of concrete and are all based on the ISO standards, different issues appear when trying to compare the studies. A first occurring problem is the composition of the concrete mixtures. Of course, the mixtures in the different articles are not equal, since these mixtures are composed according to the specific goals of the respective studies. However, all four studies use at least one concrete mixture that can be assumed conventional, and which will be used for further comparison. These mixture compositions are shown in Table 2.

Table 1: Summary of comparative elements of four studies concerning LCAs of concrete [39−42]

	Tait and Cheung [39]	Knoeri et al. [40]	Sjunnesson [41]	Dossche et al. [42]
Year published	2016	2013	2005	2015
Software + database	SimaPro 8 Ecoinvent 3.01	Ecoinvent 2.2 Unknown	LCI and LCIA data based on literature	SimaPro 7 Ecoinvent 2.0
Functional Unit (FU)	1 m³ of concrete	1 m³ concrete of a specific strength class at the construction site	1 m³ of concrete	1 m³ of concrete with a service life of 50 years
System boundaries	Cradle-to-gate	Cradle-to-gate	Cradle-to-grave, without use phase	Cradle-to-gate with options
Allocation mentioned?	GGBS and FA: only processing and transportation emissions	Allocation is avoided by system expansion and substitution (cfr. ISO 14044)	Allocation for macadam production. Other allocation: included in LCI data	Mass and economic allocation
Transport	- All transportation by road - Estimation of transport distances of the materials to the concrete plant: assumed as typical for the UK	- Average transport distances to the concrete plant: typical Swiss information - Additional transport distances for the RC options - Transport sensitivity analyses for some components	- Typical transport distances for Sweden - All transport by (medium) heavy trucks, except 'cement to depot': by ship	- Transport by road, by river and by sea - Typical transport for Belgium
Impact assessment	- Eco-indicator 99 - EPD 2008 - Ecopoints 97	- Eco-indicator 99 - Ecological Scarcity 2006 - GWP and ADP	- Indicators included: GWP, EP, AP, POCP, toxicity of superplasticizers	- Eco-indicator 99 - EPD 2008

GGBS = Ground granulated blast furnace slag	C&D waste = Construction and Demolition waste	EP = Eutrophication potential
FA = Fly ash	ADP = Abiotic depletion potential	AP = Acidification potential
RC = Recycled concrete	POCP = Photochemical oxidant creation potential	GWP = Global warming potential

A second issue appears in the LCIA phase: the studies use different impact assessment methods and -categories to present the impact of their mixtures on the environment. To be able to compare the studies adequately, only the overlapping categories can be incorporated in the comparison. The values for these overlapping categories are summarized in Table 3. For this, the values of Sjunnesson [41] had to be calculated by hand, with the help of the LCI data and characterization indicators provided by Sjunnesson.

To obtain comparable results in Table 3, a third issue had to be overcome. The different studies initially analyze a different proportion of the life cycle of concrete, as summarized in Table 1 under 'system boundaries'. Since the studies by Knoeri et al. and Tait and Cheung consider only a cradle-to-gate study, the results of the other two studies were adapted in order to also reflect a cradle-to-gate study. In this way, Table 3 shows the results for Sjunnesson with abstraction of the LCI data for demolition. In addition, in the study by Dossche et al., only the results for a cradle-to-gate were accounted for in Table 3.

When evaluating and comparing the values in Table 3, it becomes clear that all values of the same impact category are more or less of the same order of magnitude. As a matter of fact, these results are now comparable as a result of, firstly, comparing LCAs with the same functional unit, and secondly, taking into account the above mentioned issues. Still, the LCIA results remain more or less different, which can be explained by different use of data, contrasting transport distances and various means of transport, slightly different system boundaries, other impact assessment methods (especially in the case of Sjunnesson), older or newer information, and other influencing factors. The larger values for global warming potential (GWP) of Tait and Cheung's study and of the research by Dossche et al. most likely arise from a larger use of Portland cement.

Table 2: Conventional concrete mixtures of four compared references [39−42]

Tait and Cheung	"Mix 1: CEM I" kg/m³	**Knoeri et al.**	"Outdoor CC" kg/m³	**Sjunnesson**	"Ordinary concrete" kg/m³	**Dossche et al.**	"Mixture 4" kg/m³
Portland Cement	380	**Portland Cement**	300	**Cement**	295	**Cement**	335
Limestone aggregate							
10/20-mm	615	**Natural aggregates**	1890	**Natural gravel**	1093	**Coarse aggregates**	1194
4/10-mm	413						
0/4-mm fine aggregate	806			**Macadam**	749	**Fine aggregates**	832
Plasticizer	2	**Additive (superplasticizer)**	3.3	**Super-plasticizer**	1.51	**Additives**	0.8
		Filler (fly ash) ***(avoided disposal)***	-20				
Water	190	**Water**	105	**Water**	202	**Water**	127

CC = Conventional concrete

Table 3: LCIA per FU (i.e. 1 m³ of concrete) of four compared references [39−42]

	Tait and Cheung	Knoeri et al.	Sjunnesson	Dossche et al.
Eco-indicator 99 [Pt]	13.9	9.76	-	14.8
GWP [kg CO_2 eq]	339 (EPD 2008)	278	273.5	330 (EPD 2008)
EP [kg PO_4--- eq]	0.14 (EPD 2008)	-	0.09	0.10 (EPD 2008)
AP [kg SO_2 eq]	0.54 (EPD 2008)	-	0.62	0.57 (EPD 2008)

4.3. Conclusion

Out of the evaluation of the four different studies, it becomes clear that no study can be accounted as equal to another, since there will always be a very specific goal attached to each study. According to this goal, different assumptions and decisions are made. However, when taking into account the broad background information listed in the papers about the composition of the LCAs, an attempt can be made to compare the results. Here, it is important to always consider every single issue mentioned to make a fair comparison.

When performing such a comparison of LCAs, the comparative elements should be fair and equal. Tait and Cheung for example compare in their own study [39] three different concrete mix designs, and make sure that all three mix designs are capable of producing equivalent mechanical performance and durability. For example, all three concrete mix designs have the same water/cement ratio and the same overall binder content. Moreover, the LCAs are in that specific study performed according to the same system definition. Taking into account all these similar boundary conditions, the comparison made by Tait and Cheung can be assumed fair.

This fairness is not always strived for. For instance, a study in 2009 about an environmental analysis based on LCA of bridges in the Netherlands [43] had to be renewed in 2013 [44], since the results of the first study created a large discussion about the correctness of the comparative elements. This implies that producers who try to make their products more sustainable than others, have to strive for sustainability in a correct manner. In this way, the producers do not lose their credibility, and, moreover, an attempt to achieve true and fair sustainability can be made. In order to attain correctness, it is important to incorporate all the information which is necessary to fully understand the life cycle assessment. The functional unit, boundary conditions and impact assessment method cannot be omitted. Next to this, it is important to mention information about the composition of the LCA, such as details about allocation, transport, software and databases. Only when this background information is communicated transparently, an LCA can be understood completely and can induce correct reporting. In addition, sensitivity and uncertainty analyses can be a useful tool to cope with assumptions and uncertainties, and to inform others better.

5. Assets and solutions in LCA

Life cycle assessments provide a holistic approach of product environmental impacts, since the methodology accounts for the whole life cycle of a product or service. It is interesting to obtain such an overall view of the life cycle to identify the major sources of environmental impact. Furthermore, the implementation of LCA can support designers, engineers and decision makers in their work, by providing an analytical environmental evaluation [6]. Moreover, LCA is capable of analyzing products and processes based on their function instead of on their specific physical characteristics. Consequently, products that are inherently different, can still be compared when they fulfill a similar function [8].

Because of these benefits, the LCA methodology remains a very valuable system and is it worthy to solve the earlier mentioned drawbacks worldwide. In Europe, for example, several standards are being developed to stimulate horizontal standardized methods for the assessment of the sustainability aspects of construction works. The two leading organizations for this are the International Organization for Standardization (ISO) and the European Committee for Standardization (CEN). The ISO/TC 59/SC 17, or Technical Committee (TC) 59 with subcommittee (SC) 17 ‘Sustainability in buildings and civil engineering works’, has published several standards defining a framework for analyzing sustainability of buildings and the implementation of EPDs [45]. Next to this, the CEN/TC 350 ‘Sustainability of construction works’ has developed standards for the sustainability assessment of buildings (EN 15978), as well as for relevant product information (EN 15804) [28]. These standards, and other standards written by CEN/TC 350, provide a system for the environmental, social and economic performance of buildings. The purpose of this series of European standards is to enable comparability of the results of an LCA. The construction sector is for example the only sector for which the impact indicator selection process in the LCIA phase has been harmonized [17].

In addition to this positive evolution, researchers around the world try to provide answers to the drawbacks of LCA. Concerning the earlier mentioned first problem, i.e. the various databases on which an LCA can be based, Takano et al. opine that it is more realistic to develop reporting and communication systems for LCA results, rather than trying to unify the methodologies among the databases. According to these authors, the development of open databases on a national level would be helpful. Moreover, two important goals for the further development of databases are first to enrich the number of data, and second to attach to this data transparent background information [20].

In its turn, the benchmark problem is mostly being addressed on a national basis, since the practices in the construction sector can vary widely from region to region. Moschetti et al. present for example a methodology to define reference values based on the analysis of four exemplary Italian residential categories. In Belgium, the Public Waste Agency of Flanders, OVAM, in collaboration with many other institutes, seeks to communicate transparent information about the Environmental Performance of Materials used in Building Elements. In this way, decision makers in the field of constructions obtain knowledge that is required for objective and transparent creation, selection or support of eco-friendly material solutions. As a result, information which is specifically related to the Flemish-Belgian building methods and scenarios can be shared [46].

Concerning the problem with EPDs, Passer et al. tries to illuminate the differences in EPDs and the different programs. These authors present an overview of the EPD programs in five European countries. According to this comparison, it can be seen that more similarities than differences exist. All EPD programs are based on EN 15804, and some countries are working on an (additional) national appendix of this standard because of national legislations or particularities.

Next to this, the existence of many environmental claims results in the necessity for clarification and harmonization, at least on a regional level. The ECO Platform is the first step to obtain such harmonization on the EPD level [47]. In its turn, the Product Category Rule Guidance Development Initiative tries to develop a PCR guidance document to enhance and harmonize the development of PCRs [48].

As earlier mentioned, comparisons between different buildings in different countries cannot yet be performed by a rating system due to local and regional differences. This is also recognized by the European Commission since it funds the project 'Open House'. This project is about creating a methodology for LCA that enables comparisons and ratings of various buildings in different local contexts [49].

6. Conclusions

Despite the existence of a global framework about life cycle assessment, the standards ISO 14040 and ISO 14044, there are some elements which are not defined precisely enough. The standards only provide a global framework, and no exact technique to calculate environmental impacts. Due to these elements, it is possible to conduct an LCA in various ways. As a result, the LCA research is in a fragmented state. However, life cycle assessments are still internationally accepted and are a useful tool to assess the environmental impact of a product, based on its life cycle. The importance of LCA in the construction sector is still increasing, inducing a more frequent use of this tool. In this respect, the occurring problems are internationally addressed in various ways. In the meantime, it is important to communicate about life cycle assessment research in a transparent way, with as much information as possible. In this way life cycle assessments can be interpreted correctly.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

The Sustainable Infrastructure Through The Construction Supply Chain Carbon Footprint Approach

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Abstract

The sustainable development concept is an important issue in construction industry, which becomes important mainly because of its role in infrastructure provision. Infrastructure availability will affect economic growth and increase a country's competitiveness. Indonesia as a developing country still needs to build a lot of physical infrastructure. The concept of sustainable infrastructure development is in line with the Indonesian government's development plans for the period of 2014-2015 called Nawa Cita. Carbon footprint modelling is one of the methods that contributes to the realization of sustainable infrastructure development. This paper describes the approach of sustainable infrastructure development through carbon footprinting in the construction supply chain. In the construction industry, carbon footprinting gives information in total emission of carbon dioxide (CO2) in every stage of a construction project's supply chain activities. In creating a carbon footprint model, life cycle analysis (LCA) is used as a supporting instrument to estimate the carbon dioxide (CO2) emissions in each stage of the supply chain activities. It is shown that the implementation of sustainable infrastructure development needs a synergy from all parties involved in the construction supply chain.

Keywords: Sustainable development concept, Carbon footprint

1. Introduction

The sustainable issue is a growing issue almost in all sectors such as industry, economy, infrastructure, etc. The issue continues to grow and becomes an interesting issue that a lot of research has been conducted to generate a real

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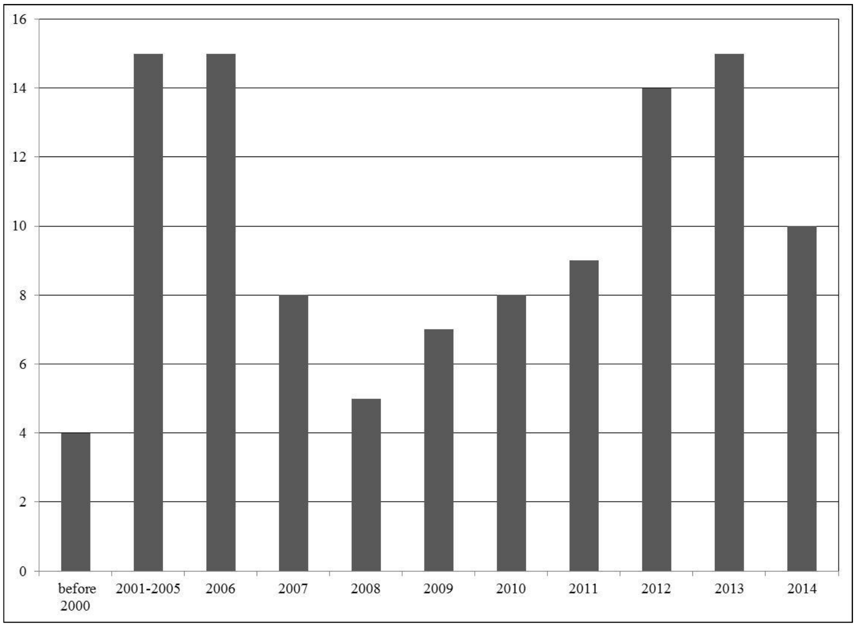
and effective action on defining the sustainable concept [1]. The today's sustainable growing issue also becomes a challenge to all countries. This means the sustainable issue has become an important issue from micro level (supporting sectors of human life) to macro level (all countries). The development of sustainable issue can be seen from year to year based on publications done by researchers. Figure 1 shows the research in sustainable issue has been started before the year of 2000, precisely in the year of 1987 through various scientific publications.



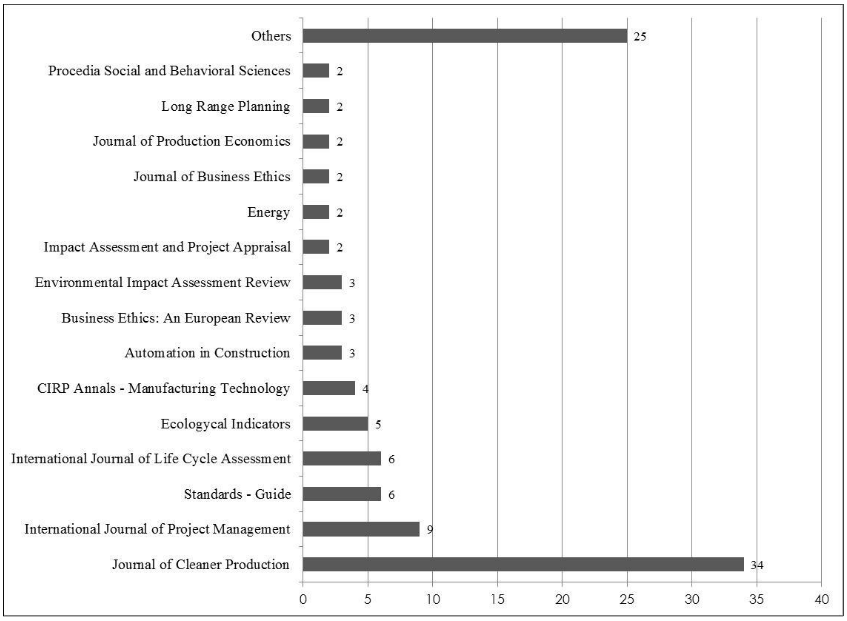


Fig. 1. The distribution of sustainable issue research based on time and publication [2]

As described in the previous section that the sustainable issue has become a challenge to all countries, including developing countries. In this context, the challenge faced by developing countries is how to provide their infrastructure development needs. In other words, the sustainable issue becomes a concept which underlies a sustainable development especially in providing the infrastructure. The availability of adequate infrastructure will boost the economic growth [3]. Yet, factors such as poverty alleviation priority, human resources strengthening, capacity building, socio-cultural and environment can't be ignored in the attempt to boost the economic growth. Therefore, the implementation of sustainable infrastructure should have an element of harmonization with other factors. Likewise Indonesia as a developing country, the sustainable infrastructure matter also becomes a challenge. There are two main challenges to implement the sustainable infrastructure in Indonesia. First of all, as being part of the world we are responsible in taking care of the environment especially in the relation of global warming. It means that the implementation of sustainable infrastructure should be able to reduce the greenhouse gas effects, one of which is reducing carbon dioxide (CO_2) emission. The other challenge is to accelerate the economic growth through MP3EI and Nawa Cita which become the vision of the Indonesian government.

Table 1. The needs of infrastructure investment in Indonesia.

No.	Economic corridor	Investment (IDR Billion)
1.	Sumatera	474.964
2.	Jawa	798.235
3.	Kalimantan	127.357
4.	Sulawesi	68.451
5.	Bali – Nusa Tenggara	43.210
6.	Papua – Kepulauan Maluku	161.627

Source: MP3EI, Coordinating Minister for the Economy, 2011

2. Literature Study

2.1. The Sustainable Development Concept

The construction industry which is part of a sector that supports economic growth is also faced to the sustainable development challenge. Started in the year of 1987 on Bruntland Comission Report, the concept of sustainable development becomes popular in construction industry [3]. Then it is followed up in the international conference of Rio de Janeiro Summit in 1992. The conference produces a resolution known as Rio Declaration on Environment and Agenda 21. This meeting is resumed in international conferences such as in South Africa Summit in 2002. Through meetings and conferences held in several countries, it is concluded that the sustainable development becomes a necessity to all countries mainly because it will affect a country's competitiveness. [4] The relationship between sustainable development and country's competitiveness is: the proper designed of environmental standards can trigger innovations that lowered the total cost of a product or improve its value. Such innovations allow companies to use a range of inputs more productively from raw materials to energy to labor e thus offsetting the costs of improving environmental impact and ending the stalemate. Ultimately, this enhanced resource productivity makes companies more competitive, not less. Figure 2 shows the relationship between sustainable development and country's competitiveness into a model.

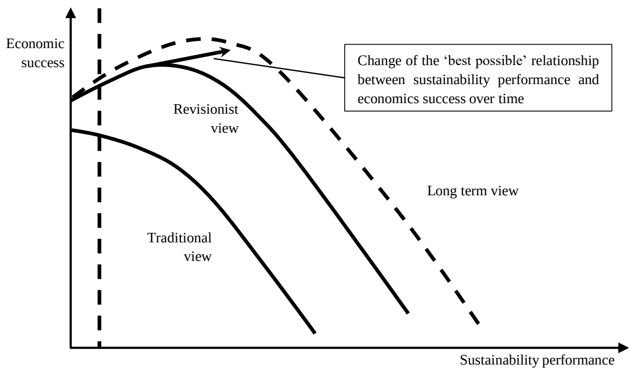


Fig. 2. The Phenomenological relationship between sustainability performance and economic success [5]

The above model shows there are 2 (two) kinds of view in this matter, traditional and revisionist view. The traditional view assumes that a development which seeks to prevent environmental damage will reduce its profit and the presence of regulation as an attempt to protect environment will cost the development. While the revisionist view assumes that a sustainable development will benefit the development. This revisionist argument is improved by researchers to implement the sustainable development concept.

The sustainable development concept then also becomes important for construction industry as a part which becomes the infrastructure provider. The sustainable development concept has been adopted in construction industry since 1994. The ground of sustainable development in construction industry is based on 2 (two) aspects, which are efficiency in the use of resources and ecological principles [6]. Yet, not all parties involved in construction industry have performed the practice of sustainable development concept. The implementation is still weak actually [7]). The biggest challenge of sustainable development practice in construction industry is a matter of material, technique, skill, innovation and management practice which related to construction supply chain [8]. An attempt to perform practice of sustainable development in construction industry is developed into various models and instruments. As for some models were developed in order to develop the practice of sustainable development in construction industry can be seen in Table 2.

Table 2. Model and criteria of the sustainable development practice in construction industry [9]

Objectives	Criteria	Metrics
1. Operational Environmental performance (ENV)	1.1. Carbon footprint index (CFI)	*cf_1*: Total amount of greenhouse gas (GHG) emissions caused by energy consumption of the housing unit and expressed in CO2 equivalent emissions (CO_2e)
	1.2. Water usage index (WTI)	*wt_1*: Total amount of housing water consumption (US gal)
2. Social quality of life (SQOL)	2.1. Thermal comfort index (TCI)	*tc_1*: Predicted percentage of dissatisfied (PPD) index (%)
	2.2. Indoor lighting quality index (LQI)	*lq_1*: Annual average daylighting illuminance (Lux)
		lq_2: Total hours exceeding glare comfort level in a year (hours)
	2.3. Indoor air quality index (AQI)	*aq_1*: Points achieved by performing the EPA recommended air quality caused by ventilation rate (%)
		aq_2: Percentage of dissatisfied people (PD) from indoor air quality by ventilation rate (%)
	2.4. Neighborhood quality index (NQI)	*nq_1*: Education level (%)
		nq_2 : Safety level (%)
		nq_3: Health conditions (%)
		nq_4: Economic conditions (%)
		nq_5: Environmental conditions (%)
3. Life cycle cost (LCC)	3.1. Life-cycle cost (LCC)	*lc_1*: Initial investment cost (US $)
		lc_2: Operation and maintenance cost (US $)
		lc_3: Energy and utility cost (US $)
		lc_4: Capital replacement cost (US $)
		lc_5: Residual value (US $)

Table 2 shows a carbon footprint is one of the model which can be used to modeling the sustainable development practice in construction industry. The carbon footprint is a total amount of carbon dioxide (CO_2) emissions produced from activities within construction industry. Those carbon dioxide (CO_2) emissions would have a domino effect. It means that each stage of the construction industrial activity contributes to the size of carbon dioxide (CO_2) emission to be produced. Therefore, if carbon dioxide (CO_2) emissions from each construction industrial activity starting from upstream to downstream are summed, it will obtain the carbon footprint. This provides information that a project management will impact to the carbon footprint. As previously described, the project management especially supply chain practice is also becomes the part which contributes to carbon footprint. Modeling the carbon footprint requires an instrument that functions in accessing the size of carbon dioxide (CO_2) emission from each activity in construction supply chain. One of the instrument used is a life cycle analysis (LCA). The LCA has been used in construction industry, especially to analyze a building's life cycle [10].

2.2. The Carbon Footprint

A footprint concept is pioneered by Wackernagel, and Rees, (1996) [11] in Columbia University, which aims to explain the impact of human activity. In its development, the footprint concept is used as an embryo of carbon footprint. The footprint phrase is very wide and used in various sectors such as transportation, urban, university's activity, infrastructure, and construction. Some definitions of carbon footprint taken from several sources are as follows [12]:

- BP, 2007 defines a carbon footprint as the amount of CO_2 produced from daily activities.
- a carbon footprint is a methodology to estimate the greenhouse total effects, one of it is CO_2 from the entire cycle of a product which is started from raw material extraction used to create certain product in manufacturing process,
- a carbon footprint is a technique to identify and quantify the greenhouse gas effects from each individual activity in every process of supply chain in producing product,
- a carbon footprint is a size of greenhouse gas effects from the impact of human activities on environment which is equivalent into ton of CO_2,
- a carbon footprint is a size of CO_2 amount produced by direct or indirect combustion
- a carbon footprint is the total amount of CO_2 and other gases from greenhouse gas effects produced from a product's cycle as a whole. The size of CO_2 is expressed in gram of CO_2 equivalent per kilowatt hour per kilowatt hour (gCO_2eq/kWh), for each gas produced from greenhouse gas effect.

Based on the definitions of carbon footprint, it can be obtained keywords as an attempt to measure the amount of CO_2 from each activity. Thus, it can be concluded back that a carbon footprint is a measurement of the total amount of CO_2 caused by an activity, either directly or indirectly. The carbon footprint size of an activity is greatly influenced by the length of process occurs in the activity.

2.3. The Supply Chain

The complexity of parties involved in construction project requires a management of the planning stage to the implementation stage. This complexity started from the upstream to the downstream parts. There's a construction material industry that functions as a supplier at the upstream part. While at the downstream part, there's a construction project as a customer / user of construction material. Besides, other parties such as planner, contractor and owner are involved in its process. Therefore, it appears that the construction project will always consist of a lot of varied and complex participants.

The number of parties involved in construction project can be described into a network called supply chain. The characteristic of supply chain in construction involves dozens and even hundreds of parties started from construction material supplier and service which support the project realization [13]. Figure 3 describes the complexity of construction's supply chain involving a lot of parties such as the service provider which consists of financier, structure service provider, mechanical, electrical, architecture, and the material provider which consists of building material / product supplier and subcontractor.

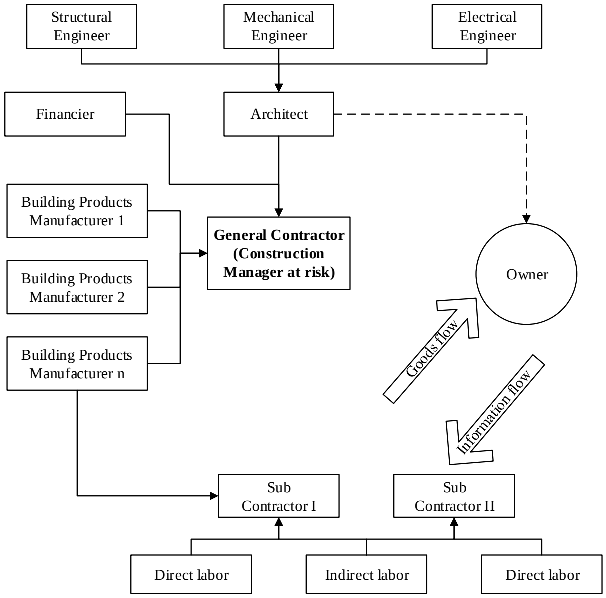


Fig. 3. Construction supply chain [14]

The principles revealed in Figure 3 can be detailed into the concept of supply chain in construction project which is described in Figure 4. The supply chain in construction project is a relatively new concept that is more recognized in the manufacturing industry. In its development, due to the numbers of parties involved, the supply chain in construction project needs to be controlled. The control is certainly based on the triple constraints in construction project, which are cost, quality and time. So that, if the supply chain is not being controlled, then the supply chain design will potentially increase the project's cost by 10% [15].

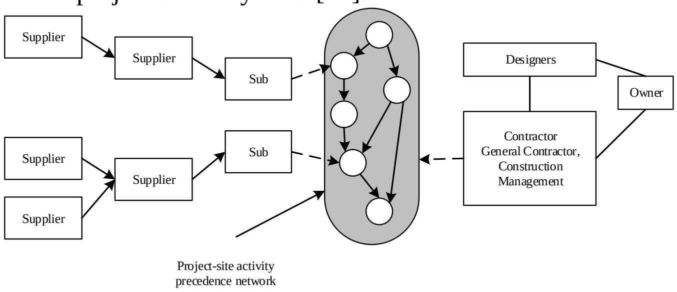


Fig. 4. The conceptual of supply chain in construction project [16]

As the presence of global warming becomes a challenge either to any sectors or to all countries, the supply chain in micro level also has the same challenge. There are some relevancies between supply chain and global warming, which are (a). transportation modes used in the distribution line of one party to another produces exhaust gases. One of these gases is carbon dioxide (CO_2) emission which is very significant to the escalation of global warming as it's part of the greenhouse gas effect; (b). energy / fuel is required in each stage started from the upstream to the downstream part. The used of energy / fuel will produce various greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), nitrogen dioxide (N_2O), hydrofluorocarbon (HFCs), perfluorocarbon (PFCs) and sulphur hexafluoride (SF_6) [17].

On the other hand, the global warming issue can not be stopped, giving an understanding that the supply chain owned by the construction project must be designed and controlled with the ultimate goal to reduce greenhouse gas effects especially carbon dioxide (CO_2) emission [18]. One attempt to do so is by identifying every line which has the potentials to produce carbon dioxide (CO_2) emission. Of course it needs supports from the decision maker and regulation, so that the role of construction supply chain can reduce the carbon dioxide (CO_2) emission.

2.4. Life Cycle Analysis

ISO 14040 [19] defines a life cycle analysis as a technique to do the assessment of environmental aspect and potential impact related to a product by compiling or inventorying inputs and outputs which are relevant to the produced product, making an evaluation to the environmental impact potencies that related to the product's inputs and outputs; and interpreting the analysis and assessment result of impact from every stage related to the study object. The life cycle analysis studies the environmental aspect and impact potencies of the product cycle from raw material, production process, product usage and product disposal.

Figure 5 shows the stage of life cycle analysis which divided into four stages, which are:

- objective, scope and definition
  the first stage of life cycle analysis is defining the scope of study including the function of each part, study limitation, detail of each level and environmental burden that will be allocated in each level.
- inventory analysis
  the second stage of life cycle analysis is making an inventory of input and output related to the study scope.
- impact assessment
  at this stage, the evaluation to the environmental impact potency is done by using the life cycle inventory result and providing information to interpret the final phase.
- interpretation
  the final stage of life cycle analysis provides conclusion, recommendation, and decision making based on the study limitation which has been set at the first stage.

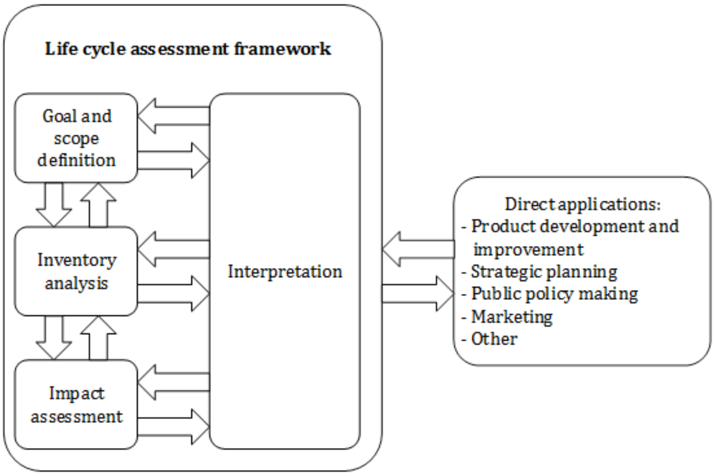


Fig. 5. The stages of life cycle analysis [19]

The scope of life cycle analysis can be divided into four kinds of scope, which are [20]:

- Cradle to grave, the scope is started from the raw material to the product operation.
- Cradle to gate, the scope of life cycle analysis is started from the raw material to the gate before the operation process.
- Gate to gate is the shortest scope of life cycle analysis because it only observes the nearest activity.
- Cradle to cradle is a part of life cycle analysis that shows the scope from the raw material to the material recycle.

3. Discussion

The sustainable development practice certainly has to involve all parties in the construction industry. Parties involved in the construction industry are influenced by the conducted supply chain, which in present paper is starting at the upstream part which is the industry that produces construction material and at the downstream part which is the user of construction material. Therefore, there's a new paradigm in the sustainable development concept that says a project's level of success is not only determined by quality, cost and time. Thus the environmental factor also becomes its parameter [21].

The following are some examples of existing sustainable development practice using the carbon footprint model.

- The carbon dioxide (CO_2) emission and carbon footprint model. The first stage conducted by [22] is compiling a work breakdown structure (WBS) which is divided into 3 level that are input, process and output. At the input section, the construction project is divided into several works such as preparation work, sub structure work and several other works. Those works are outlined under the resource needs, then the resource is mapped into direct and indirect emission and cost needs. The direct emission defines by [22] is an emission produced directly on-site as a result of the diesel and electricity fueled equipment usage. While the indirect emission is an emission produced from activity out of on-site such as manufacturing and transportation used for delivery. Based on this description, an estimation framework of carbon dioxide (CO_2) emission and carbon footprint can be described as shown in Figure 6.

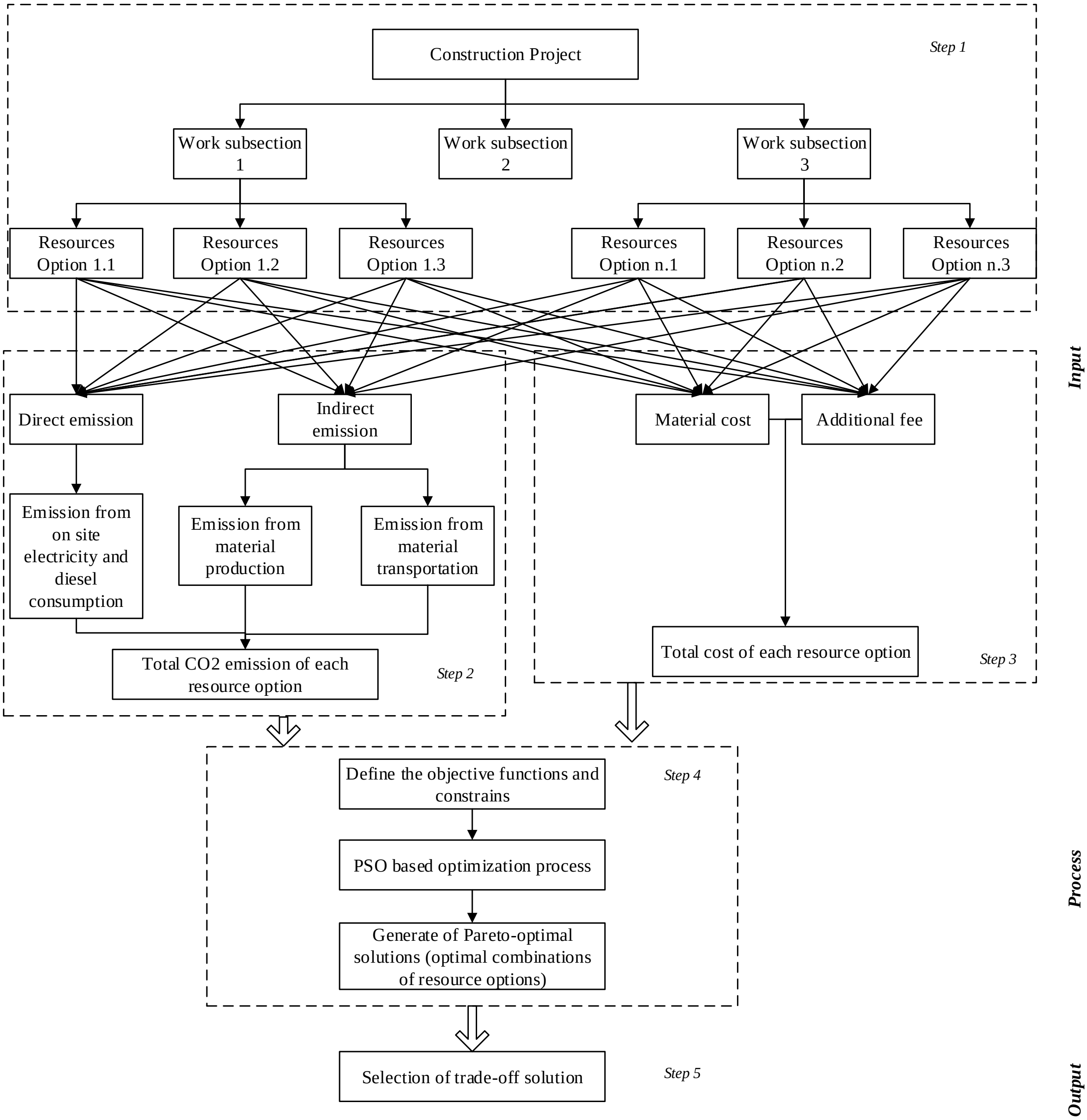


Fig. 6. The carbon dioxide (CO2) emission and carbon footprint model [22]

- The implementation of carbon footprint modeling in concreting work of high rise building construction in Indonesia [23]. Some of the running research is modeled as in Figure 7, which is the carbon dioxide (CO_2) estimation modeling in concrete casting work using a tower crane.

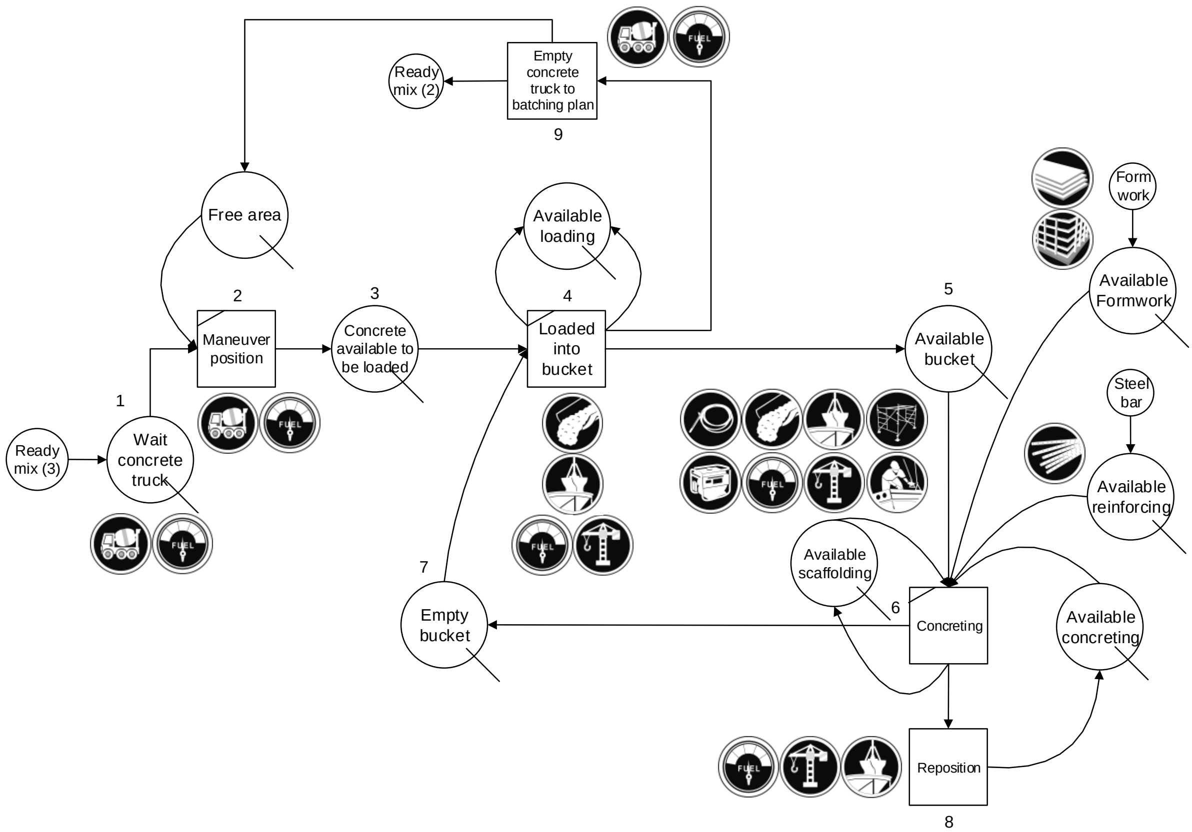


Fig. 7. The carbon footprint estimation model of casting work using a tower crane [23]

4. Conclusions

Based on description above, it can be concluded that:

a. The implementation of sustainable development requires a synergy between all parties involved in construction industry.
b. Industrial activities at the upstream part need a government regulation which related to the use of raw material and environment friendly material. The government regulation can be formed as a joint regulation from various ministries such as the ministry of industry and trade, the ministry of public works, the ministry of environment. The joint regulation is expected to affect the construction supply chain so it can reduce the greenhouse gas effects especially carbon dioxide (CO_2).
c. The construction implementations at the downstream part -which involves parties such as planning and contractor- need awareness to the sustainable development concept.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Retrofitting in the middle of project execution: a case public hospital building

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Abstract

Since the publication of the CIB's Agenda 21, local government has become an agent of change to achieve sustainability in development policy making, including implementation of building standards. The Indonesian Earthquake-Resistant Building Standard has recently been revised after considering sustainability and earthquake damage reductions by drawing lessons learnt from the past earthquakes. However, the readiness of building practitioners and local authorities to deal with those changes, particularly on the budget implications of project execution and appropriate procurement mechanism, has raised a number of issues. Several of these stem from the lack of awareness and consistency in educating practitioners and officials. As a consequence, the implementation of the new standard has been slow and problematic. This paper presents the case of retrofitting in the middle of project execution as the impact of implementation of new earthquake resistance standard in a public hospital building. The research undertook a structural simulation and field observation on an eight-storey public hospital building in Indonesia. The research found that capabilities of contractors and awareness of local authority among dynamical changes of policy implementation address the project success. The analysis suggests an empirical guidance the local authority for practical adjustments in governing retrofitting procedure in public building management.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: implementation; public building; earthquake-resistance; hospital.

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

1. Introduction

Following the earthquake phenomena into the building code has similar consequences as addressing awareness through climate changes. The earthquake impact to human population become an influencing factor to fit up the capabilities of stakeholder in terms of policy implementation and further action of prevention planning of project continuity. However, the biggest challenge in public building management which dealing with earthquake-resistant building in the middle of project execution could be an extraordinary case. In addition, a strategic building project like a public hospital also needs to carefully look along the decision making process by local authorities as a client, including retrofitting of hospital building. The adaptability of government among the critical situation to apply the new building standard needs the high consideration through the unpredictable side effects, such as adequate resources of material and experts, building project safety in a high risk activities during the retrofitting and non-technical effects (i.e. social or political impact afterward).

In the last two decades, the management of hospital buildings has been a notable topic in public building management and also the focus of property management [1–3]. Population growth has increased the demand of publicly funded healthcare infrastructure. As the loss of healthcare facilities and services in the post-earthquake is unavoidable, a consideration of adequate hospitals or healthcare unit services during crisis situation is an emerging research topic [1,4]. At the grass root level, local authorities should take a proactive role in making strategic decisions for policies adaptation amidst the increasing impacts of earthquake.

Hospitals are critical infrastructures during disaster emergencies. They are usually equipped with specific installation for emergency purposes. Generally, a hospital should have beds and sanitary facilities, patient support facilities, storage space and utility, whether fixed or movable equipments [5,6]. Following the provision of World Health Organisation (WHO) to anticipate the large number of injured people after the earthquake events, the physical structure of the hospitals should be resilient and be able to provide vital healthcare services after the earthquakes [1]. Attempts have been made to reduce the impacts of earthquake on hospital buildings in Chile, El Savador, Bangladesh, Turkey and Indonesia [4,7–9]. An example from Mexico earthquake in 1985 demonstrated how safe hospital buildings could be feasibly designed, constructed and properly functioning following the event. Adaptations of hospital buildings to withstand earthquake have been developed, and implemented in Japan and USA on large-scale investments to reduce the devastating impacts of the earthquake [6].

The the empirical evident this research present a real case from hospital building project at West-Java, Indonesia. This paper will be organised into five sections. Section 2 describes the research method. In the section 3, the structural model and following with the brief evaluation of building structure from column, beams and foundation. The discussion of engineering adjustment and policy impact will be presented. Section 4 tells about the findings and recommendation, which provides a synthesis of the simulation and retrofitting of structural elements. The last section is conclusion.

2. Method

The study utilises simulation model and observation on the public hospital project site. The structural simulation using structural analysis programme (SAP) by 3D frame analysis. The data was collected from the public hospital project, such as design drawing, field observation and interview with structural engineer and contractors of the building. The analysis also supported by field observations and corroborating evidence through reputable information. Based upon the ethical issues, the information regarding locations, name and persons who involved in the project case or related information that mention the institution of the third parties will be anonymous or implicitly described in this research. This paper will be focused in the structural analysis impact to the method of retrofitting building in the middle of project execution and draws the role of local authority in the execution and policy impact in the related stakeholders of public hospital building.

3. Result and discussion

3.1. Structural Model

The hospital building structure consists of two building blocks. Each block has eight storeys which have been separated by dilatations. The dilatation purposes to support the gravity load (dead load and live load) and seismic loads. Otherwise, whenever the soil settlement influences one side of the building, the building's settlement will not influence the strength of the other side of the building structure. There are homogenous columns of the hospital structure, which dimension is 70x70 square centimetres (sq.cm), from the first floor to the eighth floor. However, the perimeter portal has a various dimension of 60x40 sq. cm from the bottom to the top floor. The main beams of the structure have a dimension of 70x35 sq. cm by the span length of eight meters. The construction of building structure is supported by pile foundations, which sizes are 40 x 40 sq. cm and 30 x 30 sq.cm, located in 24 meters depth from firm soil layers.

a. Standard of Structural Analysis

The structural analysis was analysed by reference of Indonesian Buildings Standards, as follows: Loading Standard for Housing and Buildings [10], Standard of Reinforced Building Construction Calculation [11], Design Standard of Earthquake- Resistant for Buildings [12], Standard of Calculation for Steel Building Construction [12] and Design Standard of Earthquake-Resistant for Buildings and Non-Buildings [10].

b. Standard Quality of Material

The quality of material used setting up for the structural analysis, as follows: concrete material used f'c = 30 MPa and reinforcing used fy = 400 MPa.

c. Loading for Structure

The service load on the buildings' frame consists of Dead Load, Live Load and Seismic Load. The Dead Load (D) is calculated through the concrete structure's elements, which consist of their self-weight of slab, beam and column. Loads from floors' cover, ceilings and finishing load are determined to about 125 kilograms per square meter. The Live Load (L) caused by occupation activities for hospital buildings standard is 250 kilograms per square meter. The Seismic Load (Ex or Ey) refers to Design Standard of Earthquake Resistant for Buildings and Non-Buildings [10]. In regard to the dynamic analysis of the earthquake, the simulation was carried out using the Dynamic Analysis Methods by Spectrum Response from SNI 2012. Load Combination (Combo) for structural analysis consists of four combos:

Combo 1 : U= 1.2D+1.6L (1)

Combo 2 : U= 1.4D (2)

Combo 3 : U= 1.2D + 1.0L + 100%Ex + 30%Ey (3)

Combo 4 : U= 1.2D + 1.0L + 30%Ex + 100%Ey (4)

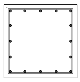
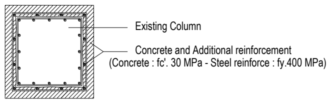
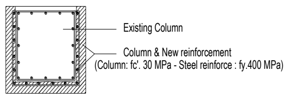
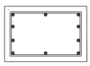
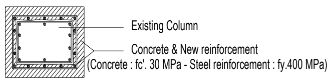
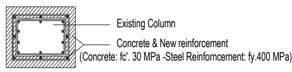
Where, D= dead load, L= life load, Ex = seismic load on direction X, Ey = seismic load for direction Y.

Evaluation of the strength of the concrete structure of the Public Hospital building was calculated based on the Standard Calculation of Concrete Structures for Buildings [11]. The design method for concrete structure employed LRFD (Load Resistance Factor Design), whereby the safety factor was used in the form of Load Factor and Strength Reduction Factor of Material.

3.2. Evaluation of Structure

a. Upper Structural Element: Column

The strength of structural column is examined by calculating the stress ratio of the existing columns. Stress ratio is the ratio between the stresses that occur in the column due to the combination of service loading on the structure with a column capacity based on the amount of reinforcement strength, which is applied. Column structures are stated quite strong if the value of the stress ratio is less than or equal to one (R ⩽ 1). From the structural analysis, the study obtained that the stress ratio for permanent load combination (Combo 1 and 2, Dead Load or Dead Load + Live Load) has a value of less than one. The maximum value of stress ratio revealed from permanent load combination is 0.86. Nevertheless, a stress ratio greater than one on the temporary load (Combo 3 & 4, Dead Load +Live Load +Earthquake Load) has been applied on the structure. Thus, it means that the retrofitting should be executed on particular existing column which stress ratios are greater than one. Regarding the retrofitting of structural column, the column with a stress ratio value greater than one (R>1) means that it needs to be strengthened to support the service load on the system of the structure. Thus, the retrofitting has been undertaken by enlarging the column dimension, both by resized geometric of the concrete body and additional reinforcement that is termed as Jacketing Method. The section details of the retrofitting colum are seen in Fig.1.

<table>
<tr><th>Difference</th><th>Existing column
(SNI-03-1726-2002)</th><th colspan="2">Retrofitting Column
(SNI-03-1726-2012)</th></tr>
<tr><td>Column reinforcement</td><td></td><td>
</td><td>
</td></tr>
<tr><td>Type of column</td><td>K1</td><td>K1PA</td><td>K1PB</td></tr>
<tr><td>Dimension (in mm)</td><td>700x700</td><td>850x850</td><td>850x800</td></tr>
<tr><td>Reinforcement</td><td>16D22</td><td>16D22+12D22</td><td>16D22+16D22</td></tr>
<tr><td>Stirrups</td><td>D10-100</td><td>D10-150</td><td>D10-150</td></tr>
<tr><td>Column reinforcement</td><td></td><td>
</td><td>
</td></tr>
<tr><td>Type of column</td><td>K4</td><td>K4PA</td><td>K4PB</td></tr>
<tr><td>Dimension (in mm)</td><td>600x400</td><td>750x550</td><td>750x550</td></tr>
<tr><td>Reinforcement</td><td>10D19</td><td>10D19+14D19</td><td>10D19+8D19</td></tr>
<tr><td>Stirrups</td><td>D10-100</td><td>D10-150</td><td>D10-150</td></tr>
</table>

Note: K1= column type 1 ;K4= column type 2; K1PA,B= retrofitting column type 1, mode A or B ;K4PA,B= retrofitting column type 2, mode A or B; D = deformed steel reinforcement (Source: As Built Drawing case building project, 2014)

Fig. 1. Reinforcement from Existing Column and Retrofitting Column

After the jacketing on the particular column which R<1 has been done, the structure has re-examined the post-stress ratio to detect the new performance reliability. The results by jacketing method denote that the value of the stress ratio of reinforced columns is less than one (R<1). This indicates the columns which have been strengthened are able to bear the load combinations (Combo 1 to 4) which have been applied to the system of structure (see some example column of Portal 1 and 7 in Fig. 2 (a) and (b)).

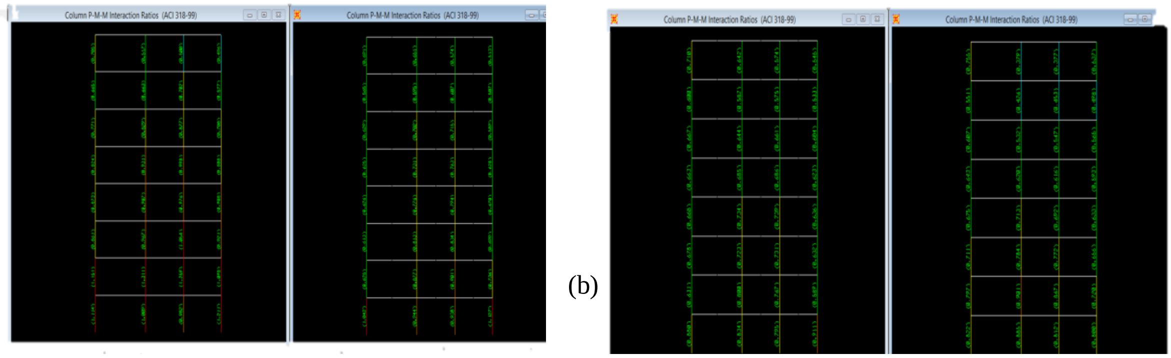


Fig. 2. Streesed Ratio Column of Portal 1 and 7 (a) before retrofitting; (b) after retrofitting

b. Upper Structural Element: Beam

Overall performance of structural beams is reliable to support the building loads, but the beams on the roof level still need strengthening from torque-moment. Therefore, the reinforcement increased from 2D13 to 6D13 (additional reinforcement is about 111 kilograms). Unfortunately, those beams which need strengthening have not been executed yet on the field.

c. Sub-structural Element: Foundations

c.1. Analysis of bearing capacity of pile foundations

The soil investigation report on the building location shows an indication that the allowed bearing capacity of one pile foundation (dimension 40x40 cm) is 120 tons. The allowable bearing capacity (Pall) of piles to support the load caused by Permanent Load Combination has been applied from the upper structure. However, based on the Indonesian Loading Standard of the Buildings, the allowable bearing capacity (Pall) tolerance can be raised up to 30 percent for cases of temporary load combination. Therefore, the allowable bearing capacity (P_{all}) becomes 1.3 x 120 = 156 tons. From the structural analysis on the case Permanent Load Combination 1 (D+L), the maximum service load on the pile foundation is 103 tons (less than Pall = 120 tonnes). Meanwhile, due to temporary load combination (Combo 2 to 3), the bearing capacity is 168.8 tons (greater than Pall = 156 tons). It means the foundation is only reliable to the permanent load combo; otherwise, on the service load or occupied, it still needs retrofitting for increasing load capacity. The node of foundation retrofitting exists only in two locations (J-1,2 and G-1,2), and the layout foundation retrofitting is shown in Fig.3.

c.2. Foundations retrofitting

The best solution of strengthening the foundation is through the addition of a bore pile with the diameter of 30 cm, 15 meters depth around the existing pile, and enlargement of the pile cap. If the first solution is not possible, another solution will need to combine the adjacent existing pile cap from the opposite node (See Fig. 2.) to be able to work together in the service load, especially during an earthquake, subsoil of composite pile cap needs to be fixed with grouting (cement + sand) to increase its carrying capacity.

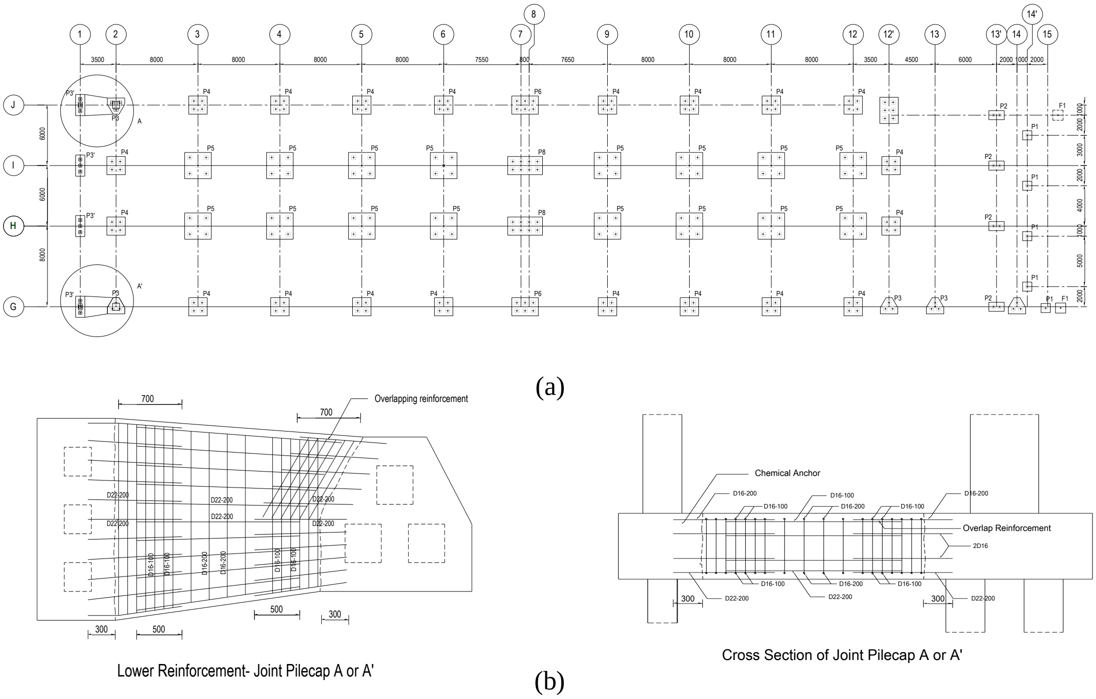


Fig. 3. Layout Retrofitting Foundations: (a) Layout, (b) Reinforcement

3.3. *Engineering Adjustment and Policy Impact*

According to structural simulation of hospital building, there were three elements to be concerned. Actually, the most consideration is given to the structural elements: column and foundation. Then, the engineering adjustment summary can be seen in Table 2.

Table 2. Summary of Structural Analysis

Structural Element	Retrofitting Action	Additional material			Comments
		Concrete volume (cu.m)	Reinforcement (kg)	others	
Beam (L retrofits =160 m)	Generally it was not required a serious treatment on the system structure, except the ring-balk on the roof level that needs strengthening against torque-moment.	N/A	111	N/A	Not costructed yet when the rotrofitting was recommended
Column	Retrofitting 30 columns (L retrofits= 4.2 m x 30 columns)	23.0	4805	N/A	Excluded installation works
Foundation (2 Nodes)	Combine 2 pile caps and increasing capacity by grouting of the subsoil.	8.4	234	Grouting + chemical rebars	Grouting: 6 node, @12 m + chemical technology for joining pilecaps
Total		31.4	5039		

Note : D = deform type of rebar, N/A = not applicable; Estimated for structural cost around IDR 100 million (< 10 percent of total cost = 700 billions)

The implication of engineering recommendation affects the large amount of reinforcement materials and a few concrete materials. The total concrete volume is 31.4 m^3, and reinforcement about 5039 kilograms of rebar (consisting of 111 kilograms for retrofitting roof-beam or ring-balk), 4805 kilograms for retrofitting column, and 234 kilograms for retrofitting foundation). Based on the structural analysis, the most reinforcement material predominantly by structural column particularly on the first floor.

In Table 2 found that the previous design of hospital structure still adequate at the most elements. The crucial element that induced by new earthquake standard need for retrofitting. For instance in the first floor column and specific location which have large service load (i.e. ICU and equipment or storage room). However, the higher risk of project stakeholder's decision is foundation retrofitting. In fact, the structure of hospital have been built at fifth floor and the reviewed design found that some foundation node (J ,1-2 and G,1-2) need for strengthening. In considering the situation of the project location, the stakeholders were decided to increasing capacity of two foundations node as recommended by structural engineer by grouting the subsoil.

Here, the cost implication is considered a constraint to execute such policy implementation. Somehow, local authority has been playing their role smoothly to accommodate the engineering adjustment to cost implication, as such dialogue between contractor and structural engineer is about reliable and feasible attempts in addressing retrofit actions, even case by case, day by day. In addition, the detailing process of the application of new standard of earthquake-resistant and intensive communication relies on the commitment among stakeholders. This case study confirmed that the harmonious role in public building management enables to reshape environmental changes.

4. Findings

The structural analysis suggests retrofitting action to some elements (see Table 2) of hospital building. The structural simulation and field observation concludes some implication through implementation of new earthquake-resistance standard:

4.1. Potential dispute between contractor and local authority

The retrofitting structure in the middle of construction works leads to the potential dispute between contractor and local authority. The first will be focused through the content of contract document and local authority compliance due to the national regulation in regard new building standard. Considering the safety factors of hospital building, the local authority's interests has a great deal in the long term impact of the compliance new standard rather than cost impact at the moment. However, conflict of interests amongst stakeholders probably emerging in the middle of project execution. Contractors won the tender of project with clear tasks from the previous contract document. Thus, in every single amendment based on the review design will affect to many aspects: the additional costs; re-scheduling project completion and investment of hospital operational; a new contract which dealing with specialist contractors for retrofitting; and local political issues such as labourers and experts resources in local buildings industry, legitimacy of local authority and local budgetary issue. In summary, many aspects can be a trigger for dispute between contractor and local authority, but at the same time the project management shift to the complex issues. In one hand compliance the new building standard is mandatory, at the other hand the consequences of the project risk increase and leads to the delay, threat the project safety and economy impact by internal or external parties.

4.2. Cost-implication of retrofitting activities

The review design of hospital building leads to retrofitting action and it means cost implication. Based on the calculation by the structural engineer, the impact cost of retrofitting works still less than 10 percent as tolerance by overhead of procurement cost. Nevertheless, the problems emerge from the capability contractors to overcome the retrofitting works, where the standard cost not included by local authority in the procurement (i.e. e-catalog or unit price). In other words, the real cost implication by retrofitting exists on the unpredictable cost and uncountable cost (i.e. delay of completion, risk value by investment or operational cost) due to the review design. The critical issue of additional-cost might be considered, particularly in accommodating that cases through the current procurement system. Basically, the project amendments due to building's retrofit should be brought to the broader issues to local construction industry. Cost-implication by the retrofitting activities could be categorized as new phenomena in local building practices that can be adapt to the procurement system of non-standard building case.

4.3. Administrative impacts of project procurement

The other impact of the implementation new earthquake-resistant standard is about administrative documents. Almost all changes of the project design implies to technical and non-technical documents. The technical document has been changed are: design drawings, shop drawing, unit price and procurement document (i.e. specification material and works, time schedule and progress report of hospital project). The non-technical documents such as contract document, payment document and local policy in public building (i.e. legitimacy of review design, minute of meeting as communication evident among key stakeholders).

4.4. The policy impact post implementation of the new building standard

The public building project at the local authority level still lack of "human resources skills and expertise capacity, adequate material resources", and only focus in " local budgetary allocation" [2:241]. In addition, the national reform and leadership in national level still become the internal barriers for the construction development sector [14, 15]. The implementation of new building standard has a greater impact in the discussion of public policy. Unfortunately, most of the public building stakeholders in the context of Indonesian building industry are still less of consideration through the interrelation impact. The collaboration of multidisciplinary parties draws a learning process and successfully demonstrates an adaptive manner through the policy implementation via retrofitting the hospital building.

The important aspect of the lesson learnt from this case study relies on the process of communication among local authority as a client (owner), engineers as an expert to provide the objective knowledge and contractors as an executor. As Stewart [16] argued that sometimes the decision process of local choice can be carried out far from the project goals. Moreover, Stewart stated that local government exists in contradictory situation between local priorities and common approach by legislation and regulation. However, the 'winning spirit of the project success' is effective communication toward the project completion. The project risk perspective successfully delivered the reconciliation among local authority, contractors and engineers. Finally, at the pinnacle success of the retrofitting action, the greater challenges exist on the readiness of local authority to prepare the operational instrument for the future procurement and an empirical guidance for practical adjustments in governing retrofitting procedure in public building management.

5. Conclusion

Retrofitting in the middle of project execution is risky activity, which needs outstanding capabilities in critical situation among key stakeholder. A hospital building project could be a representative of non-standard building at construction industry and its retrofit building standard unavailable previously at Indonesian local authorities. Thus, this research brought a new insight of relevant practical guidance for building stakeholders at local authorities. The adaptation of the new earthquake-resistant standard stipulates the local authorities' role to be more proactive toward compliance issues of national standard and local needs. The engagement among public building stakeholders in retrofitting the structure of hospital building in the middle of project execution consecutively imply in many aspects: project costs; administrative project documents in terms of payments and procurement document and others document from engineering adjustment from engineers, project management team and third parties who involved in the retrofitting actions.

There are complex situation during the decision making of retrofitting process, which has challenge for contractor to execute project in the dynamic environment. This case study demonstrates the potential conflict of interest, time management, and building effective communication under high pressure of project goals through the structural simulation and retrofitting procedures. A significant number of retrofitting implementation suggests some recommendation for retrofitting procedures in public building project. The successful retrofitting relies on the proactive roles of local authority to provide a conducive environment between contractors and engineers have been involved.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Industrialized timber building systems for an increased market share – a holistic approach targeting construction management and building economics

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Abstract

Due to the positive development of modern timber construction in recent years from a traditional niche market towards an industrialized business, a large number of designers, entrepreneurs and investors demand comprehensible basics of construction management and building economics aspects. Advancements of recently developed timber products and their application within the prefabrication process require standardization and unification of construction management processes which need to be scientifically proofed with cross company references. Professionalism of an entire industry plays a fundamental role in order to prepare practical use for a long term market share beside technical developments especially in terms of cost savings and standardization of building procedures. This current demand for the mass appeal of timber is accompanied despite the question of technical standardized system components by various economical key factors. These provide long term secure regarding costs, consistent quality, construction management optimization and sustainability. According to current expert surveys and cost investigations undertaken within this research, the integration of a consistent data workflow during the planning, production and installation process allows a significant shortened construction period with a major on site cost reduction as well as a sustainable approach to deliver a holistic construction management system for timber. Within this research field, the identified criteria and surveyed fundamentals are transferred into general construction management methods for the branch. Additionally the applicability was analyzed consequently to determine the future potentials and to generate appropriate and integral timber building systems. Especially modern timber construction methods are mostly suitable for prefabrication, caused by the material specific properties, its sustainable performance, the possibilities in prefabrication and the unpretentious assembly under dry construction circumstances. Therefore a high productivity combined with excellent quality in short installation periods provides verifiable arguments for best practice examples in the area of construction management of modern timber building systems.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: Timber construction; prefabrication; professionalism; standardization; cost reduction, sustainability; expert survey; cost analysis; performance.

1. The holistic approach

Due to the positive trend of timber construction in recent years from a traditional niche market towards an industrial and large scale business many decision makers request extensive basics on construction management and building economics for this specific material, which are scientifically proofed and can be used safely to lead their business and projects. Professionalism in the branch is therefore an absolute necessity and plays a fundamental role to ensure the practical usability beside recent technical developments with a special focus on cost reduction and standardization of workflows. The demand for the mass appeal of timber as a main building material is accompanied by the issue of technical system components but also business economics key factors in the field of costs, constant quality and optimization in construction management to provide long term secure. Therefore the question of standardized processes and production systems and their applicability in timber construction as well as existing process chains and its associated information interfaces and the recurring question on efficiency of the system used is the central theme of a holistic and comprehensive industry and system investigation and states the requirement for a clear structure on liability and decision matrix in the implementation settlement of timber construction projects. The research project “Industrialized timber construction – development & optimization of technical and economical timber construction system for the industrialized building with timber”, which was started in 2012/2013 at the Institute of Construction Management and Economics at Graz University of Technology, should provide basic knowledge and deliver decision guidance as support for professionals in the industry to be successful with the topic of industrialized timber construction from building economic aspect point of view [1].

1.1. Point of departure – why now?

Modern timber construction, which is understood by constant growth nationally and internationally, has evolved considerably in recent years especially in technical terms. Numerous product innovations contribute that timber grows from its infancy to a well-established timber system on the market, which can be implemented for the majority of large scale buildings and is radically different from the conventional timber construction known for centuries. Therefore, it is a logical conclusion and necessity that construction-related studies and construction management optimizations follow the technical developments.

The gaps of timber construction in terms of construction management or business economic aspects should be minimized and generated as a benefit for this building system. The background and input parameters for usual costing systems within special timber construction systems are not as well established as for traditional building materials such as steel and concrete [2]. With the help of investigative studies, research projects, information focusing and appropriate communication tools it is the main objective to generate the bases apart from practical experience without cross company reference and form a respectable background on data which is reliable for construction with timber and managerial decisions.

1.2. The chance of timber construction systems

The topic of the timber construction systems, in the broader sense the industrial building with timber, and the possibilities of systematization and rationalization in the construction industry bother people since time immemorial. Technological developments, the acute housing shortage after the world wars and the technical possibilities of serial prefabrication of individual construction and design elements allowed the planners and developers, especially during the last decade new approaches to integrate the ideas of industrialized building components in the conventional construction processes. Although initial attempts of modular prefabrication and systematic manufacturing were performed more than 100 years ago, automated building processes are hardly established in Central Europe till nowadays, regardless of the construction system or building material used. The emphasis in this analysis is thus based on the prefabrication of modern industrialized timber construction that is leaded by its light weight and easy process ability during prefabrication. Positive examples show the evidence of the steady development of industrial buildings with this construction material. However, the converted objects represent still prototypes. Also the experts interviewed in the survey, displayed later in this chapter, do believe that a useful form of industrialization by using system components is required via a consistent implementation for a successful substitution in the building objects.

2. Research approach

It is henceforth a key task in timber construction to establish an integrated building system that performs not only by joining single parts but also by implementing an industrialized building method using system components in an optimized construction management processes, taking the specific conditions into account.

2.1. Constraints and topics

The following main topics are considered to be relevant to generate a holistic approach [1]:

- Industrialized building with timber

Research is continuing in this core issue, to what extent the subject of an integrated industrialization of production processes in timber systems allows an industrialized construction and how this potential can be used and optimized in future.

- Modularity in timber construction

The topic of modularity in construction is considered by the investigation of the technical expansion within a building but also by prefabrication of entire 2D-elements and 3D-modules using fundamentally unchanging components with a high prefabrication grade, in which the material timber is the dominating production factor.

- Construction management in timber construction

The research deals with the usual methods in construction and tries to create an overall concept for a possible information loss-free operation. Due to the complexity and number of interfaces the implementation for a planning overview of timber construction includes mainly work scheduling, logistics and construction techniques.

- Turnkey building with timber

The research question is also raised to the extent to which a merging of the expertise within the turnkey branch and the timber skills is necessary and productive and how far it is possible to be combined, without sacrificing already established systems.

The goal of the research is therefore a holistic approach to a system solution for timber construction, which is technically and economically optimized. This includes an intensive investigation on construction management decisive factors, as well as an optimization in terms of building economic influences in large scale timber buildings.

2.2. Methodologies of research

To generate appropriate and widespread data within this research project three methods of data collection were used. Firstly an adapted methodology of REFA [3,4] was applied on site to receive facts and figures which relate directly to construction management and building economics considerations. Secondly expert surveys were conducted to receive appropriate answers on an extensive questionnaire regarding construction management themes. Thirdly extensive cost analysis on existing respectively coming projects were executed to determine cost breakdowns in conjunction with prefabrication.

Within this description the methodology of REFA as well as the results conducted on site are not included. Also the cost analysis undertaken on specific timber construction project is not part of this paper.

2.3. Expert survey on industrialized timber construction

However existing literature on specific topics regarding prefabrication within the construction management aspects investigated needed to be compared and verified by experts. Therefore accurate data and reflections on industrialized building systems with its advantages, constraints and challenges in future were investigated especially when it comes to timber construction methods and systems. To generate considerable data an expert survey was conducted from November 2014 to February 2015 [5]. The experts involved in the survey came from various disciplines such as architecture and engineering, builders and SME's, public and private investors as well as experts from the field of R&D. The results from this survey where then compared to the existing and comparable literature on these topics to verify the accuracy of the expert statements.

3. Construction management and building economic aspects

Especially the large variety of timber products developed recently and the encountered manufacturing process behind do include general construction management aspects such as modularity and prefabrication, turn-key building systems, reliable cost calculations and analysis, adequate integral planning tools as well as the existing discussion on the topic of interfaces between the involved trades. These themes were questioned in the expert survey included here.

3.1. Industrialized timber construction and modularity

To generate an industrialized building system a transfer is required of various industrialized functions from the stationary industry into the decentralized systems of the construction industry. The word prefabrication is used generally in the context when it comes to building in series and building in systems which includes mainly the production and construction with 2D-elements and 2D- or 3D-modules. Industrialized construction encompasses therefore a production of different building elements in an industry setup that is not subject to changes in weather [6].

Often it is implemented that building in systems is the typical building of the 1960's with its unification in repetitive multi-storey concrete buildings spread all over middle Europe. To achieve an economical advantage in comparison to other building materials at that time the building components were standardized and produced at a high quantity and always implemented in the same way. In contrast to that the introduction of the principles of lean production formed the leading production system which then changed the process completely [7].

Industrialized building systems are always generated by a combination of 2D-elements and 3D-modules in different circumstances. The impact factors have the opportunity to develop traditional building components into industrialized building components and systems without losing the advantages and significance of the individual tasks but generating a bigger benefit by using an intelligent combination of the planning and production factors [8].

This was found out in the expert survey by identifying the cost influence and chances using a higher grade of prefabrication within the finishing works. The expert opinions see a big benefit by using prefabricated 2D-elements and 3D-modules; however finalized turn-key 3D-modules are still indicated with higher costs but do show a very large opportunity in the upcoming years.

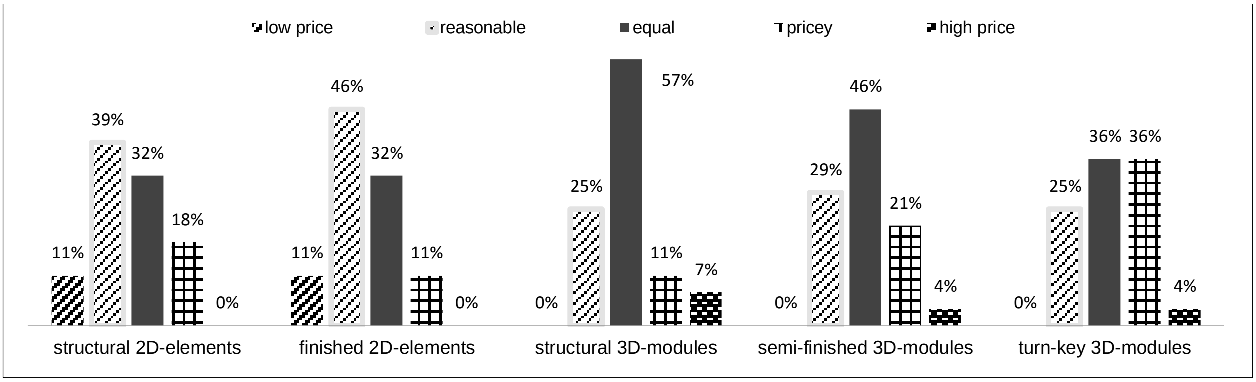

Fig. 1. Expert survey cost comparison of traditional to industrialized building systems [5].

3.2. Construction management and prefabrication in timber construction

Compared to various international research projects also the expert survey indicates that prefabricated building systems offer a positive trend and constant growth within the coming years. Especially multi-storey residential and commercial buildings as well as intra-urban and inner-city developments with industrialized building systems offer great advantages and a prosperous future.

Certainly the reasons for using industrialized timber building systems are not directly related to the material. The following figure originated through the expert survey states that especially the quality reasons, the lower general building costs on site as well as the much easier production system under dry and constant conditions do include the big advantages by using prefabricated building systems. An accurate production method as well as fast manufacturing and short installation time on site contain the main benefit by implementing more industrialized building systems within the general construction industry.

3.3. Turnkey systems in timber construction

The prefabrication grade in general offers a wide range for interpretation. There is a misleading lack of understanding even in specific literature and expert opinions conducted surveys on various economic results generated through the grade of finishing works within the prefabrication process. However the expert survey produced a constant increase of this market especially in the case of timber construction system with deep prefabrication [9]. The system includes also 3D-modules with a high grade of prefabrication as well as 2D-elements with almost finished surfaces internally as well as externally.

The required operation processes during the construction of timber buildings include mostly complex procedures and sequences, which need to be identified into depth to provide financial success at the end. This is especially the case in terms of turnkey systems when a high grade of prefabrication is set and many trades are involved in the project at the same time. As described these processes contain an intensive planning phase with a high level of detail in an early planning stage [10]. They also allow the possibility of big persuasibility prior the cost impacts of late changes rise significantly. The deeper the influences of turnkey systems gets in a project the more preparatory work is of major interest as the grade of prefabrication can only be ensured by a decent and extensive work preparation for all trades involved. This includes the planning of the production, the charts on expected time and construction progress, the set out of the required building site equipment on site, the planning of all necessary resources as well as the cost calculation implementing all those circumstances [11]. However not only the processes themselves but also the interaction in between these constraints and the interfaces need to be arranged accurately even more for prefabricated turnkey timber solutions.

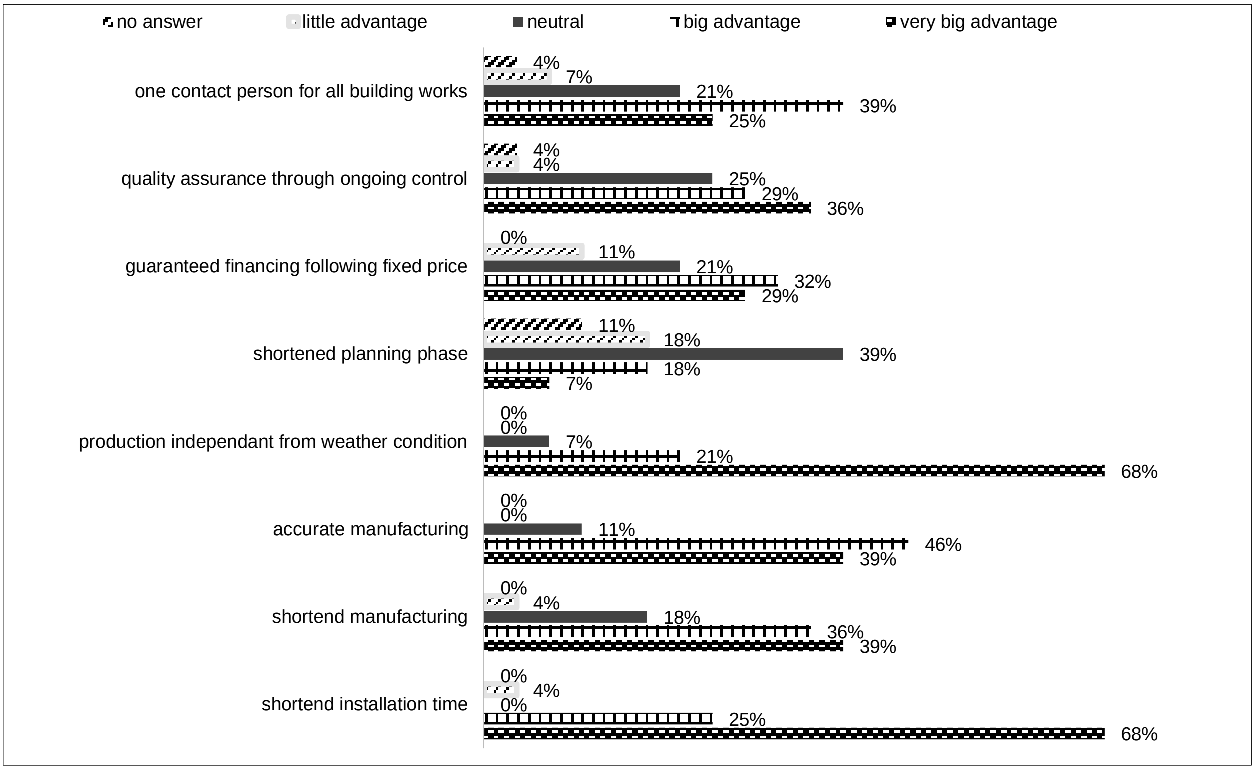

Fig. 2. Expert survey advantages of industrialized compared to traditional systems [5].

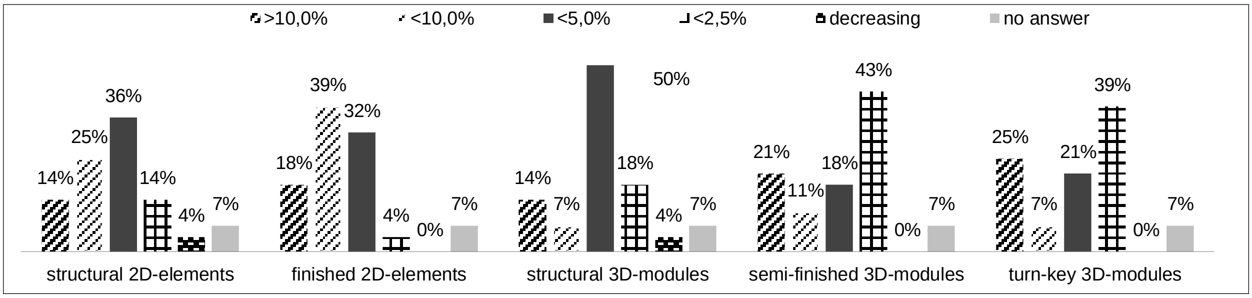

Fig. 3. Expert survey market development of industrialized timber building systems depending on the grade of finishing works [5].

3.4. Planning and tendering process of industrialized timber construction systems

Especially the discussion of planning systems, level of detail and somehow the simple questions of who is responsible for developing which detail and drawing, not only the timber industry has the discussion on responsibilities. As various timber products have been developed over the last years, a fast lack of knowledge appears not only in construction but also during the planning and tendering stage. A majority of current timber constructions are designed by specialized designers and technicians who are often working in-house in the timber industry. However many of these designers and planners as well as the general planning community with their standard education and training on conventional building systems cannot comply and fulfill the required level of detail for an appropriate timber solution. This does offer a big chance for a specialized planning industry to develop new and simple integral planning systems and tools which have a big potential for market developments in the future. On the other hand the existing large variety of new materials, building systems, possible details in the connection as well as building physics and entire timber building systems contain a risk of failure by incorporating too much variability for simple planning tasks. The more complex a 3D-systems has the exorbitant higher is the risk when implemented. So the implementation of existing and newly developed integral planning systems and tools such as building information modeling (BIM) etc. is required for the entire timber construction industry in future [12].

The big increase in complexity within the construction industry and especially in the timber section has a very big impact and offer challenges but also restricting constraints. Especially the fact that newly developed building materials and products have a rather low level of trial and error and impound the risk when implemented in today's building systems can be quite high. The number of interfaces increased rapidly over the last decades as numerous trades and business entered the construction market. The level of detail is far higher than 10 to 15 years ago when many details were solved on site and the simple question of how a new systems should be implemented in conventional buildings did not exist. Todays mostly complex CAD-CAM systems offer the chance to reduction on risk and by failing through too many interfaces. In many cases just-in-time deliveries of products, systems and services need to be implemented in standard structural elements. They offer a big chance on one hand especially cost wise. However the majority of costs nowadays are generated by building services engineering instead of structural components and level of details [13].

4. Developments and tendencies

The industrialized timber building division, which differentiates significantly from the traditional carpentries by the implementation of automated production and prefabrication methods has been developed constantly by introducing technical developments on the material level on one hand as well as computer based manufacturing processes on the other hand over the last decades [14].

The high potential of timber construction systems lies in the short installation period required on site in comparison to existing conventional and traditional building systems used nowadays. Especially the prefabrication of 2D-elements and 3D-modules deliver many arguments for a wide use of timber as the main structural material. However the cost impacts are still commonly used as arguments against timber as the leading material as these costs are hardly quantifiable and ratable in comparison to conventional building systems caused by a lack of knowledge.

4.1. Potentials of prefabricated timber construction

Even though timber as a leading construction material has a high potential for pioneering tasks especially when implementing turnkey strategies by transforming the technical advantages of a material into an integral building systems [8], the positive trend in the last years is still expandable. This is proofed by various investigations and literature as well as the expert survey incorporated in this research project. However more effort is required apart from technical and material sector but also in the building economic domains [15]. Particularly a high planning reliability and a better quality assurance with a wider standardization of building components in sum and in detail as well as standardized system components for general application are necessary within the planning and management process to professionalize and entire branch.

Additionally the constantly rising demand helps to develop a comprehensive and detailed prefabricated timber construction system in conjunction with neutral cost studies [16] to benefit from the effects of an industrialized construction and adaptation of building regulations mandatory. Therefore this helps to create an additional step towards professionalism and industrialization in the building industry by the implementation of turn-key concepts in order to generate meaningful construction management tools to allow ecological friendly material to become a widely used standardized building system.

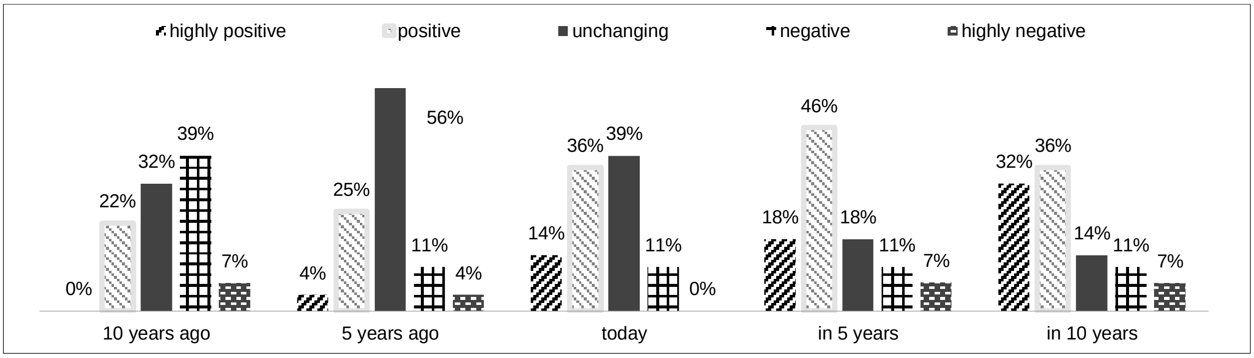

Fig. 4. Expert survey potential of modular timber building systems [5].

The high potential of timber construction can be spotted mostly in the short period of installation required on site. Also less site installation equipment is corresponding with smaller areas required for temporary storage. Apart from non-influence able weather conditions the installation time is mostly affected by the grade of prefabrication, the lifting facilities as well as the installation performance of the team on site. However these arguments are not commonly used as they are difficult to be quantified and rated. Mostly cost facts and time influencing circumstances are difficult to be split between the collaborating companies and their interfaces. Timber has a very high potential to become an integral building system widely used especially when turnkey strategies are implemented. To extend the successful way even further much more effort is required also within the scientific community not only in the technical sector but more than ever in the construction management and building economic segment to allow the usefully and ecologically friendly material to become a widely used building system.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Dynamic modelling of the relation between bidding strategy and construction project performance

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Abstract

Strategy is required in order to win the competition. Bidding strategy in construction is defined as a management skill of using all available resources, both physical and financial, to offer a comprehensive and competitive bidding, with an aim to win the competition, and provide maximum project performance. There are many factors that influence construction bidding strategy, and many indicators of project performance have to be considered. Therefore, the relation between bidding strategy and project performance is very complex. Contractors have to consider this very carefully, and they have to evaluate their bidding strategies to ensure that the company goals have been achieved. Dynamic system is a method for develop a management simulation using computer, and helps the study of dynamic complexity; understand the source of policy resistance and helps the design of more effective policies. Furthermore, dynamic system is explained as a tool simulation system that is able to solve the problem of system complexity and also can present behaviour of real world. The study aims to develop a dynamic model and the simulation of bidding strategy and project performance. Case study was carried out in the major contractor in Denpasar, and the analysis used is *System Dynamics*. The model demonstrated that bidding strategy had a direct impact to project performance. The model simulation found that the enhancement of bidding strategy by 13.67% improved the project performance significantly, by 10.55%, from bid price.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: Bidding Strategy; Project Performance; Dynamics Modelling

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Peer-review under responsibility ofthe organizing committee of SCESCM 2016.

1. Introductions

Strategy is how the company achieves a goal. Park (1979) in [1] outlines many definitions of strategy such as skillful of company management of their financial and physical resources, to reach the company goals that have been established; meeting the science and art of the management under the most advantageous condition possible; handling plans or methods carefully; management of ideas related to the firm's objectives, and how to realize these company goals and the reason to achieve them. In the simplest terms strategy means a plan for company success. However, bidding strategy in construction is not only aiming to win the competition, but also intended to achieve project success and make a profit. Therefore, the ideal outcome is that the contractor wins a project and a good performance is achieved, through the profit that has been planned. Strategy is necessary in this process because the contractor is faced with uncertainty. In addition, many factors influence the bid/no bid and mark up decisions.

2. Literature References

2.1. Bidding Strategy in Construction

Bidding is a proposal based on the requirements or specifications which have been specified to do something, submitted from one party to the other. Bidding strategy in construction comprises of two important decisions, including whether to bid or not bid; and the mark up level to be adopted. When contractors are faced with competition, two extremely unpleasant options present themselves. First a low bid proposal with high possibility of winning the competition, but an excellent chance of making no profit, and second a high bid with no chance at all of winning the competition or making a high profit. These are two extreme options, therefore a contractor must consider other alternatives, which allows the obtaining of a reasonable profit. A contractor's decision is influenced by many factors. Based on [2], [3], and construction practitioner interviews, there were three groups of related variables, identified as external, internal and environment factors. The internal factor consists of the client characteristics, project characteristics, and contract. External factor consists of business benefit, project financing, company characteristics, and company experience. The environment factor includes bidding situation, economic condition and the competition. Through bidding strategy contractors intend to not only win the competition but also implement the project in accordance with specifications, so the project can generate maximum performance.

2.2. Project Performance

The project success has to be evaluated through many criteria. Key performance indicators (KPI) is one of the frequently-used criteria [2]. But multidimensional performance criteria from other authors also propose to construct, based on empirical research [4], proposed that projects are carried out in order to generate business advantage. Thus a project is a strategic tool to produce economic value and competitive advantage while the project manager is a strategic leader who is responsible for producing expected business results. Hence the efficiency of the project, the effect on the customer, and expectation of future business, factor in the project success consideration. According to [5] project performance variable consist of six sub variables such as cost, time, quality, productivity, safety and project environment.

2.3. System Dynamics

According to [6], the dynamic system is a method to improve learning in complex systems. Learning about complex dynamic systems require the relevant technical basis to create a mathematical model. The model is an abstraction or simplification of the real world, which is able to describe the structure and interaction of elements and overall behavior in accordance with the view point and the desired goal. Furthermore, valuation of models is how far the model was useless***, so the usefulness of the model as a predictive tool, on the accuracy and precision of the prediction.

3. Methodology

The case study was carried out in one of the major contractors in Denpasar. One of the projects is taken as a case. The preliminary data was collected due to basic prices of the project such as material prices, wage rates, the price of equipment and methods. Hereinafter was determined the mark up price, based on the factors related that influence bidding estimate: internal, external and environment factors. This research uses the system dynamics method, which is divided into four stages as shown in Fig. 1. The first stage is developing a conceptual model. The conceptual model was developed from literature review related to bidding strategy and project performance. The second stage was collecting data through the process of bidding and the project report. The third stage was to develop dynamics modelling, which consist of developing a causal loop and stock flow diagram. The final stage was simulation and analysis. Modelling of the relation between bidding strategy and project performance was analyzed using system dynamics with Powersim 2.5.

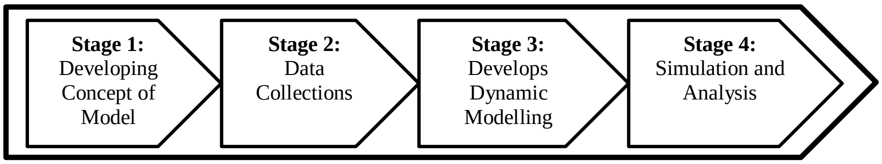

Fig. 1. Research Conceptual Model

4. Analysis and Discussion

4.1. Concept of Modelling

The research on the messo level found that the strategic decision had a direct impact on company performance [7]. The most strategic decision was strategic project selection. Based on this relation, the previous research also found that there is a direct impact of bidding strategy on project performance [3]. The modelling of this research is limited to the micro level/project level, namely the relation between bidding strategy and project performance. Figure 2 displays a conceptual model of strategic bidding and project performance.

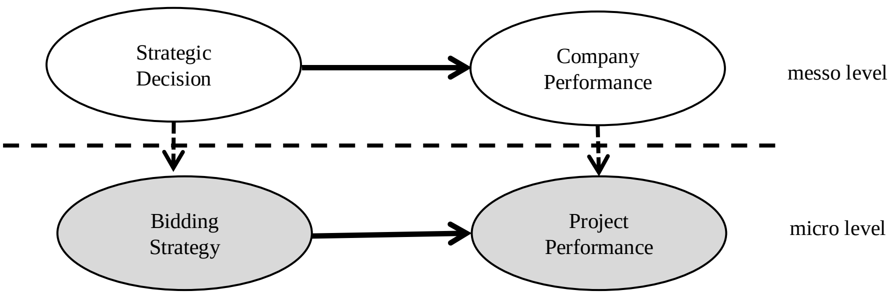

Fig 2. Conceptual Model of Bidding Strategy and Project Performance

Concept of model was built based on static analysis according to the dominant factors, as well as conditions and data available in the company. Therefore, not all of the variables in the static analysis is used in a dynamic model. Hereinafter variables of bidding strategy and project performance in the analysis are considered as sub-systems. Each sub-system consists of several sub sub-systems. The Sub-systems and sub-sub-systems of model are shown in Table 1.

Table 1. Sub System and Sub sub-System of Model

Sub System	Sub-Sub System
Bidding Strategy	A. Basic Price
	1． Cost of Material
	2． Cost of Labour
	3． Cost of Equipment and Methods
	B. Mark Up
	1. Economic Situation
	2. Competition
	3. Contract
	4. Company Characteristics
	5. Company Experience
	6. Project Characteristics
	7. Client Characteristics
	8. Project Financing
	9. Benefit
	10. Bidding Situation
Project Performance	1. Cost/Project Profit

4.2. Causal loop Diagram

Causal Loop Diagram is the disclosure of the incident causal relationship of a process that is poured into the language specific images as shown in Fig 3.

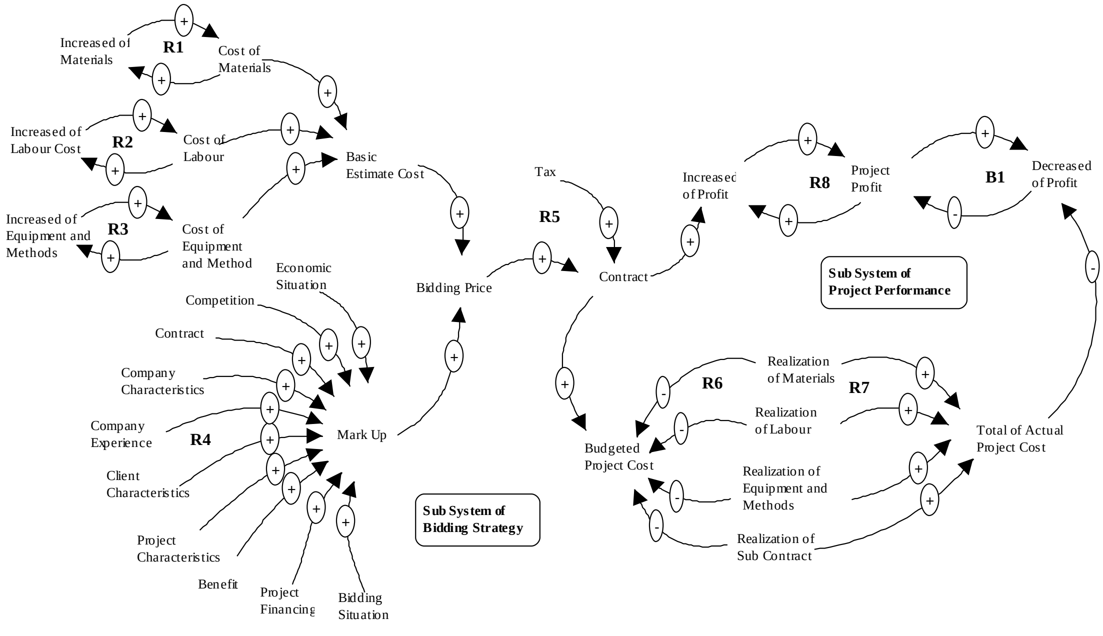

Fig 3. Causal Loop Diagram

Dynamic system describes the elements that exist in the system that interact in a feedback (causal loop) and will produce a particular behavior. The causal loop diagram is developed based on the feedback process. In other words, a causal loop is a visualization of the feedback loop system. So the characteristics of a dynamic system lies in the feedback. According to [6] causal loop diagram can be used in various situations and conditions, because the causal loop can present the linkages between elements forming and feedback process. Causal Loop diagrams are used to understand mental models and represent interdependencies and feedback in the system. Two types of feedback loop are positive and negative. Positive feedback is defined as a rise or fall of causes that lead to the rise and fall of consequences.

From Fig 3 sub-system of bidding strategy consists of two groups, base price and mark up. The first group is base price and consists of three elements: material prices, wages and equipment and methods, with positive loop R1, R2 and R3. Therefore, the increase of material prices, labor wage and the equipment and methods are mutually reinforcing. The second group is markup, consisting of ten elements i.e. the economic situation, competition, contract, characteristics of the company, the company's experience, client characteristics, characteristics of the project, benefit, project financing and the bidding situation, that formed the R4 positive loop. An increase of the ten elements will increase the mark-up. R5 is positive loop. Sub system project performance consists of four loops i.e negative loop R6 and B1, positive loop R7 and R8. B1 is negative loop, in which project costs and project overhead costs will reduce the profits so they balance each other.

4.3. Stock Flow Diagram

Stock Flow Diagram is a manifestation of the dynamic model that mimics the real world and built based on the Causal Loop Diagram as shown in Fig 4. This model consists of two sub systems namely sub system of bidding strategy and sub-systems of project performance. Bidding strategy is indicated by bidding price and project performance indicated by project profit. The model presents the relations between bidding strategy and project performance, and this study takes the case of building projects such as public buildings.

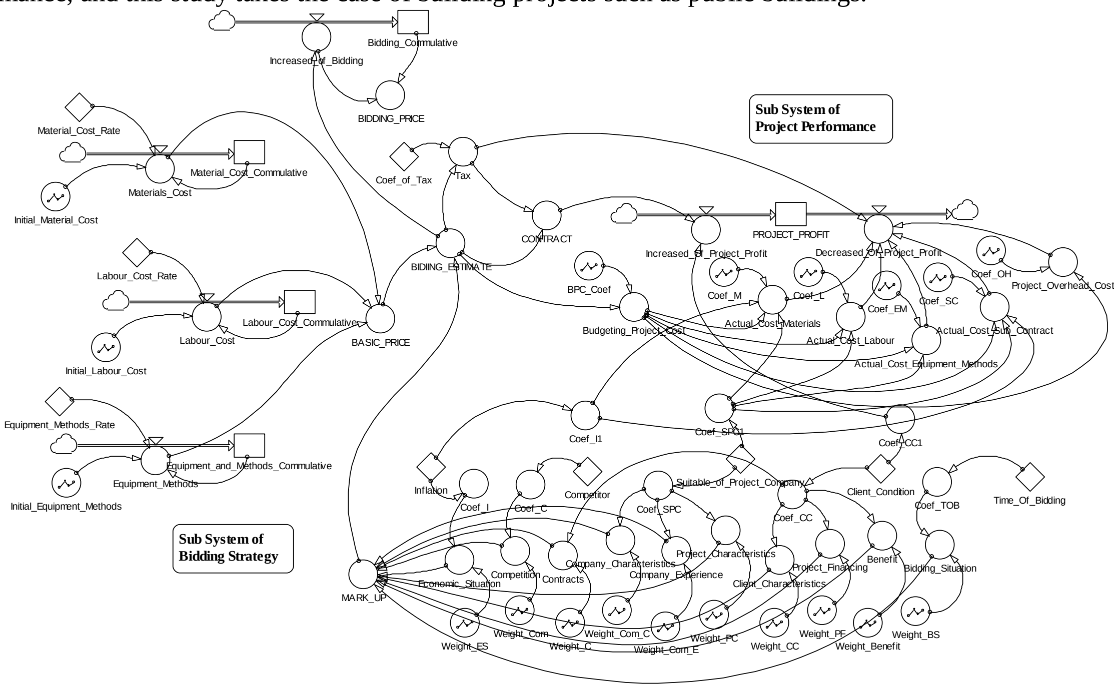

Fig 4. Stock Flow Diagram of Model

Variable state is the condition or the accumulation of the system at any one time, while the rate is regulating the flow to the state. The state is synonymous with stock, level or resources. The term is often used by Warren resources in presenting the performance of an organization in the context of System Dynamics. An example of resources according to Warren is loyal consumers, stores and staff. In engineering, stock system is better known as the state. Stock is accumulated in the system, while rate is a policy of the company which explains why and how the decision was made based on the available information in the system. Rate/flow is the only variable in the model that affects the stock. Further the interaction of this structure is translated into mathematical models, and using computers simulation to get historical behavior.

5. Simulations

Simulation is a method to study the dynamics of a phenomenon. The phenomenon has been known in the System Dynamics diagram, i.e. the collection of units, the component parts or elements that operate in some interconnected. Simulation provides a description behavior of the phenomenon (system) in its development due to increasing time. Simulations show the behavior of the system, such as the growth of the first ascending as S-curve (sigmoid), where the increase was very slow at first, then exponential growth for a period and terminated by saturation. The structure of the S curve consists of a positive feedback coupled with negative feedback [8].

Sub system bidding strategy and project performance described by the elements of the project bidding and project benefits/project profit. While project bidding estimate consists of two parts i.e. a basic price and mark up. Based on simulation from 2011 to 2020, the average increase of bidding price per year is 13.67% from the previous bidding. While the average of project profit 10.55% from the bidding price. This is shows that on the building project, the strategy of bidding offers a positive effect on the project performance, which is indicated by the increase of project profit. Therefore, when contractor faced on bidding, all the activities must be done well i.e. volume calculation must be done properly and carefully. The calculation of unit prices must consider all influence factors. Therefore, contractor offers high quality of bidding, thus not only able to win the competition, but also producing maximum performance. The relation between bidding price and project profit as shown in Table 2 and Fig 5

Table 2. The Relation between Bidding Price and Project Profit

YEAR	BIDDING_PRICE	PROJECT_PROFIT
2,011	6,552,451,455.79	0.00
2,012	15,951,352,889.47	692,075,164.72
2,013	29,543,083,043.44	1,711,606,429.44
2,014	43,797,494,446.80	3,197,472,039.12
2,015	58,747,383,056.87	4,755,782,824.47
2,016	74,427,177,866.72	6,390,124,082.18
2,017	90,873,022,421.71	8,104,259,634.53
2,018	108,122,860,409.19	9,902,140,740.88
2,019	126,216,525,524.90	11,787,915,454.46
2,020	145,195,835,829.80	13,765,938,446.67

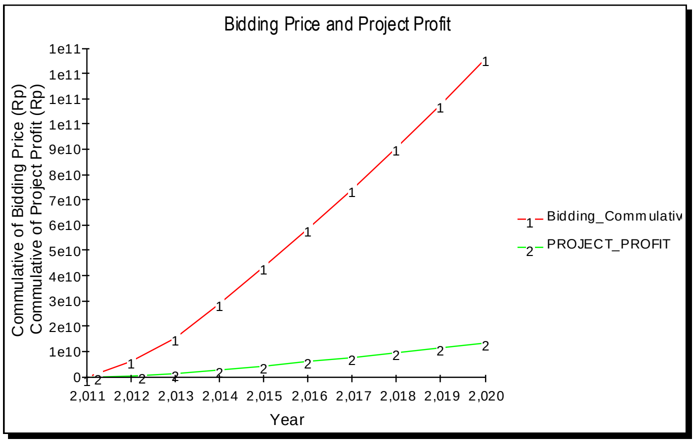

Fig 5. The Relation between Bidding Price and Project Profit

6. Conclusion

The model demonstrated that bidding strategy had a positive impact on project performance. This is indicated from the increase of project profit due to increased project quality bidding strategy. The quality of bidding influence is influenced by many factors. Contractors have to understand those related factors, simulate them and decide on a policy, to achieved the company goal, and make the effort for future improvement.

Acknowledgements

I express my profound gratitude to all participants for their encouragement and support. My special thanks for the companies and all respondent which have been given permission to do survey.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Building Information Modeling in the architecture-engineering construction project in Surabaya

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Abstract

In current practice, many digital models do not contain sufficient information from designers to contractors and operators. A great deal of literature has pointed to the importance of understanding the Building Information Modeling (BIM). BIM is a digital representation of the physical and functional characteristics of a building. In Architecture-Engineering-Construction, BIM is the development and use a computer software model to stimulate the construction and operation of a facility, to make decisions and to improve the process of delivering the facility. The aims of this paper are to explore the need of technological support to implement the site-linked of BIM, the benefits of BIM, and the challenges of BIM. The research was conducted through literature review of BIM. The data was collected from the questionnaire survey carried out to 26 valid responses within the main stakeholders of construction work in Surabaya. A questionnaire is prepared by incorporating the technological support, benefits, and challenges of BIM. The data was analyzed by using descriptive analysis including mean analysis with 5 Likert scale. The results of the research shows that the need of technological support to implement the BIM is parametric components (mean value of 4.46), the need of software package majority is prepared by contractor and construction management consultant, and the benefit of BIM is to reduce the construction cost (mean value of 4.6). In addition, the main challenge of BIM is different brand with the mean value of 4.27, in which of uncompatibility of different brand (mean value of 4.31.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: Building Information Modeling, project.

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

1. Introduction

Building Information Modeling (BIM) has recently attained widespread attention and development in the Architectural-Engineering Construction. BIM is a digital representation of physical and functional characteristics of a facility that has transformed the way building are conceived, designed, constructed, and operated [1]. This model is a data-rich, object oriented, intelligent, and parametric digital representation of the facility to generated information that can be used to make decisions and to improve the process of delivering the facility [2]. BIM suggests the concept of Integrated Project Delivery including people, systems, business structures and practices into a collaborative process to reduce waste and optimize efficiency through all phases of the project life cycle [3]. BIM supports the continuous and immediate availability of project design scope, schedule, and cost information that is high quality, reliable, integrated, and fully coordinated [4]. BIM as a design and construction term was introduced about 15 years ago to set the emerging, information- rich, architectural computer-3-D modeling apart from traditional, mainly paper-based, 2D design and drawing.The focus of BIM is to create and reuse consistent digital information by the stakeholders throughout the lifecycle, to provide a more streamlined business process, associated project and site management methodologies including complete facilitation of construction knowledge [5]. This method is to integrate digital descriptions of all the building objects and their relationships to others in a precise manner where stakeholders can query, simulate, and estimate activities and their effects of the building process during the project life-cycle [5]. The aims of this paper are to explore the need of technological support to implement the site-linked of BIM, the benefits of BIM, and the challenges of BIM.

2. Literature review

There are many definitions of Building Information Modeling (BIM). BIM is the sharing of strutured information that can be explained as a digital representation of the physical and functional characteristics of a building. A BIM model can contain information or data on design, construction, logistics, operation, maintenance, budgets, schedules and much more. The principal difference between BIM and 2D CAD is that the latter describes a building by independent 2D views such as plans, sections, and elevations. Data in 2D drawings are graphical entities only, such as lines, arcs and circles, in contrast to the intelligent contextual semantic of BIM model, where objects are defined in terms of building elements and systems such as spaces, walls, beams and columns [6]. By using BIM in construction work, drawings, procurement details, submital processes, and other specification can be easily interrelated. In addition, systems, assemblies, sequences can be shown in a relative scale with the entire facility [7]. Technologies that can be used to implement BIM are CAD, Object CAD, and Parametric Building Modeling [4]. CAD is software that its technology supports drafting automation very effectively. Object CAD seeks to simulate building components in a CAD-based environment, focusing on the 3D geometry of the building, the generation of 2D documentation from that 3 D geometry, and the extraction of object data from the building components to provide information about quantities and object properties. Parametric Building Modeling Technology is analogous to the decision support systems used in the financial community.These systems combine a data model (geometry and data} with a behavioral model (change management) that gives meaning to the data through relationships.

2.1. The benefits of BIM

According CRC Construction Innovation [6], BIM benefits are: faster and more effective processes, better design, controlled whole-life costs and environmental data, better production quality, automated assembly, better customer service, and life-cycle data. BIM enable better decisions, faster BIM reduces the abstraction and integrates the multiple disciplines, including design and documentation, reduces the time to the market, reduces the cost of design [7]. BIM also can accelerate the adaptation of standard building prototypes to site conditions for business, and reduces human resource during the entireoperation phase [4].BIM affords the design team a high degree of certainty, minimize errors and omissions, and last but not least to minimize conflict [8]. In addition, BIM model under a well managed information database can provide information on the number and types of furniture, if and when they are do for change [8]. Moreover, Arayici et al. [5] suggested that some key benefits of BIM are accurate geometrical representation of the part of the building, faster and more effective information sharing, more predictable environmental performance and life-cycle costing, better production quality, better procurement decissions, and better coordination for purchasing.

2.2. The challenges of BIM

In the current practice of building operational life-cycle management, the challenges of BIM are the revolves around information collection retrieval and sharing [5]. BIM adoption is much slower than anticipated because of technical and managerial aspect [7]. Bernstein and Pittman [9] explained that the challenges of BIM are: the need for well-defined transactional construction process model, the requirements that digital design data be computable, the need for well-developed practical strategies for the purposeful exchange and integration information among the BIM model components. On the other hand, the managerial aspect of the challenges of BIM are no clear consensus as how to implement or use BIM, no single document or treatise on BIM that instructs on its application or usage, the need for standardizing the BIM process and guidelines for its implementation. Therefore, the visual nature of the BIM allows all stakeholdes to get important information before the building is completed [7]. Furthermore, there are some obstacles to BIM such as training curve, cost of software [8]. The risks involved in adopting BIM come from two major aspects, the fisrt risks associated with the behaviors of the parties involved in a BIM project, and the second risks associated with the technological aspect [8].

3. Reseach method

Following the detailed literature review, the survey method was adopted to explore the aims of this study. A questionnaire survey was designed for respondents in Surabaya construction work to assess the need of technological support to implement the site-linked of BIM, the benefits of BIM, and the challenges of BIM. A five-point scale (described as 1=strongly disagree, 2=disagree, 3=neither agree/nor disagree, 4= agree, 5=strongly agree) was used to answer some questions on relevant indicators of the benefits of BIM, and the challenges of BIM. The first part of questionnaire was designed to assess the need of technological support to implement the site-linked of BIM. The second part of questionnaire to assess the benefits of BIM, and the third was to assess the challenges of BIM. These questionnaires were distributed from 26 respondents, 15.4 % (4 respondents) were developers, 34.6% (9 respondents) were contractors, 7.7% (2 respondents) were structural designers, 11.5% (3 respondents) were architectural designers, 7.7% (2 respondents) were construction management consultants, 7.7% (2 respondents) were contractors-developers, 3.8% (1 respondent) was contractor-structural designer, 3.8% (1 respondent) was developer-contractor-supervisor, 3.8% (1 respondent) was structural designer-architectural-mechanical &electrical, and 3.8% (1 respondent) was architectural designer-supervisor-construction management consultant. For the purpose of comparison, mean analysis were carried out for different type of respondents.

4. Result and discussion

The research was designed to be used with the mean analysis. In order to test the reliability of the measured variables in the sample data, Cronbach's Alpha coefficient was used. Construct reliability used to measure of reliability and internal consistency of the measured variables representing a latent construct [10].. The value of Cronbach's Alpha coefficient closer to 1.0 with a threshould of 0.70 is a good depiction of reliability in the data set [11]. The values of construct reliability for all attributes was 0.739 (>.0.70). It means that all attributes reliable to measure a variables representing a latent construct. BIM requires suitable technological support to be implemented effectively including CAD, Object CAD, and Parametric Building Modeling. Based on the respondents opinion, the need of CAD can be explained with the mean score of 4.00 (agree), the need of Object CAD with the mean score of 4.23, and the need of Parametric Building Modeling with the mean score of 4.46 (strongly agree). Parametric Building Modeling is a software counterparts of the actual things used to construct the physical building, such as steel beams, concrete slabs and rebar, framing, dry wall, ceiling grid and tile, ducts, windows and so on [8].The need of software package majority is prepared by contractor and construction management consultant .

Table 1 presents the mean value of the benefits of BIM by 26 respondents. In general, the respondents agree that BIM can reduce cost of construction. Through open discussion, most respondents expressed that they would welcome to use BIM in their company and would commit to the implementation of BIM becuase it can reduce cost of construction (mean value of 4.60). In addition, reducing cost of construction can be achieved by understanding of life-cycle costing (mean value of 4.58) and prediction of environmental performance.(mean value of 4.62).

Table 1. The benefits of BIM

No	Description	Mean
1	Increased speed of delivery (time saved)	4.22
2	Better quality	4.05
3	Reduce cost (money saved)	4.60
4	Greater productivity	4.14
5	Better coordination	4.20
6	Decreased labor (labor saved)	3.27
7	Better customer services	4.27
8	Business opportunity	4.23

Table 2 displays the mean value of the challenges of BIM perceived by different groups of respondents. Meanwhile, the highest mean value of challenges of BIM is different brand (mean score of 4.27), in which of uncompatibility of different brand (mean value of 4.31). It means that the different brand of BIM is generally positive with regard to potential challenges to offer BIM in existing practices. There is a challenge that software with different brand could not be used together in the same project. The survey also revealed that there is a strong opinion to focus on the transition period between drafting and modeling activities (mean value of 4.15). On the other hand, the lowest mean value that indicated the challenges of BIM is the lack of legal/contractual agreement (mean value of 3.23). This could happen maybe because the project stakeholders (owner, consultants, or contractors) still could not fully believe the BIM-legal impact. Parties working collaboratively may owe legal duties to each other even without express written contracts with each other [8]. The ideal legal framework for the BIM project should distribute the risk equally among the members of the team best able to manage the risk [8].

Table 2. The challenges of BIM

No	Description	Mean
1	Cost of modeling	3.75
2	Training	3.73
3	Transition	4.15
4	Different brand	4.27
5	Less of innovation	3.73
6	Existing technology	3.27
7	Resistance to learn by the public	3.35
8	Unavailable for all projects	3.92
9	Lack of legal/contractual agreement	3.23
10	Behavior risks	3.81
11	Responsibility	3.77

Table 3 portrays P- values of one-way Anova statistical test performed. It shows that three tests of challenges of BIM were statistically significant at α = 5%, in which different brand of software, resistance to learn BIM by the public, and lack of legal/contractual agreement where the parties working collaboratively may owe legal duties to each other. According to the different groups of respondents, they argued that there were not statistically significant in which of behavior risks. Among the behavioral risks of BIM, the parties to a BIM process should move from traditional risks avoidance and transfer philosophies to one of risk acceptance and true risk management [8]. The respondents have the same opinion that the challenges of BIM, one is unavailable BIM for all projects.Thw complete version of the information can be found from [12].

Table 3. The Anova analysis

Challenges of BIM		Sum of Square	Degree of Freedom	Mean Square	F	Sig.
Cost of modeling	Between Groups	10.76	9	1.20	1.55	0.21
	Within Groups	12.37	16	0.77		
	Total	23.13	15			
Training	Between Groups	10.48	9	1.16	1.19	0.36
	Within Groups	15.64	16	0.98		
	Total	26.12	15			
Transition	Between Groups	7.33	9	0.81	081	0.61
	Within Groups	16.06	16	1.00		
	Total	23.39	15			
Different brand	Between Groups	9.12	9	1.01	3.61	0.01
	Within Groups	4.49	16	0.28		
	Total	13.62	15			
Less of innovation	Between Groups	8.12	9	0.90	1.11	0.41
	Within Groups	13.00	16	0.81		
	Total	21.12	15			
Existing technology	Between Groups	20.70	9	2.30	1.07	.43
	Within Groups	34.42	16	2.15		
	Total	55.12	15			
Resistance to learn by the public	Between Groups	24.33	9	2.70	2.78	0.04
	Within Groups	15.56	16	0.97		
	Total	39.89	25			
Unavailable for all project	Between Groups	5.43	9	0.60	0.67	0.73
	Within Groups	14.42	16	0.90		
	Total	19.85	25			
Lack of legal/contractual agreement	Between Groups	12.27	9	1.36	2.78	0.04
	Within Groups	7.85	16	0.49		
	Total	20.12	25			
Behavior risks	Between Groups	3.73	9	0.42	0.46	0.88
	Within Groups	14.31	16	0.89		
	Total	18.04	25			
Responsibility	Between Groups	9.93	9	1.10	1.30	0.27
	Within Groups	12.69	16	0.79		
	Total	22.62	25			

5. Conclusion

Based on the respondents opinion, the results of the research shows that the need of technological support to implement the BIM is the need of CAD that can be explained with the mean value of 4.00 (agree), the need of Object CAD with the mean value of 4.23, and the need of Parametric Building Modeling with the mean value of 4.46 (strongly agree). The need of software package majority is prepared by contractor and construction management consultant. The benefit of BIM is to reduce cost (mean value of 4.60). In addition, reducing cost of construction can be achieved by understanding of life-cycle costing (mean value of 4.58) and prediction of environmental performance.(mean value of 4.62). The highest mean value of challenges of BIM is different brand (mean value of 4.27), in which of uncompatibility of different brand (mean value of 4.31). It means that the different brand of BIM is generally positive with regard to potential challenges to offer BIM in existing practices. Finally, one-way Anova statistical tests performed that the challenges of BIM were statistically significant at α = 5%, in which of different brand of software, resistance to learn BIM by the public, and lack of legal/contractual agreement where the parties working collaboratively may owe legal duties to each other.

Acknowledgments

Special thanks to the respondents in the construction industry in Surabaya who participated in the data collection. The author is also greatful to Prof. Henricus Priyosulistyo Ph. D. for his assistance in proofreading the manuscript.

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Procedia Engineering 00 (2017) 000–000

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Significant factors to motivate small and medium enterprise (SME) construction firms in the Philippines to implement ISO9001:2008

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Abstract

Motivating SME-based construction firms to adopt different management systems is not a simple task, especially if they are not aware of the benefits that they will gain from the new process-based management system. The implementation of ISO 9001:2008 Quality Management System in the construction industry is an ongoing trend, more so in the Small and Medium Enterprise. However, the level of awareness and readiness of the construction industry in the Philippines is still low as compared to the neighboring countries in Asia and in the western countries where ISO 9001:2008 originated. The purpose of this research is to determine the significant factors that will motivate SME-based construction firms in the Philippines to implement ISO 9001:2008. A field study was conducted on SME based construction firms in the Philippines, wherein a total of 139 respondents out of the 613 SME-based construction firms in CALABARZON areas were surveyed. Results reveal that the three main factors that will motivate SME-based construction firms to implement ISO 9001:2008 are (1) if required by their clients, (2) to qualify for bidding and (3) to increase customer satisfaction. Therefore, based on the results and findings, a certification of ISO 9001:2008 from an accredited auditor shall be required by clients as a constituent in accrediting SME-based construction firms and to qualify for bidding.

Keywords: ISO 9002:2008; Quality Management Systems (QMS); Small Medium Enterprise (SME).

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1877-7058

1. Introduction

Construction infrastructure projects are one of the most important factors in supporting the social economic development in the country. It could generate downstream economic activities and completely enhance productivity and competitiveness in the construction industry. Considering the significance of the construction industry in the economic growth, it is necessary to identify major issues affecting the efficiency of its sector. The main objectives of any project are improvements in time, cost, and quality [1]. In order to implement an infrastructure project effectively and efficiently the construction enterprise must adopt a management system that will guide them to ensure that projects are successfully completed within the constraints of best quality, on time, and at the minimum possible cost [2]. As building projects get larger and more complex, clients are also increasingly demanding higher standards for their delivery [3]; therefore, the need for a quality management system becomes more of a necessity than just a requirement.

According to Mohammed and Abdullah [4], QMS is the interaction of people, process, and documentation to meet the customer's stated and implied needs. The result would be a reduction in inefficiencies and waste, improved work practices, increased morale of the management team, and the opportunity for a greater market share. ISO 9000 is a series of international standards which sets out requirements and recommendations for the design and assessment of management systems. ISO 9000 is grounded on the "conformance to specification" definition of quality. The standards specify how management operations shall be conducted. ISO 9000's purpose is to ensure that suppliers design, create and deliver products and services which meet predetermined standards; in other words, its goal is to prevent non-conformity [5]. ISO 9000 certification in the construction industry has been widely accepted in many countries, and the number of certifications for general, heavy and specialty contracting companies is growing considerably. Some investigators associate ISO 9000 with multiple advantages and with positive changes in internal procedures of construction firms [6]. Yet others argue that these standards do not apply directly to the construction industry and cannot be associated with a substantial improvement in the delivery of a quality construction product.

There are at least 2,536 listed construction companies in the Philippines as of 2009, out of which 2,409 belong to the Small and Medium Enterprise or better known as the SMEs (Industry and Trade Statistics Department, 2009). SMEs play a crucial role in the development of the Philippine economy. They represent 99.6 percent of all businesses registered in the country and employ 70 percent of the total labor force. In addition, they account for 32 percent of the country's gross domestic product (GDP) [7]. In China, the SMEs are the core of the construction industry development and play main role in the urban and rural building [8].

1.1. Research Objective

The main objective of this study is to identify the significant factors that will motivate the SME-based construction firms in the Philippines to implement ISO 9001:2008 in their organization. There is still no specific data or information regarding the present condition on the implementation of ISO 9001:2008 in the construction industry in the Philippines, moreover to the SME construction firms in the CALABARZON area. This research was a proactive attempt to the Department of Public works and Highways (DPWH) memorandum that will require SME construction firms to be ISO 9001:2008 certified as part of the requirement in the eligibility or prequalification of contractors in the near future.

1.2. Scope and Limitation

The study was limited to category A, B, C, and D construction firms based on the accreditation standards of Philippine Contractors Accreditation Board (PCAB). These contractors belong to the SME-based contractors according to size of assets and number of employees. The SME-based contractors in CALABARZON (Cavite, Laguna, Batangas, Rizal and Quezon provinces) were selected from the total list of licensed contractors listed by PCAB as of April 27, 2012.

1.3. Definition of Terms

CALABARZON comprises provinces in Region IV-A in the Philippines composed of Cavite, Laguna, Batangas, Rizal and Quezon provinces, where the study was conducted.

Contractors are companies engaged in building infrastructure projects.

DPWH or Department of Public Works and Highways is the engineering and construction arm of the Philippine Government tasked to continuously develop its technology for the purpose of ensuring the safety of all infrastructure facilities and securing the highest efficiency and quality in construction for all public works and highways.

ISO (International Standard in Organization) is an international standard to provide the generic core of a quality system standard applicable to a broad range of industry and economic sector.

PCAB or Philippine Contractors Accreditation Board is the accrediting agency of the Philippines authorized to give contractors licenses with respective category level to practice construction business in the Philippines.

Quality Management System is comprised of activities of the overall management function that determine the quality policy, objectives, and responsibilities of the Company. It is implemented through quality planning, quality control, quality assurance, and quality improvement.

SME or Small and Medium Enterprise is any business activity or enterprise engaged in industry, agri-business/services, whether single proprietorship, cooperative, partnership, or corporation, whose total assets value is between 3 million to 15 million for Small and 15 million to 100 million for Medium enterprise.

2. Review of related literature

The Quality Management System for the Construction Industry is a systematic approach for the companies who want to develop and establish a quality system. The QMS gives guidelines to the introduction, structure, and contents of quality systems for the use of all parties involved in the construction industry [9]. According to the original 1987 bulletin from the International Organization for Standardization (ISO), ISO 9000 is “a series of international standards dealing with Quality systems that can be used for external quality assurances purposes.”

The ISO was founded in 1946 to develop international quality standards to facilitate worldwide trade and help Western countries regain their competitiveness. The organization consists of a coordinating group of members from more than 90 countries. The U.S. representative is the American National Standards Institute [10].

Many companies throughout the world are trying to obtain an ISO 9001:2000 Quality Management Systems certification to demonstrate to their customers that they are capable of meeting their needs and expectations. For instance, a report on ISO 9000 certifications showed that 500,125 companies worldwide had attained ISO 9001 certification by the end of December 2003 [11].

The acceptance of ISO 9000 standards in the construction industries is not as wide as in other industries such as manufacturing. There are special features in the construction industry that limit the implementation of the ISO 9000 standard. One of these features is that a construction project is usually a unique collection of people, equipment, and materials brought together at a unique location under unique weather conditions, while most manufacturing is a system of mass production wherein all of these factors are consistent with producing typical products over and over again [12].

Over the years, according to Said et al. [2], QMS application systems in the Malaysian Construction Industry have been on an increasing trend. Currently, there are more than 4,000 QMS certified organizations as compared to when it was first introduced in 1987. So far, QMS has brought about positive changes in the Malaysian Construction Industry. However, the industry is still facing problems in the implementation of QMS. From the findings of their research, four main advantages have been identified. They are (i) organization image and reputation enhancement, (ii) performance and customers’ satisfaction improvement, (iii) documentation procedures and instructions establishment, and (iv) constant quality service.

The success of the ISO 9000 family of standards is still growing and the number of countries where ISO 9000 is being implemented has increased. Over 400,000 companies in 158 countries have identified the ISO 9000 standard as a strategic management tool essential to effective control and best business practice. The construction industry has embraced the ISO 9000 standard since its inception. The Quality Management standard has become the benchmark for successful construction companies. The discipline and systematic approach has helped many companies to structure their management and processes to consistently meet the client's requirements [6].

In the United Kingdom, some of the construction industry clients made it compulsory that the contractors implement ISO 9001:2008 Quality Management System in their organizations to qualify for participating in the bids [13]. As a result, a tremendous impact was observed with more and more contractors seeking for ISO certification. Consequently, marketing and customer's insistence have become the key factors driving the ISO implementation.

In the Philippines, based on the initial study conducted on the level of awareness on ISO 9001:2008, results showed that most of the SME-based construction firms in the Philippines were not aware of the implementation of ISO 9001:2008. There is a strong implication that the initiatives of the construction industry in training, exposing, and actual learning to SME construction firms are low, which affected their level of awareness [14].

Micro, small, and medium enterprises (MSMEs) are defined as any business activity or enterprise engaged in industry, agri-business/services, whether single proprietorship, cooperative, partnership, or corporation, whose total assets, inclusive of those arising from loans but exclusive of the land on which the particular business entity's office, plant and equipment are situated, must have value falling under the following categories: By Asset Size, Micro: Up to P3,000,000; Small: 3,000,001 - P15,000,000; Medium: P15,000,001 - P100,000,000; Large: above P100,000,000 [15].

Based on the study conducted by the Philippine Institute for Development Studies, Small and Medium Enterprises (SMEs) have played an important role in industrial production in particular, and economic growth in general in less developed, developing, and transitional economies worldwide [16]. They have generally provided the bulk of entrepreneurs and employment in these economies, and the necessary foundations for sustained economic growth and rising incomes. The SMEs are the core of the construction industry development and play a main role in the urban and rural building. With the professional subdivision, the increase of professional ability, and the improvement of project sub-contract system in the construction industry, the roles of the Industry Cluster of SMEs will become more and more obvious, including stabilizing economic development, enlarging employment rate in the towns, and promoting technology innovation [8].

3. Methods

3.1. Research Design

A descriptive method of research was used in the study, wherein the principal aim was to describe and interpret the data collected. It is concerned with conditions of relationships that exists; practices that prevail; beliefs, processes that are going on; effects that are being felt or trends that are developing. In this study, it was intended to identify the significant factors to motivate SME contractors to implement ISO 9001:2008 QMS in their organization.

3.2. Research Locale

At the regional level, the largest number of construction projects were located in CALABARZON, according to the Private Building Construction statistics of the fourth quarter of 2011. It was therefore decided by the researcher to limit the study to SME-based construction firms in the CALABARZON areas.

3.3. Population and Sampling

The respondents of the study were the operational managers or supervisors and company owners of SME-based construction firms in the CALABARZON area as shown in Table 1. To come up with the desired sample size, total population of 613 SME-Based contractors in CALABARZON were extracted out of the total list of 5,573 licensed contractors listed by Philippine Contractors Accreditation Board (PCAB) as of April 27, 2012.

Table 1 Profile of respondents according to company position

Position	Number of Respondents
Company Owners	51
Operations Manager	24
Project Manager	36
Admin Manager	4
Office Manager	3
Project Supervisor	13
Project Engineer	5
Accountant	1
Office Engineer	2
TOTAL	139

Applying Precision Approach for the population proportion, assuming P = proportion of contractors aware of the ISO 9001:2008 and Q = proportion of contractors not aware of the ISO 9001:2008 = 0.50 and targeting a C of the estimate as 7.5% the sample size was determined using the formula:

$$n = \frac{NQ}{PC^2(N-1)+Q} \quad (1)$$

Where N = 613, Q = 0.50, P = 0.50, C = 0.075, resulting in n = 139 or a sampling rate equivalent to approximately 22.5 percent. Table 2 shows the allocated proportion of the SME-based construction firms in each province [17].

Table 2. Research sampling per province

Province	(N)	Size (n)
Cavite	96	22
Laguna	115	26
Batangas	195	44
Rizal	137	31
Quezon	70	16
TOTAL	613	139

3.4. Research Instrument

Survey questionnaires were used by employing the aid of enumerators in different provinces who distributed and conducted interviews with the respondents. Table 3 shows part of the survey questionnaire which include list of at least ten (10) motivating factors to choose from as a guide to respondents.

Table 3. List of significant factors to motivate SME based construction firms

Factors that will motivate to implement ISO9001:2008	Top 5 Ranking
1.0 To qualify for Bidding	
2.0 If required by clients (gov't and/or private)	
3.0 To increase employee productivity	
4.0 To reduce customer complaints	
5.0 To increase profit margins / lower operational cost	

6.0 To improve company image

7.0 To increase customer satisfaction

8.0 To deliver projects on schedule/reduce delays

9.0 To use resources more efficiently/To reduce wastage

10.0 Other (specify)

Respondents were asked to rank five significant factors using priority sorting with a rank value of 1 for the most significant, then the next most significant and value of 5 for least significant ranking. A rating scale was used to measure the level of significance for SME-based construction firms to implement ISO 9001:2008 as shown in Table 4. The data was analyzed using the Kruskal–Wallis one-way analysis of variance by ranks.

Table 4. Scale level of SME-based construction firm to implement ISO9001:20008

	Rating	Description
Rating scale	1.00 - 1.80	Extremely Significant
of significance to implement	1.81 – 2.60	Very Significant
	2.61 - 3.40	Moderately Significant
ISO 9001:2008	3.41 - 4.20	Slightly Significant
	4.20 - 5.00	Least Significant

4. Results and discussion

4.1. Profile of SME-based Construction Firm

The profile of the respondents were classified according to PCAB category with 33 respondents in category A, 30 in B, 32 in C, and 44 in D. There are 44 respondents in corporation type of business, 94 classified under sole proprietorship, and only 1 under partnership. In terms of asset size there were 30 respondents under micro size of assets, 70 in small, 33 in medium, and 6 in the large asset size. When classified according to number of employees, there were 37 under the micro, with employees ranging 1 to 9, 83 under small, with employees ranging 10 to 99, and 19 under medium with employees ranging from 100 to 199. With regard to the number of years of operating experience of respondents, 23 fell under 1 to 5 years of experience, 42 with 6 to 10 years, 28 with 11 to 15 years, 13 with 16 to 10 years, and 33 with over 20 years of construction experience. When classified according to type of construction services, there were 28 from general building, 37 from general engineering, 64 both GB and GE, and 10 from specialty type of construction services respondents.

4.2. Significant Factors to Motivate SME-based Construction Firms to Implement ISO 9001:2008

Results reveal that there are only two motivating factors that falls under "Very Significant", and those are: (1) if it will be required by the client with a mean average of 2.33, as the top priority, and (2) to qualify for bidding with a mean average of 2.44, as the second top priority that will motivate them to implement ISO 9001:2008 in their organisation. The third most significant factor falls under "Moderately Significant" and this is "to increase customer satisfaction", with a mean average of 2.64, as shown in the mean results in Table 5. This confirms results from previous studies in the United Kingdom that construction industry clients made it compulsory that the contractors implement ISO 9001:2008 Quality Management System in their organizations to qualify for participating in the bids [13], and results in the study made by Ahmadinejad et al. [18] in Iran that quality management certification as an only way for company to participate in tenders or bidding and “to meet clients’ needs” as factors that can promote services quality and make clients satisfaction.

Table 5. Level of significance of motivating factors in implementing ISO9001:2008

Factors	DESCRIPTION
1. To qualify for Bidding	Very Significant
2. If required by clients(gov't/or private)	Very Significant
3. To increase employee productivity	Moderately Significant
4. To reduce customer complaints	Moderately Significant
5. To increase profit margins/lower operational cost	Moderately Significant
6. To improve company image	Moderately Significant
7. To increase customer satisfaction	Moderately Significant
8. To deliver projects on schedule/reduce delays	Slightly Significant
9. To use resources more efficiently/reduce wastage	Least Significant
10. Others	

In all three (3) provinces of Cavite, Laguna, and Batangas, the factor that will motivate them to implement QMS ISO 9001:2008 is if it is required by clients. In Quezon province the main factor that will motivate them to implementing ISO 9001:2008 is to increase their customer satisfaction. Improving company image is the main factor among firms in Rizal province that will motivate them to implement ISO 9001:2008 as shown in Table 6.

Table 6. Significant factors to motivate SME-based Construction firms to implement ISO 9001:2008 per provinces

	PROVINCES					
Factors	Cavite	Laguna	Batangas	Rizal	Quezon	MEAN
1. To qualify for Bidding	3.00	2.73	2.14	3.13	2.30	2.48
2. If required by clients(gov't/or private)	1.33	1.95	2.05	3.64	2.63	2.33
3. To increase employee productivity	3.25	4.00	3.36	2.56	3.64	3.19
4. To reduce customer complaints	2.25	3.43	4.13	3.61	3.63	3.29
5. To increase profit margins/lower operational cost	4.67	2.28	3.50	2.89	3.75	3.11
6. To improve company image	3.62	2.62	3.17	2.33	3.57	2.99
7. To increase customer satisfaction	1.64	2.85	3.59	2.56	1.82	2.64
8. To deliver projects on schedule/reduce delays	4.33	3.85	4.55	3.55	3.00	3.81
9. To use resources more efficiently/reduce wastage	4.33	4.62	4.00	4.22	3.17	4.21

5. Conclusion and recommendation

SME-based construction firms are all represented according to company profile factors, such as PCAB category, type of business, asset size, no, of employees, years of operations, and type of construction services in this study. Among the listed factors, there are only two very significant factors that will motivate SME-based construction firms to implement ISO 9001:2008. (1) If it will be required by their clients and (2) in order to qualify for bidding. Most of the factors fall under moderately significant and the least significant factor is to use resources more efficiently to reduce wastage.

In the application of construction projects, the effective and common application of QMS particularly in developing countries, such as the Philippines, may reduce problems like the lack of supervision and standardization in construction activities.

In the global construction market, an increase in the number of firms having QMS will reduce both the project costs and develop the potential of awarding contracts to the construction firms from underdeveloped or developing countries.

Taking into consideration the literature review and questionnaire results, the following recommendations have been formed for effective application of ISO 9001:2008 QMS in construction firms and for future research:

- Government and private clients should make it compulsory for SME-based construction firms to be ISO 9001:2008 certified by accredited auditors to qualify for bidding in their construction projects.
- Activities like explaining the importance, advantages and benefits of QMS for SME-based construction firms in the construction industry, granting incentives for the application of QMS, and even granting credit facilities for firms to set up the system will be encouraged.
- Government agencies involved in the construction industry should coordinate with private developers and construction firms to conduct seminars and trainings that will focus on the advantages and benefits of ISO 9001:2008 in their organization.
- More comprehensive studies must be carried out with consideration to other industries rendering service to the construction industry, such as the Construction materials industry, by treating the construction industry in Philippines on a broader scope.

Acknowledgements

To the Divine Almighty, who gave me the strength, courage, and wisdom to fulfil this achievement, this work is humbly offered to HIM.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

The Critical Point in The Certification System For Project Manager in Indonesia_

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Abstract

The tender evaluation in Indonesia is usually done under the basis of the qualification of expertise which is valued from 50% to 70%. The expertise is indicated in the portfolio of working experience and expertise certificates. However, one who has the same expertise certificate may have different performance in the project.This paper attempts to identify the critical point of certification in Indonesia, classify the critical point based on the source, find the most affected critical point and find the problems that can cause critical point in certification system in Indonesia. The method of this study is mixed method; meaning that the data collected are in the forms of numeric and non-numeric.The results of the study indicate that the weakest point in the certification system is in the working experience reference. The fact that the working experience reference enclosed as his portfolio does not reflect the actual experience and sometime some of them are fake that of course, it does not guarantee his competence in the project. The result shows that the score of working experience = 787; the system of validation and verification of the association = 677; the incomplete fulfilment of the applicants requirement = 636; the lack of additional information which supports the working experience reference = 320; the objectivity of the assessors = 297; and the process of interviews = 240

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: certification system; project manager; certification of expertise

1. Background

Joining the auction of consultancy services in Indonesia, needs some important requirements in order to to be taken into consideration the auction. Those requirements are the company's experience in handling similar projects,

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Peer-review under responsibility ofthe organizing committee of SCESCM 2016.

the approach and the methodology of the construction and the qualification of the experts. Each requirement is weighted into the following weight: the company's experience in handling similar projects 10% to 20%, while the approach and methodology of the construction 20% to 40% and qualifications of experts such as the project manager has the weight of 50% to 70%.

The qualification of the experts including a project manager, is assesed from the level of education, professional work experience, references service users, certificates of expertise/profession as experts or skilled workers in the construction completed with other certificate which are relevant to their competence. This is in line with the law of construction services No. 18/1999, Article 9 reveal that the personnel who carry out the technical works employed by the contractor must have a certificate of skills and expertise [1]. Also government regulations no. 04/2010 article 8c concerning the Public Enterprises and the Role of Construction Services Society. In the law, it is stated that an individual who provides construction services or individual employed by a business entity that provides construction services must be certified according to the classification and qualification [2].

Ardiansyah et al, (2012) state that non-certified human resources affect the construction failure of the construction for about 30.7% [3]. The study eventually provide a conclusion that when the construction employers have been certified, the potential failure of the construction can be lessened. On the other hand, sometimes there is a gap between the real competence shown in the field and the certification of expertise owned by the project manager as the expert.

2. Objectives of The Study

Based on the background of the study, this research objectives are to:

- identify the critical point of certification in Indonesia
- classify the critical point based on the source
- find the most affected critical point and
- find the problems that can cause critical point in certification system in Indonesia

3. Project Manager Competence

Generally, project success is measured by the accuracy of the time spent, cost and quality that meet the requirements in the contracts that have been agreed. The project success requires a highly competence of the project manager.

The core competence is the combination of resources and capabilities that have functions as the source of competitive advantage for the company over its competitors (Hitt, et al, 2005) [4]. Santoso (1999) stated that to be competitive, the construction manager has been required to be experienced and have high competence in the areas of planning, organizing, directing, and controlling construction. They also have to understand the newest technology, have knowledge in materials management, human resources, experienced in the quality management, productivity, cost engineering, scheduling, strategic experience of contracts, value engineering and risk management [5]. Lei and Skitmore (2004), found that the most important skills that an effective project manager should possess are the ability to communicate, followed by ability to meet project objectives and ability to make decisions in general [6]. From all of that, the project manager is required to has a wide range of competence to assure the project success. In general, the competence is proved by a certificate of expertise including for project manager.

4. Certification in Indonesia

The fast construction development in Indonesia cause more complicated projects problems that require high competence of the project manager. In the world, there are many professional associations that issued the certificate of expertise such as the Project Management Institute (PMI) and the International Project Manager Association (IPMA). In regulating the certification process in Indonesia, the government issue the Government Regulation No. 4 2010 Article 24 then amended to be the Government Regulation No. 92 of 2010. This regulation states that in order to carry out the development of construction services it needs to establish Construction Services Development Board

(LPJK) [7]. Furthermore, in Article 28 it is stated that LPJK deserves the right to registers the construction workers including the classification, qualification, certification of the skills and the expertise of the workers in the field [8]. From these explanations, it appears the differences in the procedure of the expertise certificate issuance. In Indonesia, the association is not entitled to issue an expertise certificate of such an association in the world.

3.1 The Chronology of Certification System in Indonesia

The chronology of certification system in Indonesia when presented in the figure are as follows:

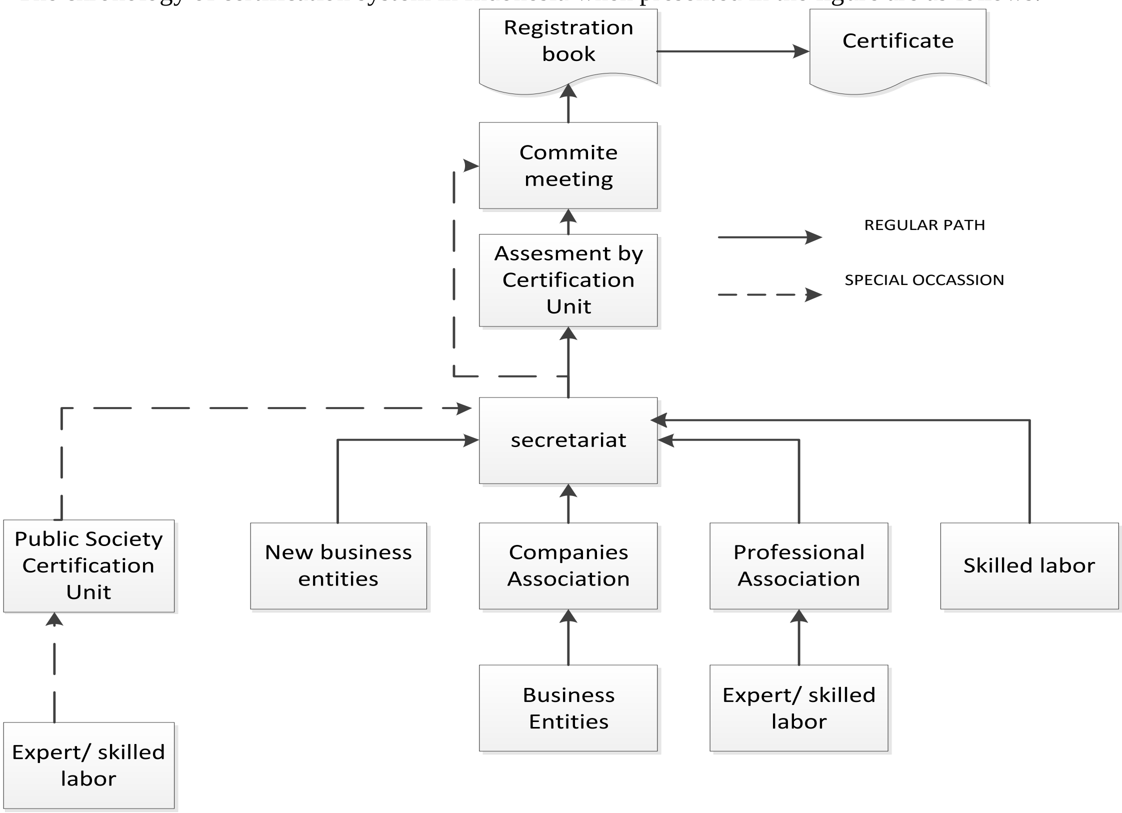

Fig.1 The Chronology of Certification System in Indonesia

Figure 1 illustrates the first phase to do is that the applicant should register at the association or directly apply to the public constituted Certification Unit and complete the requirements. The second phase, associations and certification unit verify the documents submitted by the applicant. The third phase, the documents that have been verified is handed at the secretarial institutions for further processing. The fourth phase, a document that have been accepted secretarial institution will be assessed by the assessor of manpower or experts. The fifth phase after a proper assessment of the competence of the applicant, the document will be forwarded in a meeting later recorded in the registration agency to issue certificates.

5. Research methods

The method used in this study is descriptive qualitative. To measure the perception of the weakness level in the certification project manager, it is need a ranking system ranging from less important to very important according to the number of the identification of critical points.

Validity of the result will be tested using triangulation method. The result of the questionaire for project manager will be cross checked with the experts such as the assesors and the project manager's colleagues. The questionnaire is treat ed by the ranking method of likert scale. The sum of the questionaire will be averaged and categorized as shown in table 1.

Table 1. The Range of Importance Level

Range	The Level of Importance
1≤ x ≤ 1,5	very unimportant
1,5≤ x ≤ 2,5	unimportant
2,5≤ x ≤ 3,5	important
3,5≤ x ≤ 4,5	Very important
4,5≤ x ≤ 5	extremely important

The population of the study was the project managers with samples of 158 respondents. Questionnaires were administered to identify and to provide the Critical Points in the ranking certification system ever undertaken by project managers. The following is the flow of the study:

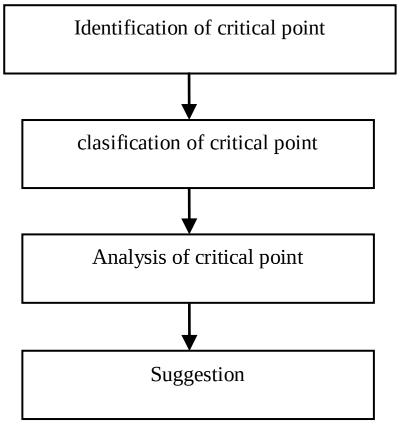

Fig 2 The Flow of The Study

The data were processed and presented in tables and graphs for the ease of understanding. While the results of observations and interviews were used to clarify the results of the questionnaires

6. Identification of Critical Point Assessment

Figure 1 shows some of the parties involved in the process of certification. With so many parties involved in the certification, the existence of more critical points is potential. In this flow there are several potential critical points that may affect the assessment and its results.

One hundred and fifty eight (158) project managers were given questionnaire, and it is obtained the following identification of a critical point

Table 2. Identification of Critical Point System Certification

No	The Identification of Critical Point System Certification	Explanation
1	The cost and requirements of the applicants are incomplete	The cost of certification which is expensive for the applicants and the requirements of the applicant are incomplete or ineligible
2	The job reference is less reflecting the real experience	No explanation on the role and the contribution in the project
3	Interview	The application or interview process is done or not
4	The objectivity of assesor	The objectivity of the assessor to the familiar applicants is questionable
5	The validation system and verification of the association	The series of validation and verification conducted by the association have been properly carried out or not
6	The lack of additional information that supports the applicants job reference	Additional information regarding the performance of the applicants, the success or failure of projects handled

The identification of the data is classified according to the source. This is intended to find out the stakeholder that are responsible for the Critical Points.

From the identification result, there are several problems that cause a critical point in the implementation of the certification. In some critical points, it can be classified based on its source

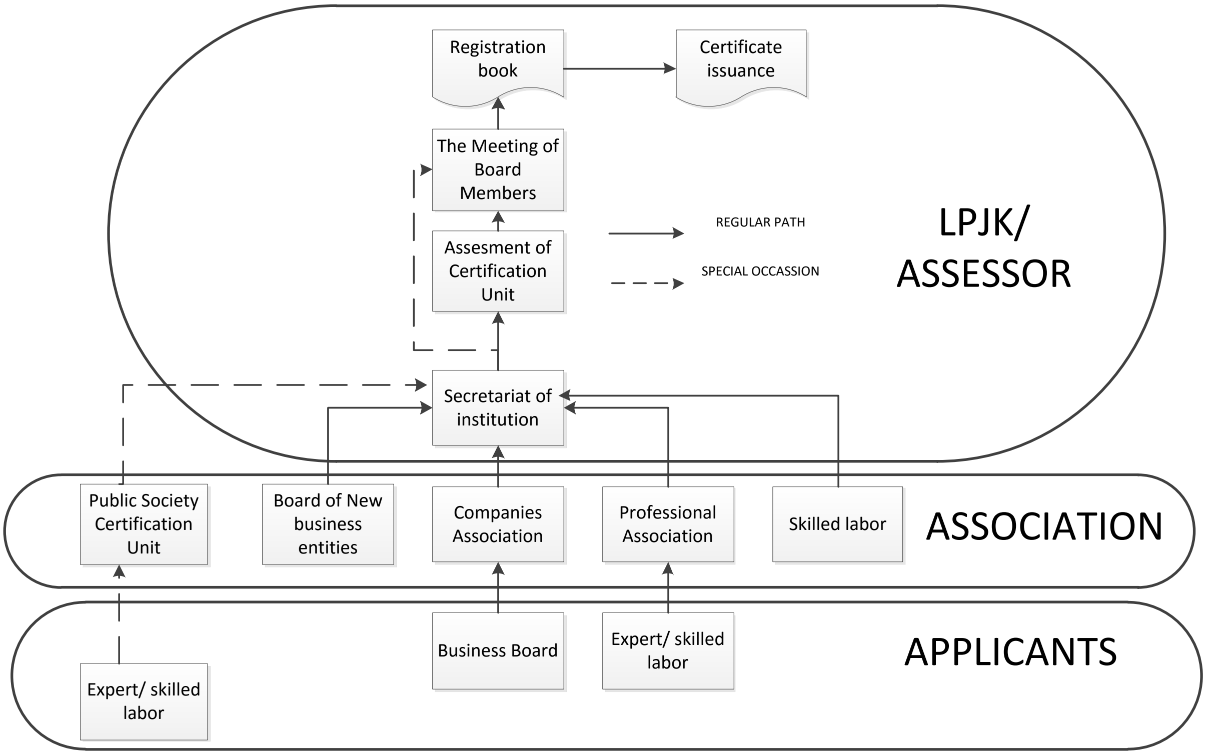

Fig 3 The Classification Diagram of The Cause of Critical points in Certification

In Figure 3, based on the source, the critical point is derived from the applicant, associations and LPJK / assessor. When presented in table then it can be seen as follows:

Table 3. Classification of the critical point source certification

No	The Critical point	The Source of Critical point
1	The requirements of the applicant are incomplete	Applicants
2	The job reference is less reflects the real experience	Applicants
3	Interview	LPJK/assessors
4	The objectivity of assessor	LPJK/assessors
5	The validation system and verification of the association	Association
6	The lack of additional information that supports the applicants job reference	Association

Based on the source, the requirements of the applicants are incomplete and the lack of the job references does not reflect the real experience. All of them becomes the potential critical point of the applicant. Interviews and the objectivity of the assessor become the critical point that emerged during the certification process in LPJK, while the system of validation and verification of the association and the lack of additional information supporting the applicants reference appears to be a critical point. It happens at the time of the certification process in the association.

7. Analysis of Critical Point Assessment

The results of the identification of critical points are ranked to determine the level of the importance based on the project managers point of view. The sum of the rankings in the questionnaires is as follows:

Table 4. The results of the score over the critical point of certification

The Critical point	Score	Mean
The requirements of the applicant are incomplete	636	4,03
The job reference is less reflect the real experience	787	4,98
Interview	240	1,52
The objectivity of assesor	297	1,88
The validation system and verification of the association	677	4,28
The lack of additional information that supports the applicants' job reference	320	2,03

The table 4 is shown in the bar graph below.

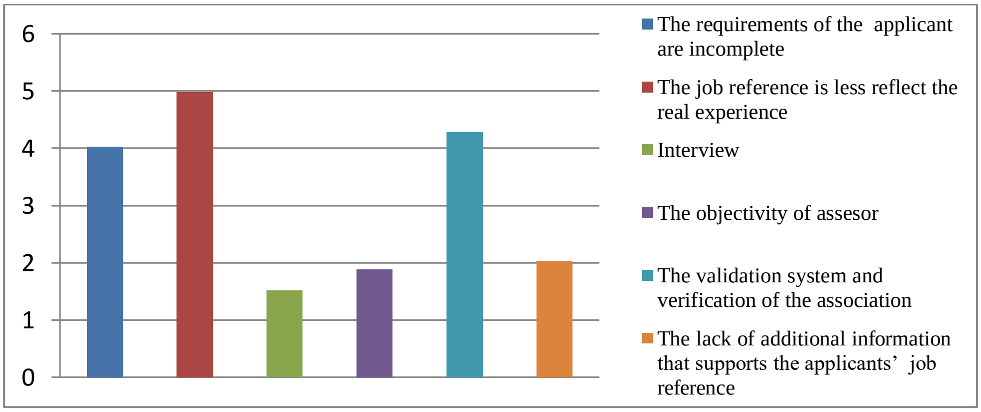

Fig 4 The Mean of The Certification Critical Point

Based on the interview from the project managers, they stated that all of the factors mentioned above are highly vulnerable if the procedure is not carried out. When the critical points are ranked, it is gained the ranking as it is shown in the table above. It is also found out that the job reference that does not reflect the real experience got the score of 787 and mean of 4,98. Based on table 1, it is categorized in the extremely important level.

Based on the results of the ranking system above, it is revealed that the lack of a job reference that reflects the real experience is the weakest point where it has most risk. Based on the interviews from the project managers, they stated that they become the project managers because of their experiences in those projects. But some of the project managers reveals that they did not have the experience that have been listed in their curricullum vitae. This could be happen because they did not applied sertification themselves. They were registered by the company where they work in. Without any further explanation concerning the role of the managers in the project, the assessors can not determine the extent of the competence and the excellence possessed by the respondents in order to obtain a certificate of competence in accordance with existing standards.

The next critical point is the system of validation and verification of the association has score of 677 and mean of 4,28 which mean that it is categorized in the very important level. According to the respondents, with many existing associations in Indonesia, it can lead to the existing differences in standards and ways of doing the validation and verification. There is an associations requiring the applicant to follow the seminars or workshops conducted by the association, do the written test and interview besides collecting the portfolio. However there are also associations that do not cross-check the data submitted by the applicants. Therefore, there is a tendency that the association VVA system is not well managed in this case and of course the different procedure can produce different quality of certification. Based on the interview with the assesor of LPJK, it's revealed that the assesors still found some of the fake education certificate of the applicants. This means that the VVA didn't work properly in some associations.

Then, incomplete requirements of the applicant has score of 636 and mean of 4,03 which mean it is categorized in the important level. Based on the information from respondents, can cause the longer process of qualification and can cause someone to offer the acceleration of certification process in a way that should not be done.

The lack of additional information supporting the applicants reference work has score of 320 and mean of 2,03 which mean it is categorized in the unimportant level. Based on the respondent of project manager, the lack of additional information supporting the applicants reference work is not really important because it will really takes time to collect the additional information such us the contract, addendum, planned and for construction drawing, etc for each project in their CV list. Even so, the information given by supervisor and the owner of the project concerning the work of the managers would be more helpful to assure the assessors to give the assessments of the managers.

Furthermore, the critical point based on the project manager point of view is the objectivity of the assessors has the score of 297 and mean of 1,88 which is categorized in the unimportant level. Based on the interview, there are times, the assessors know the applicant personally. That kind of relationship can affect the assessors assessment to the competences of the applicants. Even so, it is not really important for the project manager to take care of, because the application need 3 assesors to sign the application.

The last is an interview with the score of 240 and the mean of 1,52 which is categorized in the unimportant level. Basically in any certification process, the applicants are required to have the interview to determine the real competencies of the applicants. Based on the information from some respondents, in practice, this stage is often not done by the assessor, especially for a certificate of the basic and middle levels. But it seems this thing doesn't really matter for the the respondent, because it will be very troublesome if they are called for interview while they still working outside of the city.

8. Conclusions and recommendations

Based on the results of the study, it can be concluded that:

- The lack of the job reference that reflects the real experience is the weakest point in the certification process with the score of 787 and the mean of 4,98 which is categorized in the extremely important level.
- The next critical point is the system of validation and verification of the association has score of 677 and mean of 4,28 which mean that it is categorized in the very important level
- The incomplete requirements of the applicant has score of 636 and mean of 4,03 which mean it is categorized in the important level
- The lack of additional information supporting the applicants reference work has score of 320 and mean of 2,03 which mean it is categorized in the unimportant level
- the critical point based on the project manager point of view is the objectivity of the assessors has the score of 297 and mean of 1,88 which is categorized in the unimportant level
- While the interview is considered to be less affective in the process of certification with the score of 240 and the mean of 1,52 which is categorized in the unimportant level

Sugesstions are:

- To overcome the first critical point, the complete reference work should be required. The applicant must explain his role in the project, it is used as a reference and therefore assures the competence of the applicant.
- For the second critical point, in terms of the system of Validation and Verification of the Association (VVA), LPJK can do a random sampling to check the implementation of the VVA in association regularly. When the VVA does not follow the procedure of LPJK, the sanctions can be given depends on the infraction.
- To overcome the third critical point in terms of the incomplete applicants reqirements, the associations and LPJK can provide socialization to the prospective applicants, and monitor of the implementation of the

certification of registration to prevent parties that try to take the advantage of the circumstances of acceleration in the registration process of certification.

- The fourth critical point, the lack of additional information that supports the applicants job reference can be overcome by including the supporting documents in the form of an affidavit from the employer and the owner of the project on the work of the applicant. It also be checked against the documents by contacting the parties who gave the statement.
- The fifth critical point is the assessors objectivity. Using three assessors for assessment as has been done today, can also exchange the assessor if they are known from the same institution with the applicants.
- To overcome the sixth critical points, the interview should be addressed to each of the applicants for certification. With the interview, the competence of the applicants can be known whether the reference work is really done by the applicants or not.
- The analysis of the external factors that affect the certification system still needs to be studied further.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Innovation performance of large contractor in Indonesia: Influencing factors and its impact on firm's performance

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Abstract

This study aims to determine: factors that influence innovation performance in large contractor firm, and impact of innovation performance on firm's performance. The firm's performance may include: project performance, performance of firm's competitiveness, firm's competitive advantage, and firm's sustainable competitive advantage. Factors that influence innovation performance are classified into 3 groups: driving factor, internal factor and external factor. Data collected by a questionnaire survey sent to 452 companies (10% of the population). Only 248 questionnaires (5.5% of the population) that returned and can be analyzed further. The questionnaire use a 1-4 Likert scale as a measuring tool. Data were analyzed through three stages: descriptive statistics analysis to determine the tendency of responds, Spearman's rank correlation analysis to eliminate indicators that less than 0.50, and analysis of partial least squares of structural equation modeling to determine the magnitude of the effect of the variables studied. This study result are: 1) driving factors and internal factors positively affect innovation performance, while external factors affect negatively, 2) the influence of internal factors and driving factors at almost the same level, and 3) innovation performance affects firm's sustainable competitive advantages through project performances, performance of the firm's competitiveness and firm's competitive advantages.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: contractor; firm; innovation; performance.

1. Introduction

Since 1985, the Indonesian nation has officially participated in the globalization process. In that year Indonesia became one of the founding members of Asia-Pacific Economic Cooperation (APEC); became member of World

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Trade Organization (WTO) in January 1995; has committed to establish ASEAN Framework Agreement on Services (AFAS) in December 1995, ASEAN Free Trade Area (AFTA) in January 2003, and ASEAN Economic Community in December 2015 [1,2,3].

Indonesian economic openness has lead economic actors in the country to face stiff competition, with strong intensity and at high speed from foreign countries [4,5]. Such economic by D' Aveni and Gunther [6] and Henry [7] referred as an economy hypercompetition. In economic hypercompetition, every company have to innovate in order to survive and grow [8,9].

As part of the Indonesian economy, Indonesian construction industry also faced hypercompetition. Currently, Indonesian construction companies have to compete against each other and against foreign companies simultaneously. In a period of nine years from 2004 to 2013, the number of foreign companies entering the Indonesian construction industry has increased 72%, an increase of 8% annually [10]. That number is expected to increase.

Construction business in Indonesia are grouped into three business groups: executors, planners, and supervisors [11]. The executors are usually called contractors. In accordance with the level of complexity of the work, the amount of funds used, the amount of labor involved, and the multiplier effect both to upstream and downstream industries, contractor companies have strategic position to determine the level of competitiveness of the construction industry as a whole. The more competitive contractor companies the more competitive construction industry. Some researchers argue that high competitiveness can be achieved by innovate consistently and continuously. This study seeks to prove the truth of this opinion by analyze the impact of innovation performance on the firm's performance.

2. Literature review

By some researchers, innovation is typically distinguished by the invention [12,13]. In manufacturing innovation is defined as the practical application of one or some invention into a product or process that can be marketed [14,15]. In the construction industry, especially for contractors, the appropriate definition of innovation is the practical application of one or several new materials, new equipments, or new methods into a product or process that can increase the probability of winning the project tender, or to solve construction problems that accelerates time of construction or minimize construction costs [16,17,18].

Any construction project can be considered as a prototype, because of every single project has uniqueness as such: 1) location, 2) area of the building, 3) architectural and structure design, 4) length of completion time, and 5) project owner [19]. These uniqueness require the contractor to solve the problems by the approaches vary from one project to another. In other words, contractors are always required to innovate on every project he undertook [20].

Research on the factors that influence the success and failure of innovation contractors have been carried. Tatum [21] identified 7 critical success factors of innovation contractors: 1) organizational structure, 2) organizational culture, 3) company policies, 4) priorities of the company, 5) flexibility of the unit size, 6) coordination of intra- and inter organization, and 7) placement of the right employees. According to Nam and Tatum [22] there are 3 main factors that drive or push the contractor companies to innovate: 1) demands or requests of the project owner, 2) demand due to the problems that arise in construction work, and 3) availability of new technologies that enable improved effectiveness and efficiency of construction work. Dulaimi et al. [23] identified 6 internal factors and 3 external factors that impeded the implementation of the company's innovation. The internal factors are consists of: 1) stiff organizational structure, 2) scarcity of resources, 3) behavior that resist change, 4) non conducive values of the organization, 5) work culture, and 6) company's burden. The external factors consists of: 1) laws and regulations, 2) government agencies authorized to issue regulations relating to the construction industry, and 3) conditions and market perceptions. Blayse and Manley [24] concluded 6 key factors that influence the success and failure of innovation contractors: 1) client/partner/owner and manufacturing companies, 2) structure of construction industry production, 3) industry relations, 4) procurement systems, 5) rules, regulations, and standards, and 6) resources of the organization, such as: innovation culture, absorptive capacity, innovative individuals, knowledge codified, and innovation strategies.

Research on the effects or benefits of innovation in the company's contractors have been conducted by Lim et al. [16]. According to Lim et al. [16] innovation can be a useful tool to improve the competitiveness of contractors, by implementing the innovations that can reduce overall project costs and at the same time accelerate the completion of projects. This kind innovations will increase the productivity of companies which will further increase the chances of the company to achieve a sustainable competitive advantage.

In this study the factors that influence the performance of innovation in the firm's contractors are grouped into 3 groups: driving factors, internal factors and external factors. The driving factors consist of: 1) owner’s demand, 2) problem demand, and 3) availability of new technologies in the industrial market [22,24,25]. The internal factors which include: 1) creative and innovative employees, 2) managers who know and understand innovation, 3) technological capabilities, 4) financial support, and 5) organizational culture [21,23,24]. As for the external factors consist of: 1) regulations, laws, and standards, 2) governmental and non-governmental agencies, 3) structure of the construction industry, and 4) internal relations of the construction industry [23,24].

The firm's innovation performance is measured by innovation frequency. The project performances are measured by: 1) project quality improvement, 2) accelerate project completion, 3) project cost reduction, and 4) an increase in owner satisfaction. The performance of firm’s competitiveness are measured by: 1) productivity improvement, 2) increase in profit, 3) an increase in the value of the project, 4) an increase in the number of the projects, and 5) an increase in the number of customers. The firm’s competitive advantages are measured by: 1) productivity excellence, 2) profit excellence, 3) market share excellence, and 4) growth excellence. The firm’s sustainable competitive advantages are measured by: 1) sustain productivity excellence, 2) sustain profit excellence, 3) sustain market share excellence, and 4) sustain growth excellence.

3. Research problem

This study aims to determine the factors that influence innovation performance in large contractor firm, and the impact of innovation performance on the firm's performance. Its objectives are to: 1) analyze the influence of driving factors, internal factors and external factors to innovation performance, and 2) analyze the impact of innovation performance on project performance, performance of firm’s competitiveness, firm’s competitive advantage, and firm's sustainable competitive advantage.

4. Research method

Data collected by a questionnaire survey sent to 452 companies (36.8% of the population [26]). Only 248 questionnaires (20.1% of the population) that returned and can be analyzed further. The questionnaire use a 1-4 Likert scale as a measuring tool. The data were analyzed through three stages: descriptive statistics analysis to determine the tendency of respond, Spearman's rank correlation analysis to eliminate indicators that the coefficient less than 0.50, and analysis of partial least squares of structural equation modeling to determine the magnitude of the effect of the variables studied.

In this study, the driving factors, the internal factors, the external factors, and the innovation performance have 3, 5, 4, and 1 indicators, respectively. The project performance, the firm’s competitive advantage and the firm’s sustainable competitive advantage each have 4 indicators, while the performance of firm's competitiveness has 5 indicators. These indicators can be seen in Table 1.

On the Driving factors, the 1-4 Likert scale indicating answer for “No”, “Sometimes”, “Frequently”, and “Constantly”; on the Internal factors: “Nothing”, “Inadequate”, “Adequate”, and “Very adequate”; for the External factors, the Project performances, the Performance of firm’s competitiveness, the Firm’s competitive advantage, and the Firm's sustainable competitive advantage indicating answer for “Disagree”, “Less agree”, “Agree”, and “Strongly agree”; and on the Innovation performance: “Never”, “As owner’s demand”, “When problem arise”, and “On every project”.

5. Data analysis

In this study the characteristics of respondents concern is head office, length of work, and level of manager. The head office of respondent are compared with the distribution of population to determine the sample representativeness. The length of work is used to determine whether the respondents' experience can be regarded as sufficient, and the level of manager is used to determine the sample representativeness of respondents in terms of firm organization. The head office, length of work, and level of manager, of the respondents can be seen in Table 2.

Table 1. Variables, indicators, and label.

Variable	Indicator	Label
Driving factors	Owner's demand	DF1
	Problem demand	DF2
	Availability of new technologies	DF3
Internal factors	Creative and Innovative employees	IF1
	Managers who know and understand innovation	IF2
	Technological capabilities	IF3
	Financial support	IF4
	Organizational culture	IF5
External factors	Regulations, laws, and standards	EF1
	Governmental and nongovernmental agencies	EF2
	Structure of the construction industry	EF3
	Internal relations of construction industry	EF4
Innovation performance	Innovation frequency	IP
Project performances	Project quality improvement	PP1
	Accelerate project completion	PP2
	Project costs reduction	PP3
	An increase in owner satisfaction	PP4
Performance of firm's competitiveness	Productivity improvement	PFC1
	Increase in profit	PFC2
	An increase in the value of the project	PFC3
	An increase in the number of projects	PFC4
	An increase in the number of customers	PFC5
Firm's competitive advantages	Productivity excellence	FCA1
	Profit excellence	FCA2
	Market share excellence	FCA3
	Growth excellence	FCA4
Firm's sustainable competitive advantages	Sustain productivity excellence	FSCA1
	Sustain profit excellence	FSCA2
	Sustain market share excellence	FSCA3
	Sustain growth excellence	FSCA4

Table 2. Head office, length of work, and level of manager of the respondents.

Category	Percentage	Category	Percentage
Head office:		Length of work:	
Java	50.4%	< 10 years	17.3%
Sumatra	12.5%	10-20 years	50.8%
Kalimantan	13.7%	> 20 years	31.9%
Sulawesi	10.5%		
Papua	9.3%	Level of manager:	
Bali	3.6%	Line manager	51.6%
		Middle manager	42.7%
		Top manager	5.6%

Based on data from the Construction Service Development Board [26] by September 2015, 60.8% big construction companies (contractors & consultants) located in Java. Thus the profile that 50.4% of respondents were in Java can be considered close to the distribution of the population. In terms of the length of work of respondents, since 82,7% have more than 10 years experiences then the experience of the respondents can be regarded as sufficient. The level of manager of the respondents are 94,4% middle and line managers. Those were supervisor, innovation team leader, engineering team leader, site manager, project manager, and division manager. It has meant that the respondents are persons who is really involved directly in the company's innovation process with sufficient experience.

5.1. Summary of the respondents' answers

A summary of the respondents' answers can be seen in Table 3.

Table 3. Summary of the respondents' answers.

Label	Likert scale				Label	Likert scale			
	1	2	3	4		1	2	3	4
DF1	3.6%	6.5%	9.7%	80.2%	PP3	6.5%	10.9%	17.3%	65.3%
DF2	6.9%	22.6%	41.5%	29.0%	PP4	1.6%	6.0%	11.3%	81.0%
DF3	42.3%	32.7%	25.0%	0.0%	PFC1	4.8%	8.5%	12.9%	73.8%
IF1	7.7%	9.3%	63.3%	19.8%	PFC2	3.6%	6.9%	11.3%	78.2%
IF2	24.6%	42.3%	23.8%	9.3%	PFC3	7.7%	13.3%	19.0%	60.1%
IF3	8.5%	25.0%	50.8%	15.7%	PFC4	9.3%	14.9%	21.8%	54.0%
IF4	29.8%	39.5%	26.2%	4.4%	PFC5	10.9%	16.5%	25.0%	47.6%
IF5	28.6%	38.7%	25.8%	6.9%	FCA1	7.3%	15.7%	21.0%	56.0%
EF1	75.0%	9.7%	15.3%	0.0%	FCA2	6.9%	9.3%	13.7%	70.2%
EF2	81.0%	7.3%	11.7%	0.0%	FCA3	35.9%	44.0%	16.9%	3.2%
EF3	56.0%	16.9%	27.0%	0.0%	FCA4	68.1%	21.0%	10.9%	0.0%
EF4	14.9%	17.3%	48.0%	19.8%	FSCA1	23.4%	39.5%	23.0%	14.1%
IP	3.6%	23.4%	67.3%	5.6%	FSCA2	19.8%	38.3%	24.6%	17.3%
PP1	7.7%	12.9%	27.4%	52.0%	FSCA3	68.1%	21.4%	8.5%	2.0%
PP2	0.0%	5.6%	11.7%	82.7%	FSCA4	74.2%	18.1%	7.7%	0.0%

5.2. Descriptive statistical analysis

It is necessary to determine the tendency of the respondents' answers. This research used statistics descriptive analysis to determine the tendency of the respondents' answers. The result of the analysis is the average value and the standard deviation. The average value is interpreted using Fig. 1. The result can be seen in Table 4.

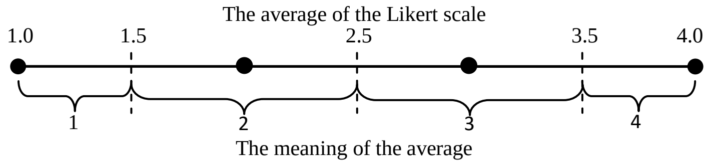


Fig. 1. The evaluation scale.

5.3. Spearman's Rank Correlation Analysis

The influence of each indicator variables to innovation performance needs to be analyzed. This research used Spearman's rank correlation to analyzed those influences. The result can be seen in Table 5. By using correlation coefficient 0.500 as a limit to determine the influence strength of the indicators then there are three indicators that eliminated in this stage. Those are EF1, EF2, and FSCA4.

5.4. Partial least square path analysis of structural equation modeling

Model of the relationship between variables created using a structural equation modeling approach. Partial least square path analysis used to calculate the value of each path. The value indicates the degree of influence between the two variables related. This study uses a software SmartPLS 2.0 as a tool for developing the model [27]. The results of the calculation can be seen in Fig. 2(a).

Table 4. The average, standard deviation, and result analysis of indicators.

Label	Mean	St. Dev.	The Meaning	Label	Mean	St. Dev.	The Meaning
DF1	3.665	0.756	Constantly	PP3	3.415	0.922	Agree
DF2	2.927	0.887	Frequently	PP4	3.717	0.649	Strongly agree
DF3	1.826	0.803	Sometimes	PFC1	3.556	0.842	Strongly agree
IF1	2.951	0.772	Adequate	PFC2	3.641	0.766	Strongly agree
IF2	2.177	0.909	Inadequate	PFC3	3.314	0.972	Agree
IF3	2.737	0.824	Adequate	PFC4	3.205	1.011	Agree
IF4	2.052	0.859	Inadequate	PFC5	3.092	1.035	Agree
IF5	2.108	0.899	Inadequate	FCA1	3.258	0.972	Agree
EF1	1.403	0.741	Disagree	FCA2	3.471	0.921	Agree
EF2	1.306	0.669	Disagree	FCA3	1.875	0.802	Less agree
EF3	1.709	0.865	Less agree	FCA4	1.427	0.681	Disagree
EF4	2.725	0.946	Agree	FSCA1	2.278	0.977	Less agree
IP	2.750	0.611	When problem arise	FSCA2	2.395	0.992	Less agree
PP1	3.237	0.950	Agree	FSCA3	1.443	0.734	Disagree
PP2	3.770	0.539	Strongly agree	FSCA4	1.334	0.614	Disagree

Table 5. The spearman's rank correlation between inovation performance and others indicators.

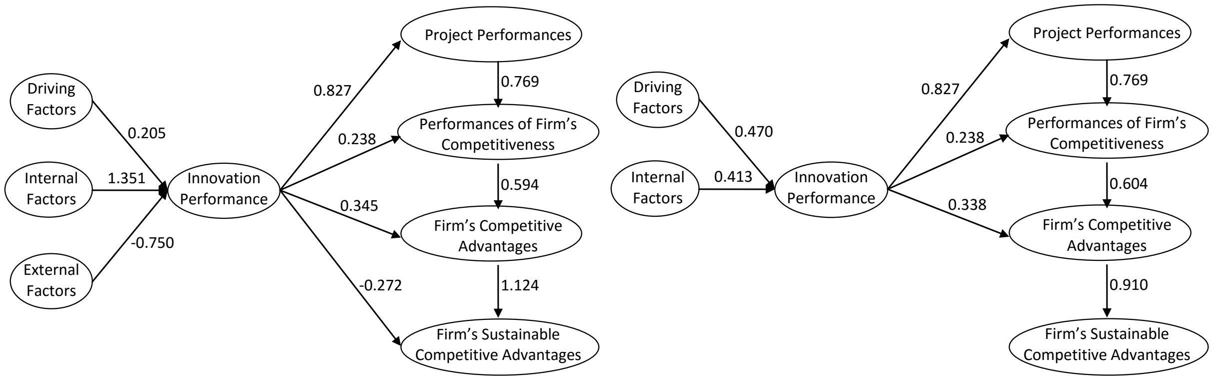
Label	Correlation Coefficient	Label	Correlation Coefficient
DF1	0.776	PP4	0.758
DF2	0.818	PFC1	0.912
DF3	0.691	PFC2	0.819
IF1	0.729	PFC3	0.815
IF2	0.825	PFC4	0.806
IF3	0.835	PFC5	0.812
IF4	0.828	FCA1	0.806
IF5	0.843	FCA2	0.889
EF1	0.473	FCA3	0.780
EF2	0.450	FCA4	0.522
EF3	0.577	FSCA1	0.799
EF4	0.834	FSCA2	0.760
PP1	0.776	FSCA3	0.526
PP2	0.724	FSCA4	0.493
PP3	0.840		

One purpose of this study was to determine the factors that influence innovation performance in the contractor company. As can be seen in Fig. 2(a), there are two paths is negative. Those are the path of the External Factors-Innovation Performance and the Innovation Performance-Firm's Sustainable Competitive Advantages. A negative value on the External Factors-Innovation Performance path indicating that the External Factors inhibit the Innovation Performance. While a negative value on the Innovation Performance-Firm's Sustainable Competitive Advantages path indicating that the Innovation Performance has no direct impact on the Firm's Sustainable Competitive Advantages. For further analysis, both paths are eliminated.

After eliminate the path of the External Factors-Innovation Performance and the Innovation Performance-Firm's Sustainable Competitive Advantages, the model were recalculated. The results can be seen in Fig. 2(b).

There are two situations that can be seen in Fig. 2(b). First, the influence of the Driving Factors and the Internal Factors on the Innovation Performance at almost the same level. Second, the path of the Innovation Performance-Performance of Firm's Competitiveness and the Innovation Performance-Firm's Competitive Advantages have value 0.238 and 0.338. Those values indicate that the Innovation Performance has very weak influence against the Performance of Firm's Competitiveness, and the Innovation Performance has weak influence against the Firm's

Competitive Advantages. Therefore, for the next phase, both paths are eliminated, and the model were recalculated. The results can be seen in Fig. 3.



(a) (b)

Fig. 2. (a) model of the 1st calculation; (b) model of the 2nd calculation.

As can be seen in Fig. 3, the Innovation Performance does not directly impact the Firm's Sustainable Competitive Advantages, but through the Project Performances, the Performances of Firm's Competitiveness, and the Firm's Competitive Advantages.

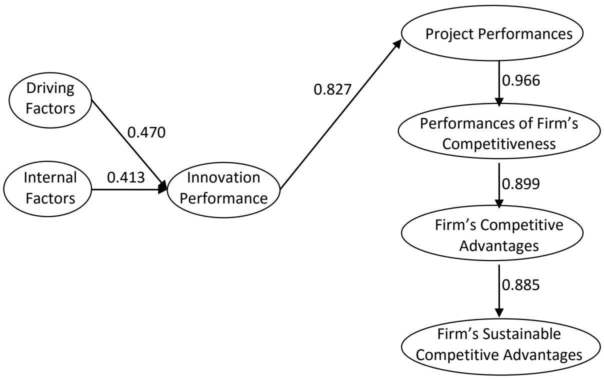


Fig. 3. Model of the last calculation

6. Result

This study result are: 1) two indicators of external factors and 1 indicator of firm's sustainable competitive advantages, are eliminated, 2) driving factors and internal factors positively affect innovation performance, while external factors affect negatively, 3) the influence of internal factors and the driving factors on innovation performance at almost the same level, 4) the influence of innovation performance directly to the performance of firm's competitiveness, and firm's competitive advantages are relatively weak and can be ignored, 5) the innovation performance does not directly impact the firm's sustainable competitive advantages, and 6) the innovation performance affects the firm's sustainable competitive advantages through project performances, performance of the firm's competitiveness and the firm's competitive advantages.

7. Conclusions and implications

There are two indicators of the external factors that do not have influence to the innovation performance. Those are 1) regulations, laws and standards, and 2) governmental and non-governmental agencies. This means two things. First, regulations, laws & standards need to be readjusted, revised and updated in order to encourage the contractor to actively innovate. Second, vision and mission of governmental and non-governmental agencies need to be updated in order to be an effective partner for contractors, particularly in terms of innovating consistently and continuously.

The innovation performance does not have impact to sustain growth excellence of the company. Therefore, for contractors that want to maintain the growth excellence need to do other strategies as well, while still innovating consistently and continuously.

The influence of internal factors and the driving factors on the innovation performance at almost the same level. That means, while the management of the contractor company focused on internal improvements in order to innovate consistently and continuously, then the other stakeholders (project owner, government and non-government agencies) need to implement policies that are encourage contractors to innovate freely, while use the specifications in the contract as a guidance.

The innovation performance affects the firm’s sustainable competitive advantages through project performances, performance of the firm's competitiveness and the firm's competitive advantages. That means the contractor’s innovation team should focus on accelerate the project completion, reduction the project cost, and minimize the possibility of accidents, while keeping the specification requirements. The innovations will improve the performance of the project and in turn,, like a domino effect, will increase the company's sustainable competitive advantage. Therefore, the contractor firm should focus on building a culture and enterprise management systems that encourage and facilitate its employees and innovation teams to innovate consistently and continuously, by providing incentives and facilities needed to innovate.

Acknowledgement

The study was funded by directorate general of higher education, the ministry of national education, under grants doctorate. This support is gratefully acknowledged. We also greatly appreciate the willingness of many respondents who took their valuable time to answered the survey.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Innovativeness: a keyfactor to support contractors' business success

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Abstract

Indonesian contractors are challenged by high levels of competition both locally and globally. In order to be successful in competition, a contractor is required to be innovative. This study aims to clarify the concept of innovativeness and to explore its implementation particularly in Indonesian contractors. Following a thorough examination of the literature on innovativeness, semi-structured interviews were carried out with top managers of contractors in Indonesia to determine the innovativeness characteristics of Indonesian contracting firms. The qualitative data were analyzed using an inductive thematic analysis method. This study found three contractor actions to support innovations: carrying out research and development, challenging staff to be innovative and supporting programmes that spark innovation.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

*Keywords:*innovation; contractors; Indonesia; qualitative data; thematic analysis

1. Introduction

The construction industry in Indonesia has been growing rapidly in the last few years. The size and value of the construction market is one of the most important factors encouraging Indonesia's economic growth. In 2012, the Indonesian Chamber of Commerce and Industry noted a significant increase in the Indonesian construction industry. It was valued at IDR 284 trillion and then it became IDR 369 trillion in 2013. Global Construction 2025 projected the increment in value from 2012 to 2025 to increase by an average of 6% per year. If this estimation is reached, Indonesia's construction industry in the global construction market will move from the position of the tenth biggest

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Peer-review under responsibility ofthe organizing committee of SCESCM 2016.

to become the fifth biggest.

In addition to the rapid growth of the construction industry in Indonesia, competition in the Indonesian construction market is high, both locally and globally. The Bureau of Indonesian Statistics identified the number of local contractor was extremely large, in 2013 it was recorded approximately 130,000 contractors. In addition to competition among local contractors, the force of global free trade creates increasingly higher and harsher competition. In 2013, 302 foreign contractors have been registered in Indonesia. This number shows a significant increase compared to the number in the previous two years, with only 128 in 2011. Although the number of foreign contractors entering the Indonesian construction market is very small compared with the number of local Indonesian contractors, they are contractors with very good reputations; therefore they are strong and threatening competitors for the Indonesian contractors to try to deal with. Currently Indonesian contractors also face the 2015 ASEAN Economic Community (AEC), in which ten Southeast Asia countries are launching a single market for goods, services, capital and labour. Obviously the AEC will increase the competition in Indonesia's construction market.

However, these opportunities and challenges are faced by the unpreparedness of Indonesian contractors to excel in business competition. Among that huge number of Indonesian contractors, the majority are small businesses. Wirahadikusumah and Pribadi [1] noted that the majority of the contractors had only poor to fair performance. Out of the 130,000 only about 100 contractors can be considered 'excellent' to be trusted to deliver high quality performance. Large numbers of small contractors with poor performance leads to various other problems in the Indonesian construction industry, such as:

- Low competitiveness because of failure to develop relevant strategies in running their business [2-4].
- Business orientation that focused on short term benefit rather than long term business sustainability [2]
- Low competitiveness, lack of marketing strategy, lack of entrepreneurial strategy, lack of capability to compete with foreign contractors [3]

This situation resulted in un-conducive business environment in the Indonesian construction industry. In order to improve contractors' competitiveness, the contractors in Indonesia, need to be innovative because the appropriate innovations can address the problem of projects, as well as meet the client's demands. Frese [5] mentioned innovativeness refers to creating and implementing new ideas such as new product, new service, new system or new strategy in order to achieve success of the company.

Contractors have been considered as project based firms (PBFs) that run their business on the basis of projects. As PBFs, contractors are characterized by a temporary project's organization within the permanent firm's organization. Contractors are required to deliver project as a unique end product specifically designed to meet clients' demand. In this business circumtances, contractors run their activities in many unique ways. Due to the specific nature of the contractor's business and the the condition of contractors' business in Indonesia, innovativeness of contractors in Indonesia is considered as distinct from companies in other sectors as well as contracting companies in other countries. Therefore, this study is aimed at investigating innovativeness of contractors with a specific focus on contractors in Indonesia. In order to achieve this aim, the specific research objectives of this study are: to explore theoretical concepts and previous work on innovativeness with a specific focus on innovativeness in construction and contractors, then to identify the key factors of innovativeness for contractors based upon the experiences of contractors in Indonesia.

2. Literature review

The literature review in this study is aimed to obtain a deeper understanding of the concept of innovationess and its related aspects such as: antecedents, outcomes and affecting factors. The literature review has been carried out both in general context and in construction as a focus of this study.

2.1. Innovativeness

Innovativeness is interpreted as an effort to gather and to support the invention of creative new products, services and processes [6-8]. Innovativeness was linked to different types of innovations, such as product innovation[9, 10] and service innovation[11]. Product innovativeness was defined as a propensity to introduce innovative product characterised by properties such as newness, uniqueness, pioneering, and technology adoption. Service innovativeness was introduced in order to provide customer satisfaction, meet customers' needs and to improve the firm's value at an acceptable risk.

According to Andersson, Bengtsson, Ekman, Lindberg, Waldehorn and Nilsson [12], product innovation is categorized as 'tangible' innovation while service innovation is 'intangible'. The researchers mentioned that innovation was usually associated with tangible innovation only; however, company innovativeness should be focused on intangible innovation as well as business model innovation, networking and management innovation.

Liu and Chen [9] found market orientation and technology orientation as the antecedents of product innovativeness, while Tsai, Liao and Hsu [10] found knowledge integration influenced product innovativeness. The study about service innovativeness has considered both the internet and people as enablers of service innovations. The findings shows that internet innovativeness should be maintained in most industries and people innovativeness is needed in human-dominated industries [11].

2.2. Innovativeness in construction

After a thorough examination has been done regarding several issues related to innovativeness in construction, a theoretical framework of innovativeness in construction was developed as can be seen in Figure 1. The framework consists of three main components: antecedents, factors that influence innovativeness and outputs of innovativeness. Each component of innovativeness in construction is explained further in the following sections.

Winch [13] mentioned that innovativeness is necessary to excel in competition, especially when dealing with changing conditions. He addressed innovativeness as the extent to which the construction company designed its organization to support the creation of innovation. Several studies linked innovativeness to the competitive advantage of a construction company. Barrett, Sexton and Lee [14] mentioned that appropriate exploitation of innovations can enhance sustainable competitive advantages of small, project based construction firms. By focusing on a large construction company, Pellicer, Yepes and Rojas [15] found innovative performance is an important tool to achieve and maintain success in competition. In the more specific context, Lim, Schultmann and Ofori [16] and Gambatese and Hallowell [17] found that innovative construction firms gained several benefits such as decreasing construction cost and increasing productivity, so that eventually their reputations and success rates will start to improve reputation.

Several studies were carried out to identify factors that influence innovativeness of construction companies. Barrett and Sexton [18] found the innovation activities of small, project based construction firms are predominantly dependent on the commitment of the owner; innovation is directly related to their operational activities. Furthermore Pellicer, Yepes and Rojas [15] found the innovative performance of construction companies is affected by various factors including the demands of the new types of project, global markets, high competition, regulatory demands, business culture and, of course, the financial climate. Following this research, Pellicer, Yepes, Correa and Alarcón [19] found that innovation in construction companies is strongly driven by a project's technical issues, client's demands and top management encouragement.

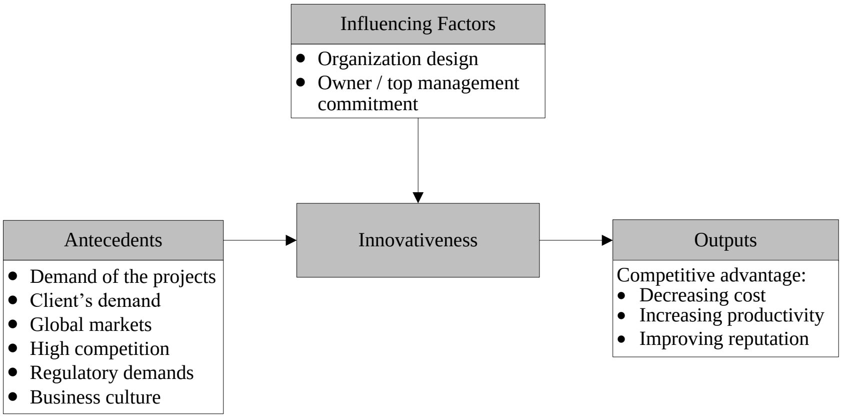

Figure 1 Theoretical framework of innovativeness in construction

3. Research method

This study adopted two main research methods. First, comprehensive review on several literatures was carried out to gain a better understanding about innovativeness in construction industry. Second, exploratory approach was conducted to identify innovativeness of contractors under specific circumstances of Indonesia. This approach has been chosen due to a lack of previous research in innovativeness in the area that is particularly related to contranctors in Indonesia. Data collection and data analysis for exploratory study are explained in detail in the following sections.

3.1. Data collection

Data for this study was collected through face to face semi-structured interviews with the top managers of contractors in Indonesia. The top managers of contractors are considered as an appropriate source of data because they are the most knowledgeable persons regarding the condition of their companies, and all strategic information is in their hands or accessible to them. They are intensively involved in planning, developing and implementing regulations, policies and programs for their companies. According to Quinlan [20], this constitutes judgemental sampling which determines the criteria for potential participants by considering the capacity of participants to provide proper and appropriate information related to the issues under investigation.

Prior to the interview, an interview guide was sent to the interviewees by e-mail in order to give them an idea about the interview. The interview guide consists of several questions about the implementation of innovativeness that were explored based on several references. During the interviews, the format and sequence of questions did not always expressly follow those outlined on the interview guide. Communication varied depending on the flow of the conversation and extra questions were asked to follow up on issues which appeared to be important and relevant to the topic of the interview. The interviews were controlled by the interviewer to make sure the focus of discussion was maintained. Interviews lasted between 30 to 60 minutes and each was audio-recorded and then fully transcribed.

3.2. The process of data analysis

The data collected was analysed using thematic analysis. Braun and Clarke [21] defined thematic analysis as a method for data analysis in order to identify themes that are related to the research questions. There are two ways to implement thematic analysis: induction and deduction. The first follows 'bottom up' approach that is data driven, in which themes are identified mainly based on the data. The second follows a 'top down' approach that is driven by the related theory to identify themes.

This study adopted the 'bottom up' thematic analysis model because of a lack of previous research in the area. The identified themes are directed to the issues that relate to innovativeness of contractors. The following processes were carried out to analyse the data and identify the key factors.

- Each transcript was read twice in order to enable the researcher to be familiar with the data and then initial ideas were extracted from the data.
- The coding process started manually. In this stage, as many phenomena as possible that emerged from interviews were coded.
- The next coding process was done using NVivo 10 software. In this stage, codes were refined and re-categorized into the appropriate nodes that are considered as important issues related to innovativeness of contractors.
- The coding process was refined and then the codes were re-allocated into appropriate themes. The issues that arose were continuously reviewed in three rounds using NVivo 10 software to check whether the issues work in relation to the entire data set or not.
- Finally important issues that explained the innovativeness of contractors were identified then the names and the definitions of the theme is decided.

4. Data Analysis

Data analysis was carried out using the data gathered from 19 top managers of contractors in Indonesia. The contractors where the top managers are involved vary in size and ownership. The ownership of contractors can be private or state, while the size of contractors were varied from small contractors with less than 100 employees to very big contractors with more than 1000 employees. Therefore, information obtained will represent various classes and ownerships of contractors.

Following the process of thematic analysis bottom-up approach, coding was done by clustering together statements which are related to the similar issue in one node or theme. Then based on all codes in one theme, the name of the theme was determined and then the definition and the important issues of each theme were identified to provide better and deeper understanding about the themes.

In order to give an idea about the coding process, the example of coding process for one node is explained here. This example showed statements, which are related to how contractors challenge their staff to create innovation, have been coded in one node. The example of statements that are clustered in one node because they are related to similar issue can be seen in Table 1. These statements are stated by several interviewees and one interviewee can contribute more than one statement.

After reviewing all codes in this example node or theme, issues related to the contractors actions to challenge staff to create innovations were found. Based on these findings, it was decided the name of this theme is ‘challenging staff to be innovative’ and and then this theme was defined as contractors’ willingness to encourage staff to create innovations through an appropriate rewards system, such as bonus, recognition, promotion, etc.

Table 1 Example of coding

Interviewees	Statements
1	Every 2 years, we held innovation day. All proposed innovations was examined and the finalists should present their ideas on the innovation day.
2	Innovations proposed by staff individually is judged by his or her supervisor and the result will be considered for evaluating staff's performance. For innovations proposed by team, they will get a reward.
3	Usually we held innovations competition. We give reward for the winner, the reward is not always in the form of money but surely we provide a reward.
4	To distinguish the staff who has achievements and who does not. We have standardized reward and punishment system.
5	We give bonus for the staff who has achievements.
6	We have 2 systems for incentive in our company, for staff at high position, the incentive is profit sharing. For staff at the lower levels, an intensive is bonus
7	We have regular program for innovation competition that also cover the improvement of way of thinking. It's started from small scale, from project as well as department in head office. The innovation is proposed to head office, then will be evaluated by innovation team
8	If they work efficiently, we give them point for promotion
9	The last competition is about innovative site office, we have not handed the award to the winner
	The winner get money and we held ceremony to present the award
	We have reward and penalty system. If project cost can be reduced, the difference between budgeted and actual costs will be shared to project team, it is done proportionally
10	For example, project team must achieve 10% profit after tax and then they create innovation that increases the profit to 15%. The difference will be shared with them and they get points for promotion
	Every year we send staff to study in India, Thailand or universities in Indonesia. This program is one type of reward to the staff
11	If they can construct project successfully, they will get incentive, bonus, etc. This incentives motivate people to be innovative. Reward can be material and immaterial such as promotion
12	We provide a freedom, the staff are challenged to create innovation
13	When project has problems on site, they must find solution that they consider it as the best solution
	If they can construct project under budget, the difference will be shared with them proportionally

5. Innovativeness of contractors in Indonesia

The analysis of interviews to contractors' top managers in Indonesia found several efforts of contractors to become innovative. In order to be innovative, contractors need to carry out research and development activities by conducting experiments to create new products and/or services. Large contractors usually have a Research and Development (R&D) department to handle these activities with the support of all staff, each of whom is directly involved in a construction project. Small and medium-sized contractors usually do not have a R&D department; therefore, the innovations are developed by the people in a project. Companies usually support this activity as far as the budget is acceptable and the results can be accounted for.

Contractors need to challenge staff to be innovative in order to encourage staff to create innovations. The challenge is carried out through an appropriate rewards system, such as bonus, recognition, promotion, etc. for innovators. In addition, there are contractors that regularly hold formal competitions for innovation among the project teams. Each project is required to produce an innovation; then, the most promising innovationis trialled in several projects and finally, if successful, itis set as a company standard.

Supporting programmes that spark innovation is another effort to create innovations. Contractors have to conduct programmes that encourage the creation of innovations, such as hiring consultants, managing knowledge properly, organizing discussion forums for knowledge and experience sharing, providing training, and determining the target of each project. Besides these programmes, the exemplar of top management behaviour and financial support are also considered as important factors to create innovations.

These findings show that contractors' innovativeness are mostly directed to meet client's demands and to achieve the efficiency and effectiveness of projects. These findings are in accordance to the business environment of contractors as PBFsthat run their business on the basis of projects and deliver a project specifically designed to meet the client's needs.

In addition to contractors' efforts to be innovative, this study also found innovativeness supports contractors to be different compared with competitors because they areable to offer something new and different from its competitors such as innovation in construction methods, materials, etc. In particular context of external factors, this study foundinnovative contractors need to be risk taker because innovation has risks such as technical risk. Then autonomy of staff for proposing suggestions for the improvement of projects and company's performance, as well as, autonomy of the project team in planning and managing projects' were found supporting contractors' innovativeness. Finally Figure 2 was prepared in order to provide clear picture of the findings of this study.

6. Conclusions

Innovativeness of contractors is characterized by several activities supporting the creation of innovations. Those activities are: (1) carrying out research and development activities, (2) challenging staff to be innovative and (3) supporting programmes that spark innovation. Innovativeness helps contractors to differentiate themselves from their competitors. Innovativeness of contractors is influenced by other factors such as autonomy of contractors' staff and willingness of contractors to take risk.

The explanations about the particular circumstances of contractors' business in Indonesia clarify the issues behind the development of innovativeness in this study. However the findings of this study are considered appropriate for adoption by contractors in general although they need to be examined further and adjusted accordingly to the circumstances of the local construction industry.

The findings of this study provided noteworthy contributions to knowledge in the areas of construction management to fill the gap left by lack of research into the innovativeness of contractors. To date research in construction management is more focused on innovation rather than innovativeness. This study also provides reference on how to be an innovative contractor in order improve competitive advantage in the construction market place.

Furthermore, in order to be an innovative contractor, both the existing and the target innovativeness characteristics of the company need to be understood. Then strategy can be developed to fill the discrepancy between them. Therefore further studies can focus on development of a model for measuring the level of innovativeness of contractors based on the findings of this study. Subsequently, the relationship between the level of innovativeness and a contractor's performance can be explored further.

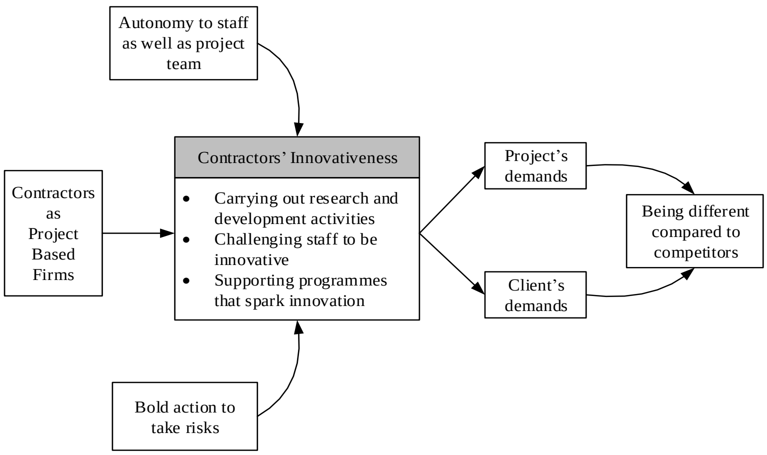

Figure 2 Innovativeness of contractors in Indonesia

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Strategy for small-medium scale contractor performance improvement in ASEAN competitive market

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Abstract

In facing current pressing sustainable issues and ASEAN Economic Community (AEC) where construction sector is on so-called 'free competition', national private construction industry players, i.e. consulting firms and contractors, must enhance their performance in order to improve their service, compete, and gain advantage. These players must apply the concept of strategic management in which environmental analysis and strategic alternative decision stage is involved. This study identifies the prevailing problems encountered by the Indonesian contractors firms. The case study focused on and collected data from small to medium contractors in Central Java. Data were analyzed and strategic decisions were formulated based on current baseline. The appropriate strategic alternatives for small contractor were market development by maintaining clients' trust, improving the human resources through certification, and implementing effective and efficient construction methods which minimize waste. For medium contractors, the attractive market development can be attained by optimizing the role of enterprise organizations, building teamwork, improving the control system, applying sustainable construction via efficient construction method.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: strategic management, contractor, construction sector, ASEAN Economy Community

1. Introduction

Political and economic development, government policy on regional autonomy, world agreement on free market – marked by the ASEAN Free Trade Area (ASEAN Economic Community) –forces national construction industries to face an increasingly competitive market. The changes in market conditions drive contractors and consultants to

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

observe their internal condition, their potential competitors as well as their position in industry landscape. In order to survive the competition, determining the appropriate strategy for the company is an important stage to carry out. The objective of this study is to formulate this appropriate strategy for small to medium contractors in facing ASEAN competitive market.

Delay in completion project, over budget, overusing resources, and construction waste are the most challenging problems of small to medium national contractors. Further, poor construction quality is also problematic. Many facilities and infrastructure which had just been built while still in the maintenance period were damaged and need serious improvements. These conditions are considered as barriers to be able to compete in the free market, which already started effectively in 2016with the implementation of ASEAN Economy Community (AEC). Within AEC framework, there are wider possibilities that overseas construction companies penetrate Indonesian construction sector, making already competitive construction industry will be even more competitive.

Compared to another industrial sector, construction sector is very limited in adopting and developing long term business strategy. One of the major reasons is that many contractors, especially small – medium size contractors, only care about short term profit. There is quite obvious paradigm that contractors do not require strategic plan to make profit. Contractors tend to think that profits will come naturally as long as they can win the bidding process even though they must bid with the lowest price possible. Therefore they perform tight cost control and construction time that sometimes hampers final product quality. They are less concern with strategic management. This mode of operation may not be conducive for the national long-term development of construction sector.

2. Strategic management and its formulation

The internal and external environment of contractor's companies is very dynamic, forcing the contractors to make use strategic decisions in doing the business [1]. In the current market, the continuity of a contractor's company depends on their performances. It is achieved continuously by paying attention to economic, social, environment, law, and ethical aspects when carrying out the construction works [2]. Further their existence depends on its capability in seeing and anticipating the opportunities [3].One of the ways to survive is using a specific strategy not only to win short term project bidding but also to rebuild long-lasting continuous competitive prominence [4].

Currently, small to medium contractors build up about 99% of Indonesian construction industry with 15% of market share. Meanwhile 1% of big contractors have 85% market share. This inequality shows the tight competition among small to medium construction industry player. In addition, small to medium contractors' performance is still low [5]. They need to improve continuously in order to attain higher competitiveness and maintain their continuity [6].

Performance – where a company achieves its goal and business targets –is seen as a perpetual process [7]. It is yielded from a process, products and services which can be evaluated and compared relatively with goals, standards, previous results and other organizations [8]. It involves performance of individuals within the company as well which depends on the competence, motivation, accepted support, and relation with the company [9].

In the modern practice of construction, sustainability becomes an emerging issue that needs to be implemented by contractors. The six principles of sustainable construction are Minimize resource consumption (Conserve), Maximize resource reuse (Reuse), Use renewable or recyclable resources (Renew/Recycle), Protect the natural environment (Protect nature), Create a healthy, non-toxic environment (Non-Toxics), and Pursue quality in creating the built environment (Quality) [10].

One of the comprehensive methods in formulating strategy is Rational Decision Model procedures suggested by David [11]. The procedures in developed with three stages; input, matching, decision, each is expressed in matrices consistent with the size and type of the organization. Thus, such a tool can help decision makers to identify, evaluate and choose the right strategy.

At the input stage, there are two kinds of matrix, i.e. IFE and EFE matrix. IFE matrix is used to acknowledge the internal factors of a company associated with the strengths and weaknesses that are considered important. EFE matrix is used to evaluate the external factors of the company. External data are collected to analyze matters relating to economic issues, social, cultural, demographic, environmental, political, government, law, technology, competition in markets where the company is located; and other relevant external data. At the matching stage, SWOT matrix and Internal-External matrix (IE) is developed. The first step is to fill in the SWOT items on the existing cell, and afterwards to develop alternative strategies with respect to the adjustment of internal to the external factors.

Alternative strategies generated must be logically consistent with various internal aspects of the company, according to the external trends that realistic and practicable (feasible). Internal-External Matrix (IE) is useful to positioning a Strategic Business Unit (SBU) of the company into a matrix consisting of 9 cells, as seen in figure 1. IE matrix consists of 2 dimensions, i.e. a total score of the IFE matrix on the X axis and total score of the EFE matrix on axis Y. IE Matrix is useful to positioning a SBU of company into a matrix consisting of 9 cells. From the company's position on the nine of these cells, a strategy can be formulated as follows: SBU located on cell I, II, or IV can be described as Grow and Build. A suitable strategy is intensive strategy such as market penetration, market development and product development. Another strategy can be chosen such as integration strategy, like backward, forward and horizontal integration. SBU located on cell III, V or VII can be described as Hold or Maintain. A suitable strategy is market perpetration or product development. SBU located on cell VI, VIII or IX, its strategy is Harvest or Divesture.

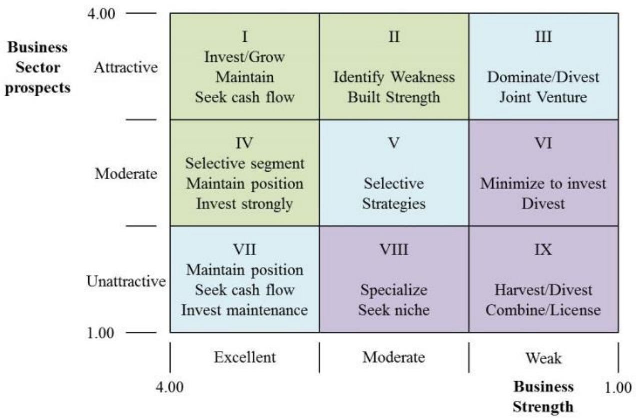

Fig. 1. Internal-External (IE) Matrix

The most successful company is a company that is able to control business on cell I. At the Decision Stage, of the several alternatives available, the Quantitative Strategic Planning Matrix (QSPM) is used to choose the best strategy. This technique provides an assessment which strategy is best. Quantitative Strategic Planning Matrix uses a matrix input from external, internal matrix, SWOT matrix, IE matrix, which is used as information to make the Quantitative Strategic Planning Matrix (QSPM). The highest Total Attractiveness Score determine the strategy the contractors should take.

In this paper, the strategy was formulated using Rational Design Model where data were taken through questionnaires and interviews. The respondents of the research are the national private contractors (small to medium contractors) in Central Java. These contractors have at least 5 year experience and a healthy financial condition.

3. Result and discussion

Prior to formulating small to medium contractors' competitive strategy within AEC frameworks, it is imperative to examine their current situation and position. This was carried out through interviews and questionnaires to several respondents. As sample for this research, they were small to medium contractors in Central Java. A descriptive result of the survey is described in the following section.

The highest human resource education level for small contractors mostly is high school (secondary) education level or lower. While for the medium contractors, the majority of the technical personnel have university degree. Regarding the quality of the human resource, most respondents rate that the quality of Indonesian human resource is below foreign labors. In addition most of them have no certificate of competence. The reasons of this limited certified personnel were the certification process is expensive (from the personnel side) and lack of information about the certification benefits (from the contractors side).

All respondents have no or very narrow understanding of the principles of sustainable construction. In general, small and medium contractors do not employ construction method which minimizes resources and construction waste. However, a small portion of medium contractors already implement these efficient and sustainable construction methods as seen in the table 1.

Table 1. Recapitulation of the questionnaire on Sustainable Construction.

Options	Small contractor	Medium contractor
Level of education		
a. The vocational education (Secondary level)	50%	10%
b. Diploma	30%	30%
c. Under graduate program (S1)	20%	60%
Contractors understanding of sustainable construction concept		
a. Not at all	0%	0%
b. Few	100%	100%
c. Understand clearly	0%	0%
Applying construction method which minimize resource consumption		
a. No	100%	90%
b. Yes	0%	10%
Applying construction method which minimize construction waste		
a. No	100%	100%
b. Yes	0%	0%

3.1. SWOT factor

Table 2 shows the results of the SWOT factors inventory. The table shows that the contractors have a same perspective on human resources quality, teamwork and company experience. In this case, quality of human resources, teamwork and company experience are the strength factors for performance improvement in ASEAN competitive marked.

Table 2. SWOT Factors

SMALL CONTRACTOR		MEDIUM CONTRACTOR	
STRENGTH	OPPORTUNITIES	STRENGTH	OPPORTUNITY
1. Quality human resources	1. Government Support	1. Credibility of the company	1. Client trust
2. Financial	2. Client Trust	2. Experience of the company	2. Government support
3. Teamwork	3. Construction service law	3. Quality of human resources	3. Construction service law
4. Experience & Reputation	4. Regional Autonomy	4. Quality control	4. Domestic Market Development
5. Network	5. Equipment	5. Teamwork	5. Regional autonomy
WEAKNESS	THREATS	WEAKNESS	THREATS
1. Quality Control	1. Loan Interest	1. Control System	1. loan rates
2. Material	2. Environmental issues	2. Equipment	2. the exchange rate
3. Construction Method	3. New Tax Rules	3. Problem analysis and decision method	3. inflation
4. Equipment	4. Corrupt practices	4. Construction method	4. political situation
	5. Foreign Investment	5. Company Organization	5. corrupt practices

From the table it can be deduced that the contractors have same perspective on equipment, materials and construction method. In this aspect, equipment, material and construction method are the weakness factors for performance improvement. It can be understood that having their own equipment for contractors, in general, is not important. For efficiency, contractors prefer to rent that equipment. On the other hands, it is not easy to find high quality materials, except by importing it. Moreover, small to medium contractors have not implemented effective and efficient construction methods which minimize resources as well as waste. Nevertheless, contractors have the same perspective on opportunity and threat factors in the construction industries.

3.2. Strategy formulation for small contractor

Rational Design Model through three stages – input, matching, and decision – was employed in formulating strategy for small contractors of the interest.

3.2.1. Input state

In this stage, Internal Factor Evaluation (IFE) matrix and EFE matrix were developed. The combined matrix is shown in the table 3.

Table 3. IFE matrix and EFE matrix for Small Contractor.

INTERNALFACTOR	WEIGHT	RATE	SCORE	EXTERNAL FACTOR	WEIGHT	RATE	SCORE
1. Quality human resources	0,28	3,02	0,85	1. Government Support	0,26	3,00	0,78
2. Financial	0,24	3,02	0,73	2. Client Trust	0,13	2,67	0,34
3. Teamwork	0,10	3,02	0,30	3. Construction service law	0,13	2,80	0,36
4. Experience & Reputation	0,07	3,11	0,21	4. Regional Autonomy	0,11	2,70	0,29
5. Network	0,04	3,00	0,12	5. Domestic Market Dev.	0,11	2,71	0,20
1. Quality Control	0,10	2,90	0,29	1. Loan Interest	0,11	2,31	0,25
2. Material	0,07	2,76	0,19	2. Environmental issues	0,05	2,04	0,10
3. Construction Method	0,05	2,84	0,14	3. New Tax Rules	0,05	2,13	0,10
4. Equipment	0,05	2,67	0,13	4. Corrupt practices	0,04	2,13	0,08
				5. Foreign Investment	0,03	2,04	0,05
IFE matrix score	1,00		2,96	EFE matrix score	1,00		2,64

The IFE matrix total score is 2.96 indicating that the internal position of small contractor is strong. Meanwhile the EFE matrix total score is 2.64 meaning that small contractor have responded adequately the existing opportunities and demonstrated good ability to overcome the existing threats.

3.2.2. Matching stage

In this stage Internal-External Matrix (IE matrix) and SWOT matrix were analyzed. Based on the IE matrix in Fig 1, where the total score IFE Matrix is 2,96 and EFE Matrix is 2.64, the Strategic Business Unit of contractors located on the cell V is Hold or Maintain Strategy. A suitable strategy is market penetration, market development or product development. The SWOT matrix is then developed based on analysis of the factors in table 1 leading to several strategy alternatives shown in table 4.

Table 4. SWOT Matrix for Small Contractor

	STRENGTH S1: Quality of human resources S2: Financial S3: Teamwork S4: Experience & Reputation S5: Network	WEAKNESS W1: Quality Control W2: Material W3: Construction Method W4: Equipment
OPPORTUNITIES O1: Government Support O2: Trust Client O3: Const. Service law O4: Regional Autonomy O5: Development of Domestic Market	S/O STRATEGY STABILITY 1. Build Network with the owner of the local government and government agencies involved (S5/O4) 2. Maintain a client's trust with quality human resource use	W/O STRATEGY MARKET DEVELOPMENT 1. Maintain a client's trust by improving and implementing a strict quality control on every project (W1, O2) 2. Improve construction methods implementing effective and efficient contruction method which minimize waste (W3, O2)
THREATS T1: Loan Interest Rate T2: Environmental Issues T3: New Tax Rules T4: corrupt practices T5: Foreign Investment	S/T STRATEGY TURNAROUND 1. Maintain reputation by always using quality human resources so as to compete for the project without corrupt practice (S4, S2, T4)	W/T STRATEGY HORIZONTAL INTEGRATION 1. Get the equipment by renting to avoid a large tax (W4, T3) 2. Establish relationships with producers of materials in the country (W3, T1)

3.2.3. Decision state.

Several strategy alternatives were then reformulated in the table 5. The best strategy was formulated by means of Quantitative Startegic Planning Matrix (QSPM) shown in the table 6.

Table 5. Alternatif Strategy for Small Contractor

1. Alternative 1 (Market Development)
- Maintain a client's trust by improving and implementing a strict quality control on every project
- Improve construction methods implementing effective and efficient contruction method which minimize waste
2. Alternative 2 (Backward Integration)
- Get the equipment by renting to avoid a large tax and Establish relationships with producers of materials in the country
3. Alternative 3 (Turnaround)
- Maintain reputation by always using quality human resources so as to compete for the project without corrupt practice

Table 6. Quantitative Strategic Planning Matrix (QSPM) for Small Contractor

Key factors	Weight	Alternative 1		Alternative 2		Alternative 3	
		AS	TAS	AS	TAS	AS	TAS
Quality human resources	0,28	1	0,28	4	1,12	1	0,28
Financial	0,24	2	0,48	1	0,24	3	0,72
Teamwork	0,10	2	0,20	1	0,10	2	0,20
Experience & reputation	0,06	3	0,18	1	0,06	4	0,24
Network	0,05	2	0,10	4	0,20	1	0,05
Quality Control	0,10	4	0,40	2	0,20	1	0,10
Material	0,07	1	0,07	4	0,28	1	0,07
Construction Method	0,05	4	0,20	2	0,10	1	0,05
Equipment	0,05	1	0,05	3	0,05	1	0,05
Government Support	0,26	4	1,04	1	0,26	1	0,26
Client Trust	0,13	4	0,54	2	0,26	2	0,26
Construction service law	0,13	1	0,13	1	0,13	1	0,13
Regional Autonomy	0,11	1	0,11	1	0,11	1	0,11
Domestic Market Development	0,11	1	0,11	3	0,33	1	0,11
Loan Interest Rate	0,11	1	0,11	3	0,33	1	0,11
Environmental Issues	0,05	1	0,05	1	0,05	1	0,05
New Tax Rules	0,05	1	0,05	1	0,05	1	0,05
Corrupt practices	0,04	1	0,04	1	0,04	3	0,12
Foreign Direct Investment in Indonesia	0,03	1	0,03	1	0,03	1	0,03
Total Score	1,00		4,15		3,99		2,9

The Quantitative Strategic Planning Matrix shows that alternative 1 (market development) is the most attractive alternative strategies.

3.3. Strategy formulation for medium contractor

The same procedure of Rational Design Model was implemented as well for formulating competitive strategy for medium size contractors. This involves three stages – input, matching, and decision – leading to some alternatives. For this medium construction sector player the strategy is formulated as follows.

3.3.1. Input state

The result of the input stage is two scores. Firstly, the total score of IFE matrix is 2.93. Secondly, the total score of EFE matrix is 2.86. The first score indicates that the internal position of medium contractor is strong, while the second score indicates that the medium contractor have responded well to the existing opportunities. They also have positive ability to reduce the existing threats.The Internal Factor Evaluation (IFE) matrix and External Factor Evaluation (EFE) matrix are shown in the table 7.

Table 7. IFE Matrix and EFE Matrix for Medium Contractor

INTERNAL FACTOR	WEIGHT	RATE	SCORE	EXTERNAL FACTOR	WEIGHT	RATE	SCORE
STRENGTH				OPPORTUNITY			
1. Company credibility	0,25	3,28	0,81	1. Client trust	0,27	3,20	0,88
2. Company experience	0,10	3,28	0,32	2. Government support	0,17	2,96	0,49
3. Quality of human res.	0,06	2,96	0,16	3. Construction law	0,14	2,80	0,39
4. Problem.an. & decision making	0,06	2,96	0,16	4. Domestic Market Dev.	0,11	2,88	0,31
5. Quality control	0,05	2,96	0,16	5. Regional autonomy	0,07	3,00	0,21
WEAKNESS				THREATS			
1. Control System	0,31	2,72	0,83	1. Loan Interest Rate	0,08	2,40	0,20
2. equipment	0,05	2,80	0,14	2. the exchange rate	0,07	2,80	0,20
3. teamwork	0,05	2,70	0,13	3. inflation	0,04	2,56	0,10
4. material	0,05	2,70	0,13	4. political situation	0,02	2,16	0,05
5. Company Organization	0,03	2,70	0,08	5. corrupt practices	0,02	1,69	0,03
IFE matrix score	1,00		2,93	EFE matrix score	1,00		2,86

3.3.2. Matching state

For medium size contractors, the two scores above-mentioned indicated that their Strategic Business Unit lies within cell V of the matrix in figure 1. It is Hold or Maintain. A suitable strategy for this type of contractors is market penetration, market development or product development. Then, SWOT matrix for medium contractor is developed leading to several strategy alternatives shown in the table 8.

Table 8. SWOT Matrix for Medium Contractor

	STRENGTH S1: Credibility company S2: Company Experience S3: Quality human resources S4: Problem.analysis and decision making S5: Quality control	WEAKNESS W1: Control System W2: equipment W3: teamwork W4: material W5: Company Organization
OPPORTUNITY O1: client trust O2: Government support O3: Construction law O4: Domestic Market Development O5: Regional autonomy	S/O STRATEGY - Maintain client confidence by applying a strict quality control on every project. (S4, O1) - Maintain credibility and use the experienced and qualified human resources to achieve the domestic market. (S1,S2,S5,O4)	W/O STRATEGIY - Optimize the role of enterprise organizations by utilizing the support of the government. (W5, O2) - Building teamwork, improve the control system and applying sustainable construction via efficient construction method (W1, W3, O1)
THREATS T1: Loan Interest Rate T2: the exchange rate T3: inflation T4: political situation T5: corrupt practices	S/T STRATEGY TURNAROUND - Competent human resources to use in analyzing problems and making decision that can reduce overall project costs. (S2,T1)	W/T STRATEGY HORIZONTAL INTEGRATION - Get equipment by renting to avoid a big tax. (W2, T3) - Enhance team work to get the project company without corruption. (W3, T5)

3.3.3. Decision stage

From the strategies developed in the matching stage, the best strategy was chosen based on Quantitative Startegic Planning Matrix (QSPM) score. The alternatives are shown in the table 9 and QSPM calculation is shown in table10.

Table 9. Alternative Strategy for Medium Contractor

1. Alternative 1 (Market Development)- Optimize the role of enterprise organizations by utilizing the support of the government and building teamwork, improve the control system and applying sustainable construction via efficient construction method.
2. Alternative 2 (Horizontal Integration) Get equipment by renting to avoid a big tax and enhance team work to get the project company without corruption.
3. Alternative 3 (Turnaround) - Competent human resources to use in analysing problems and making decisions that can reduce overall project costs.

Table 10. Quantitative Strategic Planning Matrix (QSPM) for Medium Contractor

Key factors	weight	Alternative 1		Alternative 2		Alternative 3	
		AS	TAS	AS	TAS	AS	TAS
Credibility company	0,25	4	1,00	4	1,00	4	0,75
Experience companies	0,10	4	0,40	1	0,10	2	0,20
Quality human resources	0,06	4	0,24	1	0,06	4	0,24
Problem analysis and decision making	0,06	1	0,06	1	0,06	4	0,24
Quality control	0,05	3	0,15	1	0,05	2	0,10
Control System	0,31	3	0,93	1	0,31	2	0,62
Equipment	0,05	1	0,05	4	0,20	1	0,05
Teamwork	0,05	1	0,05	4	0,20	1	0,05
Material	0,05	1	0,05	1	0,05	1	0,05
Company Organization	0,03	1	0,03	1	0,03	1	0,03
Client trust	0,27	4	1,08	4	1,08	4	0,54
Government support	0,17	1	0,17	1	0,17	1	0,17
Construction service law	0,14	1	0,14	1	0,14	1	0,14
Domestic Market Development	0,11	4	0,44	1	0,11	1	0,11
Regional autonomy	0,07	1	0,07	1	0,07	1	0,07
Loan rates	0,08	1	0,08	3	0,24	4	0,32
the exchange rate	0,07	1	0,07	1	0,07	1	0,07
Inflation	0,04	1	0,04	1	0,04	1	0,04
Political situation	0,02	1	0,02	1	0,02	1	0,02
Corrupt practices	0,02	1	0,02	4	0,08	1	0,02
Total Score	1,00		5,09		4,08		4,37

The Quantitative Strategic Planning Matrix shows that alternative 1 (market development) is the most attractive alternative strategy for medium contractors.

4. Conclusions

After examining their current situation and position, formulating strategy for Indonesian small to medium contractors, especially in Central Java, was carried out by means of Rational Design Model, as explained in this report. Several strategy alternatives may be formulated and then chosen by means of Quantitative Strategic Planning Matrix scoring.

The appropriate strategic alternatives for small contractor were market development by maintaining clients' trust, improving the human resources through certification, and implementing effective and efficient construction methods which minimize waste. For medium contractors, the attractive market development can be attained by optimizing the role of enterprise organizations, building teamwork, improving the control system, applying sustainable construction via efficient construction method.

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Procedia Engineering 00 (2017) 000–000

Procedia Engineering

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

A model of integrated multilevel safety intervention practices in Malaysian construction industry

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Abstract

Construction safety management improvement could be aligned with the condition at the workplace. The aim of this research is to identify the most significant safety practices at each intervention levels in improving behavioral safety performance of workers in the construction industry. A literature review was used to identify and determine the relevance of a list of safety intervention practices that take place at various levels; a total of 42 safety practices were identified. Questionnaires were then circulated to measure the level of significant each safety intervention practices towards a positive behavioral safety performance of workers. Targeted respondents are safety personnel and middle level personnel from construction companies that manage differ of construction projects such as oil and gas, infrastructure and building projects. The data will be collected at least from 430 respondents and will be analyzed using structural equation modelling (SEM) to determine the most significant safety practices at each intervention level. From the first result will be references to develop a dynamic model of integrated multilevel safety intervention practices in construction industry. Findings expected to be useful as a guidance in safety construction management in order to improve behavioral safety performance of multinational worker.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: Multilevel safety intervention; Malaysian construction industry; safety behaviour; structural equation modelling; system dynamics.

1. Introduction

According to recent Department of Occupational Safety and Health (DOSH), occupational accident statistics by sector in Malaysia in 2014 estimates, there were 184 fatal accidents in total and 70 fatal accidents at workplaces was

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

in construction sector indicates the highest number has been recorded. As noted by Mohamed et al. [1], the importance of hazard identification on site indicated that construction operations are habitually involved hazard. In construction industry where involved dynamic environment with critical and heavy work is complicated to handling hazards that diminish injury rates. Therefore, construction can be considered as an industry that frequently exposure to accidents [2]. Numerous of research studies noticed the construction site is the hazardous place. Construction has known as a vulnerable industry with hazard activities at workplace delineated a comparatively high number of injury and fatal accidents [3−5]. Hence, safety issues have gained vital attention in the construction industry as a whole [6]. Workers are the end person who easily exposed to hazardous on site should be able to prevent the incident and accident [7−10]. However, safety is a responsibility to the whole individual in construction project organization. Hence, an integrated safety practice at each intervention level is necessarily crucial to be identified.

1.1. Problem statement

Recent study by Chi et al. [11] indicated that the results of multiple accident causes been categorized into five main causes with the percentage of frequency which are tabulated (see Table 1). Based on the result research study in Taiwan construction industry, the highest percentage of accident cause indicates 47.9% is unsafe behavior. On top of that, unsafe work behavior found as the most vital factor cause of accidents at construction sites according to some previous studies [4, 12, 13]. Unsafe behavior considers as wrong bodily action while handling the job [11]. There have many examples of unsafe behaviors such as improper use of PPE, poor work practices, overexertion, insufficient capacities, do not use safety harnesses and the like [11, 13]. These unsafe behaviors may due to lack of safety awareness, lack of safety competency, lack of safety understanding, less in safety sharing, not work safely together, less in safety caring among the workers.

Table 1. Frequency of accident causes.

Accident cause	% of frequency
Unsafe behaviour	47.9
Unsafe machines & tools	5.5
Unsafe environment	32.7
Harmful environment	14
Unknown	0

Generally, safety management system implementation must be tailored to increase behavioral safety performance especially at the end user, the worker, where most failures tend to occur. As is well known, safety intervention is required in order to change unsafe behavior to safe behavior. Kristensen [14] showed some effectiveness of behavior change from appropriate interventions (see Table 2). Some of these simple examples indicate the impacts of intervention on behavior change. Therefore, the importance of well selection in safety practices at each intervention levels in construction industry is necessary to improve behavioral safety performance.

Table 2. A few examples of behavior change as a result of intervention imposed.

Intervention	Exposure/Behaviour
Rules about smoking at the workplace	Reduced passive smoking
Established of self-governing group	Increased decision latitude and social support
Course in lifting techniques	Reduced heavy lifting, adequate lifting behaviour
Health promotion program	Reduced smoking, better diet
Establishment of worksite safety committee	Better safety behaviour
Leadership training of front-line supervisors	Higher role clarity, less role conflicts, fewer conflicts

Wealth of safety research has been studied [15−19] on the safety program should be implemented by construction industry globally. In addition, huge number of behavioral safety research studies on Behavior Based Safety (BBS) analysis in identifying the effectiveness of the program towards safe worker behavior improvement such as Sulzer-

Azaroff & Austin [20], Choudhry [12, 21], Ismail [22] and Mengchun Zhang & Fang [13]. Most of the findings indicated that management commitment is the most important factors to ensure the BBS program successful been conducted.

Moreover, previous safety researchers only focused on single level safety intervention practice [22−27]. Yet very little research has been carried out by academics and practitioners on the appropriateness multilevel safety intervention affect towards behavioral safety performance in the construction industry. According to Wirth & Sigurdsson [28], Safety professional facing difficulties in order to select best intervention practices. The reason behind this is lack of detail documented of various behavioral safety process in safety literature.

1.2. Rational of research

Haupt [29] indicated the notion that behaviours of worker should alter from unsafe became safe attitudes to achieve preeminent site safety performance. Therefore, research in behavioural safety of worker is necessary to be focus in order to promising improvement of safety performance in construction industry. To achieve the need for guiding the construction industry in critically identify and prioritise the most significant safety intervention practices at each level, it is pivotal to exploit this research together with the necessity to fulfil significant gaps in recent research, which aims to identify the most influential multilevel intervention safety practices for improvement of worker safety behaviour. In the meantime, the significance of this research expected to strengthen safety culture within organization.

1.3. Research objectives

The broad objective of research is to evaluate the integration multilevel safety intervention practices affecting behavioural safety performance of worker in Malaysian construction industry. To accomplish the broad objective, two specific objectives are identified. First objective is to identify the most significant safety practices at different intervention levels that affecting a positive behavioural safety performance of worker. While, second objective is to develop a dynamic model of integrated multilevel safety intervention as a guidance to create a policy for safety management in construction industry.

The overall scope of practice of safety interventions basically need to be explored theoretically and practically to achieve the objectives stated above. The results of the research also will use as a tactical guideline in selecting the appropriate safety intervention successfully in order to change positive behaviour of worker at workplace.

2. Literature review

2.1. Malaysian construction industry

Although Malaysian accident and death cases in workplace statistics in 2000 till 2009 reported from Social Security Organization (SOCSO) as highlighted in research by Taylor et al. [5], indicate a trend of slightly decline in the construction industry, the industry still has an unpleasant reputation of being one of the most unsafe industries in Malaysia in respect of high risk accident at workplace. Occupational accidents cause injuries and fatalities bears an immense cost on the industry [30]. The construction industry is one of key economic to the GDP of Malaysia. Accordingly, it is better to prevent in advance of incurring losses due to accidents at workplace. In addition to this, health and safety concern in construction industry are vital to circumvent accident at workplace [6].

2.2. Safety intervention

The significance of safety interventions is recognized as one of the effective ways to improve safety performance and reduce hazards in the workplace [17]. In recent years, the effort in conducting safety interventions has become compulsory due to own Occupational Safety and Health of national regulation each country and has increased dramatically since showed a great opportunity to reduce injuries and accidents. Purpose of safety interventions in general is to control the work processes, equipment, environment and employees for the aim of reducing incidents and accidents in the workplace. Before elaborating further on research safety interventions this construction, it is beginning with understanding the term of "safety intervention".

2.2.1 Definition

There are a number of safety intervention's definitions stated in some literature. Nevertheless, the meaning has similar perception that emphasizes the way that all individuals in the workplace to do something in improving safety performance. Some definitions are expressed as follows:

"…intervention means changing external conditions of the system in order to make safe behavior more likely than at risk behavior…"

Geller [7]

"…very simply as an attempt to change how things are done in order to improve safety. Within the workplace it could be any new program, practice, or initiative intended to improve safety (e.g., engineering intervention, training program, administrative procedure) …"

NIOSH [31]

"…described as an attempt to alter or change how things are done in order to improve safety could be in the form of a new program, practice, or initiative and idea which is intended to improve safety…"

Oyewole et al. [32]

Moreover, Dyreborg et al. [17] mentioned that safety intervention may run for a shorter or longer period of time or represent a permanent change, as for example new regulations or legislation. A safety intervention program can be initiated at the workplace by the employer or the employees, or initiated from outside the workplace by public authorities, social partners or other stakeholders. However, the intervention must take place and be aimed at improving safety in the workplace or during work. Intervention is not constant and ever changing in terms of cost, business administration and participant involvement. Simple intervention is as written activators are often used such as sign, posters and the like. While, other activators are requiring a lot of time consuming and effort to deliver such training and technical commitment [33].

2.2.2 Multi-level safety intervention

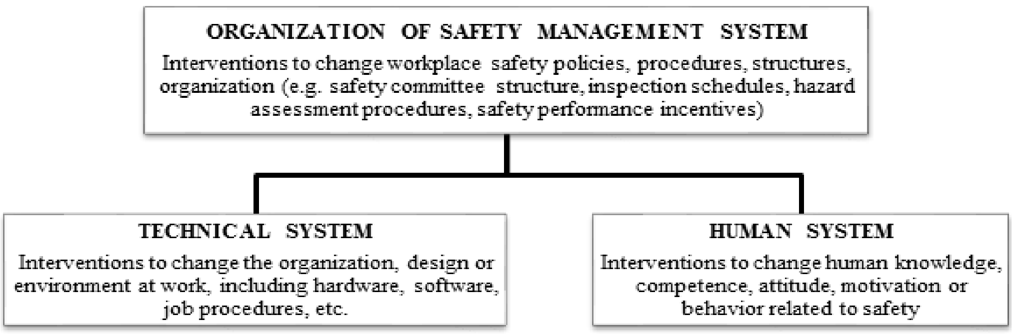

Fig. 1. Intervention levels within workplace safety system.

Oyewole et al. [32] argued safety interventions take place at different levels of safety implementation. Basically, main safety selection and intervention attempt are usually direct towards the level of safety management system in organization. The safety interventions implemented at different levels in the workplace safety system. These include safety management level and the level of human and technical systems within the organization (see Fig. 1) [31, 34].

2.2.3 List of safety intervention practices

Numerous of previous safety researcher lists the safety practices in organization. The lists of safety practices (see Table 3) were classified into each intervention level, safety management system, technical system and human system based on the most stated in various related literature. NIOSH [31] stated that safety could be improved by striving the safety intervention as a strategy to reform how practices to be focus are selected. Therefore, the list of multi-level safety intervention activities in construction industry is required.

Table 3. List of safety practices in each intervention levels.

Level	Label	Safety Practices	Sources
Management Safety Intervention Practices	M1	Safety policy and standards	[6, 23, 35, 36]
	M2	Safety vision and objectives	[37]
	M3	Safety organization, Safety committee	[6, 36, 37]
	M4	Management behaviour	[6]
	M5	Safety procedure, standardization	[25]
	M6	Management worker interaction (Periodic safety meetings, Regular site visits)	[32, 37−39]
	M7	Daily safety records	[40]
	M8	Incident investigation and analysis, Accident analysis and prevention	[32, 35−37]
	M9	In-house safety rules and regulations	[35, 36]
	M10	Contracting strategy (safety requirement and capability)	[36]
	M11	Information management and feedback	[38]
	M12	Safety audit	[38]
	M13	Reviewing and implementing safety programs	[38]
	M14	Delivering safety communications mechanism	[22, 38]
Technical Safety Intervention Practices	T1	Inspecting hazardous conditions, facilities, plant and equipment	[6, 38]
	T2	Personal protection equipment (PPE) program	[6, 36, 40]
	T3	Physical safety settings	[41]
	T4	Ergonomics machine design	[42, 43]
	T5	Safe work practices, safety procedure	[24, 35, 39]
	T6	Safety equipment availability and maintenance	[38 ,39]
	T7	Implementation of safety inspection	[35, 36,40]
	T8	Data base safety monitoring	[40]
	T9	Scheduled maintenance for all machinery and equipment, safety process control program	[35]
	T10	Movement control and use of hazardous substances and chemicals	[35, 36]
	T11	Emergency responses preparedness	[35, 36]
	T12	Design for safe construction	[b]
	T13	Safety permits are issued and used	[32]
y Inter venti	H1	Behavioural-based safety (BBS) program	[12, 20, 41, 42, 44]
	H2	Safety training	[6, 32, 35, 36, 38, 39,

		45, 46]
H3	Safety inductions	[47]
H4	Implementing awards, safety promotion, safety incentive	[6, 27, 32, 35, 36, 38]
H5	Safety knowledge program, safety education, consultation	[40, 47]
H6	Safety supervision, on-site HES monitoring is provided for high risk and or large jobs	[26, 27, 32, 39, 40]
H7	Co-worker intervention	[39]
H8	Safety awareness, safety campaigns, weekly safety topics	[37,40]
H9	Safety information, safety specific, bulletin boards	[37,40]
H10	Safety expertise	[40]
H11	Safety risk identification and analysis, JHA, JSA, Pre-task hazard assessments	[32, 35,36, 38, 40, 42]
H12	An employee safety plan	[35,36,38]
H13	Daily tailgate and regular safety meetings are conducted	[32, 38]
H14	Crew inspections	[38]
H15	Accident repeater program	[48]

3. Research methods

Selected research methodology will use to underpin research work and methods will use in order to collect data. For the first objective is quantitative data which measuring variables and verifying hypotheses. While for the second objective is to develop a dynamic model of integrated multilevel safety intervention practices based on the first objective's results. Moreover, it is to ensure the model is relevant with the construction industry in Malaysia. The model will be conducted more practical and will be developed separately for each construction industry (oil and gas, infrastructure and building) within a period at least six months.

3.1. Structural Equation Modelling (SEM)

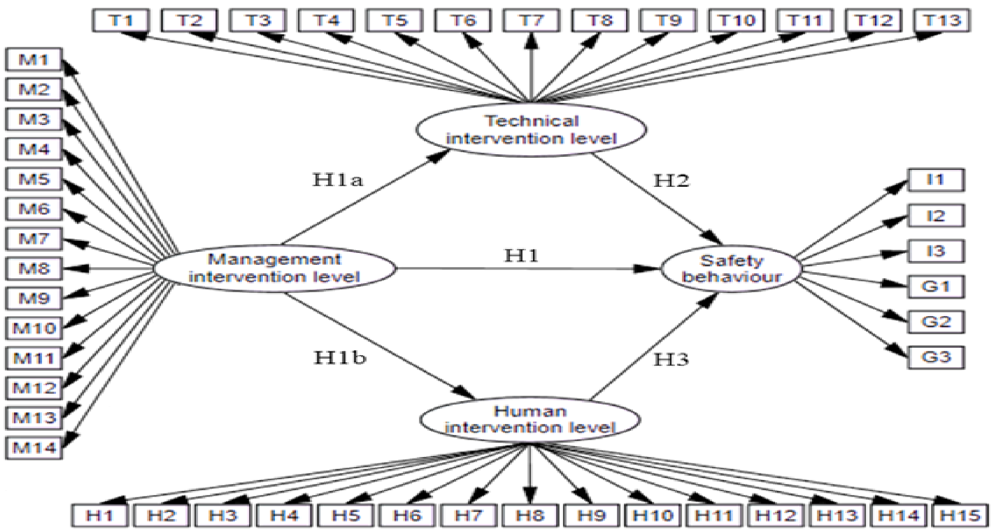

Fig. 2. Hypothesised SEM model of integrated multilevel safety intervention

The hypothesised model of multilevel safety intervention is presented in Fig. 2.

H1	:	Management safety intervention has direct effect on behavioral safety performance of worker
H1a	:	Management safety intervention influence on technical safety intervention
H1b	:	Management safety intervention influence on human safety intervention
H2	:	Technical safety intervention has direct effect on behavioral safety performance of worker
H3	:	Human safety intervention has direct effect on behavioral safety performance

The abovementioned hypotheses are could be analyzed by using Structural Equation Modelling (SEM) method. Even though existed another technique in analysis such as correlation and regression, only independent equations and relationships within constructs could have shown. Hence, complicated for those findings to develop an overall integration model. These hypothesize to test the multi-level safety intervention practices towards the safety behavioral performance of workers.

As is known construction workplace involve multitude of workforce. According to Geller [33], behavioral safety should not only consider individual but also as a group. For example, actively caring person concept shows the willingness to help others often work safely. Hence, it shows a positive behavioral safety performance should be taken into account.

3.1.1 Content validity

Initially, 43 safety intervention practices were identified. The lists verified by five safety experts to evaluate the content validity and relevance in behavioral safety of worker performance. The experts were required to evaluate the relevance, clarity and comprehensiveness of the safety activities list in each intervention levels. The experts are safety officer consists of three from building construction, one from infrastructure construction and from oil and gas construction with more than 10 years in construction safety experience. One list which safety culture policy was discarded and left 42 safety intervention practice. Prior to the Malaysian construction industry as the real data for analysis would be collected, this expert review was to ensure that the safety intervention activities were relevant.

3.1.2 Data collection

Malaysian construction industry is selected to be as a target population in this research. Anderson [49] noted that if engineering, technical and system aspects are in place and adequately managed than behavioral interventions will be successful. Hence, before major hazard sites embark on a behavioral safety intervention, have to ensure that safety organization of the company have satisfied several conditions in safety management. As consequences, for this study is focus on conducting a research for the construction company that performs highly commitment on safety management.

A large construction company is expected to comply a safety management system that fully implemented the safety intervention practices at all level of safety control. Using a list of contractor companies registered as grade (G7) from the Construction Industry Development Board (CIDB), 600 questionnaires are design by using Google Form and the link were sent via email. Afterwards, contacted the construction company via telephone to follow up the survey feedback. At least 430 questionnaires feedback are required to run SEM analysis. For this time being, the respondent rate achieved was under 10%. After a few weeks, the respond rate had shown a quite low progress. Therefore, personal visits to the company and construction site in the cities of Kuala Lumpur, Selangor, Pulau Pinang, Sabah, Sarawak and Johor were the selected solution in order to accelerate the response rate. Data collection expected to be completed by August 2016.

4. System dynamics

System Dynamics (SD) is a selected methodology and modelling technique in understanding the integration of multi-level safety intervention practices and discussing the outcome of worker safety behavior performance.

Forming a dynamic hypothesis is necessary in order to explain the dynamics characteristic problem in terms of the feedback system. The modelling process is move forward through the reality apply subject to revision and abandonment [50]. Previous studies reveal that incident rates are dramatically influenced by safety intervention practices such as safety training, job planning, technical trainings, facilities inspections, audits and assessments, preventive maintenance activities and the like [38,34], which in turn cause of the dynamics of behavior safety performance [51].

The dynamic hypotheses of research are thus constructed and divided into four parts (organization safety management, technical system, human system and positive behavioral safety performance). Therefore, to get a specific about the causal relationships the feedback loops will based on the first objective findings. Expected the feedback loop will be concerning organization safety management level, concerning technical level and concerning human level.

5. Conclusions

This research investigated the most significance multilevel safety intervention practices affect towards the positive change of worker's safety behavior at workplace. The beneficial for this outcome is expected safety personnel should be able to decide an adequate action to improve safety behavior. Also will use as a strategic guideline in selecting the appropriate safety practices at each intervention level. On the other hand, it is important to note that study's limitations are only cover construction's company within some developed states in Malaysia and did not involve the process of intervention period. Further studies could perhaps cover all states in Malaysia and examine specific the safety intervention practices effectively improve behavioral safety performance of worker within a certain period with a certain time baseline.

Acknowledgements

The main author would like to thanks to her supportive and kindness supervisor who help her in finalizing this research and provide an opportunity for her to participate in this conference.

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Identification of Safety Culture Dimensions based on the Implementation of OSH Management System in Construction Company

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Abstract

The factor of safety culture in construction industry gives a profound influence to the economic and social condition of a nation by which that affects its competitiveness. The data in the field, in fact, shows that the level of accidents on construction projects in Indonesia is notably poor. On the other hand, facing the era of *ASEAN* Economic Community (AEC) Indonesian contractors are demanded to increase their competitiveness in which one of their projects runs with zero accidents. This study was conducted in the objectives of (i) evaluating the OSH standard implementation in the construction companies in Indonesia. (ii) Identifying the safety culture dimensions at the construction industry in Indonesia The research result presented that OSH standard implementation based on both areas and company qualifications was still in the unsafe condition with the score under 50%. That identifies safety culture dimensions which are necessarily built in the level of both corporation and project such as managerial leadership, contract system, policy, strategy, process, cost, people, value and behaviour

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: Safety Culture, Construction Accident, OSH Management System, Construction Project

1. Introduction

In developing countries, the rate of accident in construction sectors is three times worse than that of developed countries (Koehn, 1995). A safety culture concept is relatively new in construction industries. However, it can be

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1877-7058
Peer-review under responsibility of the organizing committee of SCESCM 2016.

popular because of its capability to wrap all the factors including perception, psychology, attitude, and managerial (Choudhry, 2007). It constitutes one of the important components of organization culture which discusses individual safety, performance safety, and several things which are prioritized by safety organization. Safety culture, according to Uttal (1983), is the combination of values and beliefs which interact to the organization structure and the adjudication system which form attitude norms (as cited from Cooper, 2000). On the other hand, Turner (1992) argues that safety culture is a group of belief, norm, attitude, rule, and social practices as well as a technique which is directed to decline a condition which can endanger workers, managers, customers, and society.

The poor safety culture is one of the main attributes which causes injuries and deaths in the construction industries around the world (Choudhry et al, 2007). Lately, there was a movement of the way to measure safety and working safety, started from a measurement which only considered on quantity or the level of working safety to a measurement which concerned on working safety culture (climate) (Cooper, 2000). This consideration is supported by an awareness that the primary cause of working accidents is from organization and management factors (Reason, 1995). Therefore, an effort to measure working safety culture is exceedingly important in order to create a working condition which is safe and finally to reduce working accidents in construction. Research about working safety culture is started to undertake in manufacture industries (Cheyne et al., 1998; Oliver et al., 2002), yet that rarely happens in construction industries. Mohamed (2002) attempts to comprehend a relation among cultures.

The impact caused from working accidents is relatively significant, besides deaths and workers' life quality decline, working accidents in construction projects causes project delays, increasing product cost, medical burden, and other negative consequences (Chen et al., 1995). The results of International Labour Organization (2003) research states that working accident levels of a nation depends on the level of competitiveness (competitiveness index) of that nation. This research concludes that the trend which illustrates how high the level of working accidents is inversely proportional to the competitiveness index of the nation.

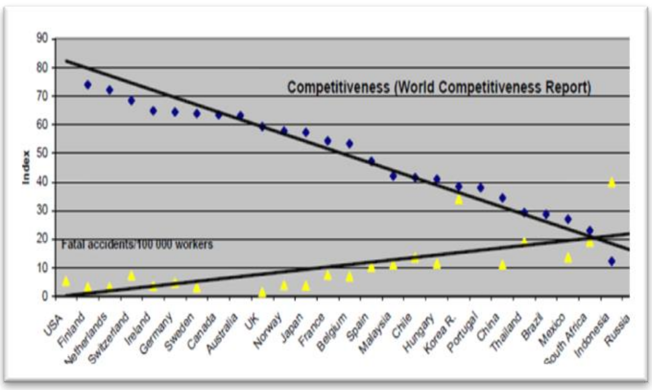

Fig 1 Relation between Competitiveness Index and The Level of Working accidents (Source: *The Global Competitiveness Index*, 2011)

The data gained that Indonesian competitiveness index positions in the second top from the lowest level with fatal working accident index of 40 per 100.000 workers (The Global Competitiveness Index, 2011). In Indonesia, working safety and health have not got attention from any parties. Working safety standard in Indonesia is the worst compared to other South East countries and is marked by the number of accidents which is written no more than a half from the real number of the accidents as several parties in Department of Labour admit (Wirahadikusumah and Ferial, 2007).

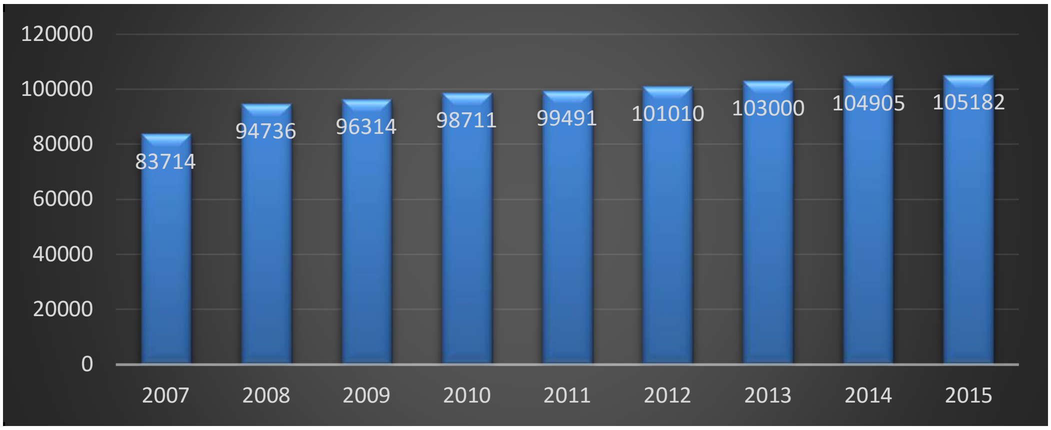

Fig 2 Indonesian Working Accidents Graph (Source: Rosmariani, 2014; Ketenagakerjaan, 2015)

Based on the Social Security Administration Body for Employment's (BPJS Ketenagakerjaan) data from 2007 to 2015, it shows Figs which are fluctuated and their trend are increasing, and these Figs constitute the highest level of working accidents compared to other South East countries (Anshori, 2008 as cited from Abduh, 2010). ILO (International Labour Organization) research in 2009 reports that Indonesia positions the 152nd out of 153 countries with the worst working accident level (http://www.nakestran.go.id). However, ILO research, in 2012, states that there are 96.314 cases along with 2.144 tolls of dead and 42 tolls of defect. The damage caused by the accidents is forecasted to rise about Rp. 280 trillion per year or reach at 4% from Gross Domestic Product (GDP). Recent data shows that construction industries sit in the highest position at 32% compared to other sectors (Jurnal Nasional, 2009).

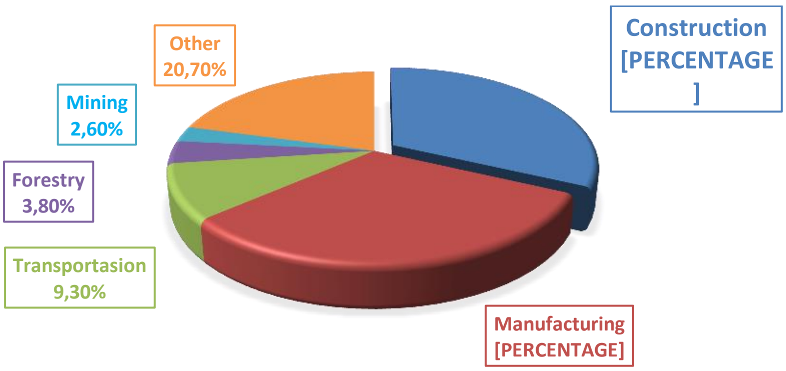

Fig 3. The Level of Working Accidents in Several Sectors (Source: Jurnas, 2009)

Furthermore, the data from *BPJS Ketenagakerjaan* presents that 70% considered working accidents happened in the company inside, 20% considered as traffic accidents, and 10% happened outside the company, as follows:

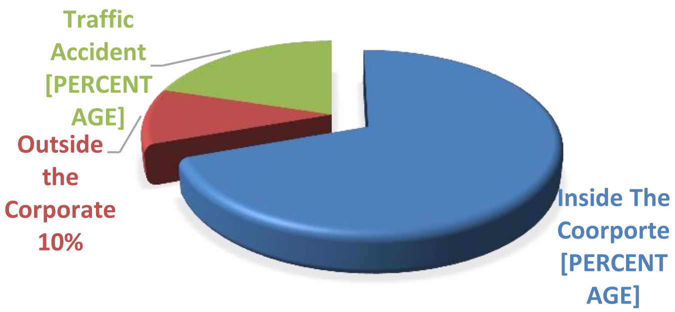

Fig 4. The Data of Working Accidents based on the locations (Source: *BPJS Ketenagakerjaan*, 2014)

The data presents that safety culture system in a company is still far from what is expected by several parties. This research underlines how important safety culture in the construction industries. It can be recognized that the rise of safety culture assists organizations to reduce the number of accidents, fix industries' reputation, and increase working safety (Kartam, et al., 2000) Before trying to fix safety culture, organizations have to gauge the implementation of safety culture now, then plan to fix the safety. Unfortunately, as Speirs and Johnson (2002) argue that safety culture is difficult to be gauged because it is not a product or a result but a process. Therefore, it is essential to differ between needed results and processes of safety management.

Based on the details above, there are two formulated problems which will be discuss in this research:

(i) The implementation of working safety culture in the construction companies in Indonesia

(ii) What safety culture dimensions can support the success of OSH policy implementation

2. Theoretical framework

Working safety culture concept is considered one of the main management principals. It is because working safety culture constitutes basic values of attitude safety in operational quality improvement activities, continuing learning processes, and improvement processes in a mind-set towards OSH without enforcement (Manik, 2004). However, stated in literature till now, working safety culture concept and working safety climate possess the same definition in which one is a part of another, so it causes a debate about those two concept (Cheng, et al., 2009)

Working safety approach through a company culture is Figd out in an artefact form. After a working principal is implemented, it must be practiced. The practices can be noticed in the achievement a good working environment orderliness. It is not be able to be separated from the active roles of workers, for instance, by doing several activities such as dismissing unnecessary stuffs, keeping stuffs orderly, and throwing the garbage properly. Those plans will be better when they are done as accident preventing activities. Besides it must be created a condition which is safe for working activities. Zo and Zeta (2004) learn safety in Hong Kong construction industries and build up four culture key factors (environment, attitude, organization and individual) which influence CSC. They infer that safety culture and its meanings are different between one country and another caused by culture diversities. Indeed, the workers can perform differently because of their culture background diversities (race, nation, religion and community). According to Hofstede (2008), culture diversities are based on five value dimensions such as the power of distance, avoiding inconsistencies, individualism versus collectivism, and masculinist versus feminist, and long and short term focus. This theory consists of four primary factors of CSC (environment, attitude, organization, and individual). It is stated that safety culture in an organization will not succeed if the organization has lack of support from those four factors. An analyses conception towards those factors is conducted in safety study and discussions with the stakeholders. Those factors are divided deductively into these classifications as follows: (i) culture, (ii) construction industry, (iii) corporation/ company, and (iv) project. Mohamed (2003) creates an equipment Balanced Scorecard in order to measure safety culture of organizations, and argues that the equipment has a capability to provide a medium to move safety plans and processes to a clear objective set which is changed into a performance measurement system in turns. The equipment offers advantages in providing a combination of an objective and subjective performance measurement which can effectively communicate a strong strategy focus in safety to the whole organizations.

3. Research Methodology

The research methodology is based on a thinking framework which sees a phenomenon that the level of working accidents in construction industries is exceedingly high. This research was started by the theoretical framework of the previous related research as well as the supported theories. Deductive analyses is conducted to define what dimensions which can support the success of the ideal currency of a working safety culture as can be seen in the operational research model as follows.

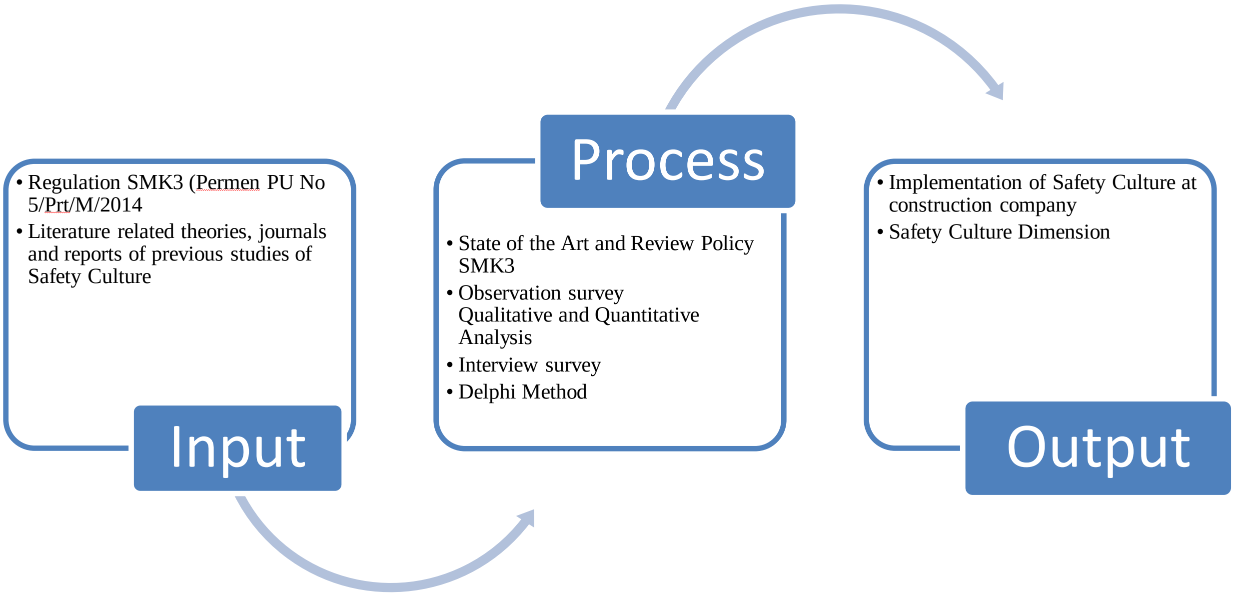

Fig 5. Operational Research Model

The next is the review of construction industry policy of OSH Management System. After that activity is done, the result of desk study as well as the review of the OSH policy will be the basic arrangement of audit system which will be the instrument of the direct observation survey to the contractors and at the depth interview to the party of OSH management/ OSH officers that are carrying out construction projects which are conducted by those contractors. The direct observation survey is conducted to see how good the implementation of OSH policy at the corporation level as well as at the project level in all groups of company (lower-class Company, moderate company, and upper-class Company). The observation survey will be conducted directly in 100 companies which are actively listed as members of Gapensi and are carrying out construction projects when the survey is ongoing progress. The companies which will be observed are defined based on the proportion from the percentage of lower-class, moderate-class, and upper-class companies in Indonesia. This project survey will be completed with a recording/ video taking and photos which describe a condition besides OSH program infrastructure which exists in that project.

4. Research Result

Overall the results of the study and the empirical field data processing can be drawn the conclusion that the application of the regulation and standard OSH in construction projects is still very far from ideal standard. Implementation of the fulfilment of the PP 50/2012 and candy PU 04 2014 is still very low implementation in construction projects in the Environment Ministry PUPR. The results of this study show that is still very necessary strategies that are effective in encouraging the perpetrators in the business of the construction industry to improve aspects of environmental projects in the HSE either from the side of the service provider or Contractor in the matter of service users in this Ministry PUPR. From the research to the construction companies handling the projects, there were two clusters based on areas and classifications. The data processing for the cluster based on areas in Indonesia resulted the implementation condition towards OSH Management System in the construction companies were all unsafe and is presented in the Table 1 as follows:

Table 1. The Implementation of OSH management system in the construction companies based on areas

Territory	Safety Implementation Level	Category
Java	47,80%	Unsafe
Papua	31,79%	Unsafe
Kalimantan	27,47%	Unsafe
Sumatra	24,57%	Unsafe
Sulawesi	23,53%	Unsafe
NTB and Bali	9,62%	Unsafe
INDONESIA	**27,3%**	**Unsafe**

OSH Management System implementation measurement result based on the qualification of Construction Services Business Entity (BUJK) or Service Provider concluded that the condition which existed in the field was also unsafe because its implementation reached only 0% to 49%. It can be seen in Table 2 as follows:

Table 2. The Implementation of OSH Management System in the construction companies based on qualifications

Qualification Contractor	Safety Implementation Level	Category
Grand Qualification	34,06%	Unsafe
Medium Qualification	27,60%	Unsafe
Small Qualification	22,78%	Unsafe

The results of the implementation of OSH in the Directorate in the Department of PUPERA also get results that are far from the perfection of the fine from the Directorate of highway, Human Settlement, Water Resource and Housing. Seen that the results of the score gap analysis in each Directorate is at 0%-49%, meaning the implementation of OSH on projects in unsafe conditions it can be seen in Table 3 as follows

Table 3. The Implementation of OSH Management System in the construction companies based on Directorate of Department housing and public work

Directorate	Safety Implementation Level	Category
General of Highway	32,29%	Unsafe
General of Human Settlement	24,09%	Unsafe
General of Water	22,18%	Unsafe
General of Housing	16,92%	Unsafe

The documentation of this research described that activities occurred in the field were still far from the word "ideal" as an example that the researcher presented as follows:


Fig 6 and 7 unsafe condition in construction project

As can be seen in the picture above that the workers do not protect themselves by using Personal Protective Equipment (PPE) which has been applied before, not wearing helmets, gloves and pants. Moreover, there are no signs and safety rules. Those could cause working accidents which appeared because of attitudes and unsafe conditions.

From the data, either the OSH management system implementation result or the real condition in the field could be inferred that the attitudes which existed in construction projects in Indonesia were caused by Working Safety Culture which has not been built yet.

With the Delphi method, researchers conduct interviews structured with experts to the cultural dimension of the HSE safety with effective data-driven implementation of OSH on a project that has been carried out in all regions of Indonesia. The HSE experts recommended for the interview is experts from various fields, among others, contractors, academics, consultants, manager OSH, Coach OSH. The Delphi method is done with two rounds with the result there are 9 dimensions in the culture of safety that is, leadership, Behaviour, processes, policies, strategies, Costs, contracts, OSH people, and Value. Based on the expert validation which has been conducted, the researcher succeeded to identify Working Safety Culture Dimensions in the relation to the result of OSH Management System implementation in the construction companies in Indonesia. As can be seen in the Fig below:

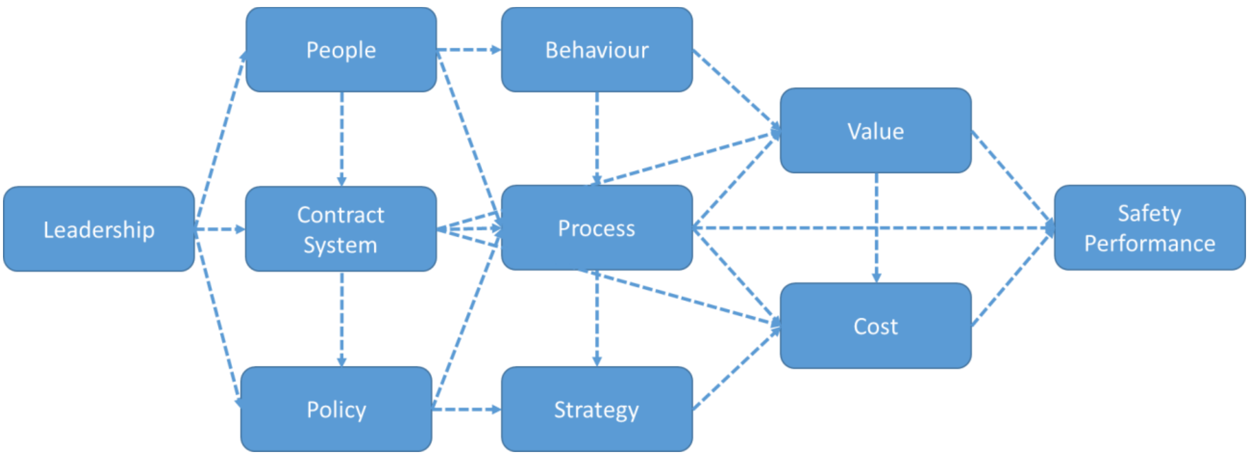

Fig 8. Safety Culture Model

5. Conclusion

From the result of the whole data processing, now OSH rule and standard implementation in the construction projects are still far from what are expected. The implementation of both *PP* 50/2012 and *Peraturan Menteri PU* year 2014 is still exceedingly low in the construction project in Indonesia.
Based on the result of data processing from analysis gap, it can be concluded that the entire projects which have been evaluated belonged to the unsafe category with the score under 50%. The projects in Java shows the highest OSH implementation with the grade scoring at 47% (unsafe condition).
Based on the Service Provider Qualification, the project which is carried out by the Upper and Moderate Service Provider has a quite good implementation compared to the project which is carried out by the Lower Service Provider, even though it is still in the unsafe condition if it is seen from the scoring process.
Of data per Directorate obtained results Directorate Highway is the highest level of implementation of his compare the Directorate more although still in the categories of insecurity.
From the result of recorded documentation, it can be seen that the unsafe condition also threatens the workers in the field because the working safety culture which has not been built perfectly. From the result of the library study which has been validated by the experts infers that the identified working safety culture dimensions supposed to be able to decline the level of the accidents are managerial leadership, contract system, policy, strategy, process, cost, people, value and behaviour. The dotted line shows the relationship between dimensions of safety culture that affect the performance of safety which will be discussed in future studies.

6. Recommendation

The next research can be conducted comprehensively about working safety culture which is considered from the relation pattern among the dimensions which need to be done so that the safe condition both at the corporation level and at that of project can be built up perfectly.

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Procedia Engineering 00 (2017) 000–000

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Multi-level safety culture affecting organization safety performance: A system dynamic approach

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Abstract

All over the world construction industry has been considered to be highly hazardous. Almost 80–90% of accidents are strongly associated to unsafe behavior of workers affected by safety-related factors e.g. management focus, safety programs, and working environment. A lot of work has been done to avoid such fatalities. Reactive approaches involve accident investigation and feedback process while proactive approaches include safety hazard analysis, behavior safety, and safety culture. Occupational safety remains ignored in developing countries like Pakistan because of contending legal, social, economic, and political encounters. This research focuses on the dynamic modeling of multi-level safety culture to see its influence on safety performance. The objectives include the identification of safety culture variables in multi-level hierarchy of organization and the safety performance indicators used. Furthermore, the causal links among variables are identified to develop the theoretical model. This theoretical model will be then discussed with experts from top management to worker level through interviews and by applying group model building approach. After periodic interviews, a practical causal loop model will be finalized. It will be converted to stock and flow and using safety record, a system dynamic model will be developed and policies will be formulated to monitor the safety performance.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: Safety culture; Multilevel culture; Safety performance; System Dynamics

1. Introduction

Despite global efforts to address occupational safety and health issues, ILO 2009 statistics reveal that probably two million work related mortalities and 330 million work-related accidents occur every year. The statistical figures

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Peer-review under responsibility of the organizing committee of SCESCM 2016.

vary extremely between developed and developing countries. As cited by Khan [1], it has been estimated that people in developing countries face more than 80% of worldwide occupational hazards. These hazards are related with risks that are expected to cause diseases, injuries, even death to workers. The belief of occupational hazard and risk is global but mitigation to keep these risks as low as realistically practicable is different because of different situation that each geographical location carries. Why developed countries are observed stricter about work place safety; because they value human life and the need to improve safety. It is therefore clear that developing countries do not take safety as priority or have inadequate legislation to decrease these risks. Pakistan, even though a member of international labor organization (ILO) has not yet signed its convention 187 on promotion of occupational safety and health at work place. The key law, which administers these issues, is chapter 3 of factories act of 1934 [1].

Pakistan has still to offer a proactive response to recent technological improvements, because a huge portion of construction work is being executed by humans that has led to increased number of fatalities and casualties. It is predicted that around 6-7 percent of labor is in a straight line associated with construction, oil & gas and civil engineering industry. As far as safety nonconformance is concerned, the main reasons include absence of legal laws, improvement of construction sector in terms of modernization and industrialization, deficiency of professional management practices that has led to risky project site [2].

Unfortunately, developing countries don’t have the perception of safety culture. For example, driving a car without seatbelt or motorbike without safety helmet deliberately knowing that if a law enforcement agency stops us, we can argue the law or if an industrial accident occurs, mass media covers it a lot but nobody inspects about its root cause or recommends mitigation measures to avoid any future accident. In emerging countries like Pakistan, awareness and perception about occupational safety is very diverse than in developed countries [1]. Although the contractors know about the safety measures, but those are not implemented.

Safety is measured after injuries have already happened. These measures are categorized reactive, trailing, downstream, or lagging indicators because they count on retroactive data. Aiming on these measures e.g., accident rates and compensation costs often means that the “success of safety is measured by the levels of system failure” [3]. In modern years, there has been a drive away from safety measures entirely based on retroactive data toward leading and current indicators for example site investigation and evaluation of safety climate [4].

In Pakistan, there is a substantial variance between large and small contractors. Most of large firms do have a safety policy documented, but employees overall are not aware of its presence. However, a number of major contractors show a concern for safety and have well-known various safety procedures. They also provide training to the workers and maintain safety of workers on the jobsite. For the mainstream of contractors, however, exploiting profit is the major concern [5].

2. Problem statement

Although the concept of measuring safety performance has been changed from lagging indicators to leading indicators like safety behavior, safety climate & safety culture, yet there is need to further elaborate the effect of proactive measures like safety culture that affect the safety performance. An organization is a social entity, a group of different people with different personal, behavioral and situational aspects. Present organizations are outsized and multifaceted and thus the idea of a single uniform safety culture looks overly naive [6]. Safety culture of the organization varies from top management to worker level because all of them have their own perception about safety and different work environment. The safety culture of top management affects the worker level and in return the workers’ feedback affects the safety culture of top management. So, it becomes a continuous feedback loop. The effect of this feedback loop is really important to find the root cause to develop the safety culture and ultimately improve safety performance of organization. In order to cater these issues, this study focuses on the current scenario of perception of safety culture, safety performance indicators used and the effect of multilevel safety culture on safety performance in oil and gas sectors of Pakistan construction industry.

3. Identification of safety culture and safety performance variables

3.1. Safety culture

The word safety culture can be traced back to 1986 nuclear explosion at Chernobyl [7]. The International Safety Advisory Group (INSAG), an advisory group to the International Atomic Energy Agency (IAEA) investigated the Chernobyl accident and used the term "poor safety culture" to pinpoint reasons leading to the Chernobyl accident [8]. There are a number of definitions developed since 1986 but the one that is mostly used is the one established by the Advisory Committee on the Safety of Nuclear Installations (ACSNI), "The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management". Even though definitions differ there is a harmony towards safety culture as being a proactive measure to safety [11]. This study has followed Cooper's Model as shown in Fig. 1. to define safety culture of an organization.

Many studies have found the existence of subcultures within an organization which advocates the nonexistence of a unified safety culture. Subcultures are probable to appear when employees within the same organization practice different working conditions [11].

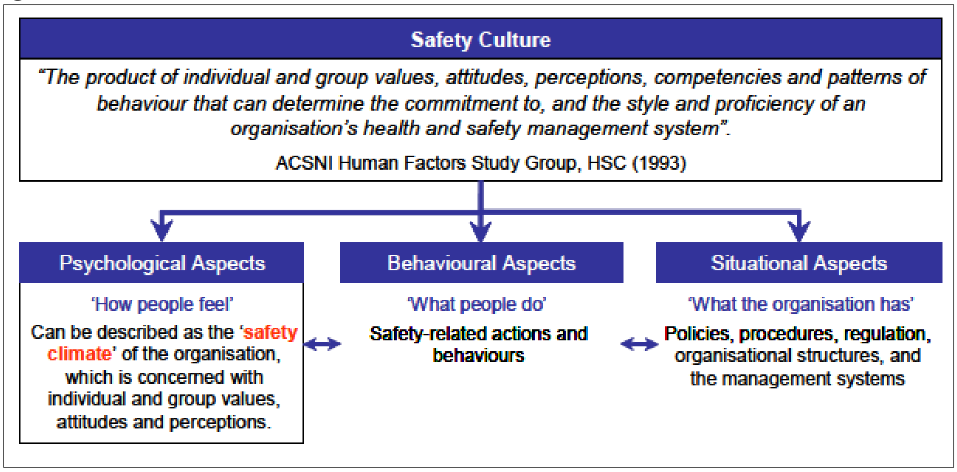

Fig. 1. Cooper's Model 2000

Employees (manager, supervisor and workers) based on organizational structure show sub-cultures which generate obstacles [12]. Within an organization there are frequently different groups that have their own style of management and have diverse levels of concern for safety issues; basically, they have their own safety subculture. Mearns, Whitaker et al. [13] found the sign of subcultures in their study of 10 offshore installations. The subcultures changed mainly by occupation, age, shift pattern, prior accident involvement and grade. More over existence of onshore safety subcultures has been observed within the road construction industry. Glendon and Litherland [14] observed differences in the safety climate between occupation subgroups, still no difference was found between two regional areas of the same organization. But, Clarke [15] did observe substantial differences between areas in terms of train driver intentions to report incidents. Harvey, Bolam et al. [16] found the indication of two different safety cultures in the nuclear industry; a management safety culture which also comprised of professional and technical staff and an industrial employee safety culture. They proposed that the differences between managers and workers could possibly cause problems for communication and risk taking behavior as well as other safety issues. Nevertheless, Harvey, Bolam et al. [16] did not see the presence of two different cultures as objectionable, and felt that better communication between the two groups would help to bond the gap between groups.

Research recommends that groups interpreted safety through their own subcultures, instead of sharing an overall vision of safety. Through extensive literature review 52 factors were identified and classified as personal, behavioral and situational factors according to different levels of organization structure i.e top management, middle management and worker level as shown in Appendix A.

3.2. Safety performance

There is no collective definition of safety performance. For example safety performance may take into; safety organization and management, safety equipment and safety measures, accident record, safety training and appraisal, accident inquiries and safety training. Safety performance can be reflected as a subcategory of the overall performance of an organization [17]. The safety methods presently used in industry do not deliver information that is adequately enough to be used in this way on most construction projects. To be actually operative in safety management, maximum number of companies will need to choose to apply several methods of safety performance [18]. There are numerous types of safety performance measures that can be used on a construction project. Some have been in wide practice in the construction industry like Lost Work Day (LWD), OSHA Recordable Injury Rate (RIR), Near Miss and number of accidents etc., while others have been newly familiarized in the construction industry.

Recently, there has been a deviation from safety measures purely based lagging indicators such as accident rates, towards leading indicators for example site investigation and measurements of safety climate [4]. Proactive indicators are upstream, predictive, heading and positive but reactive indicators are downstream, historical, trailing and negative. Lagging indicators are dimensions that are related to the consequences of an accident such as injuries and fatalities [19]. These are outdated metrics that measure past safety efforts. When using lagging indicators, data is collected after a number of accidents or illnesses, after two years of workers' compensation, etc. Lagging indicators provide an organization with response in terms of how good performance has been in past time. Examples of lagging indicators include accident records, loss reports, injury and illness statistics, injury costs, and workers' compensation costs. Current indicators articulate an organization about how well the management systems are working present day, as opposite to in the past. Furthermore, they provide a measure of possible losses over the short term. Examples of current indicators consist of measures of safe and unsafe acts, incident investigation reports and safety audits. Current indicators can deliver the safety manager with immediate response on areas that need improvement. Leading indicators are measures that can be operative in forecasting future safety performance. These can be well thought-out "before the-fact" measures. These measures evaluate outcome actions taken before accidents happen and are measures of preemptive efforts designed to lessen losses and avoid accidents. Examples of leading indicators include measures of the excellence of an audit program, including schedule obedience, the number of repeat injuries, and analysis of process hazard reviews. The advantage of leading performance indicators is that they ascertain the insubstantiality in safety management practices before they convert into accidents. A good amalgamation of trailing, current and leading indicators, based on the company's own requirements, is always unsurpassed.

4. Research Methodology

Oil & gas projects are tremendously complex, consisting of multiple codependent components, highly dynamic; involve several feedback processes and nonlinear relationships. To manage such intricacy properly, a model must be capable of expressing systems with these features, and it must be comprehensible and functioning by the managers of the projects [23]. The impacts of managerial actions to deal with occupational health & safety problems are commonly delayed. As a result, managers may not be capable to perceive their effects. Such features of OHS management render system dynamics (also known as systems thinking) a right analysis tool for expressing and better understanding OHS problems [21,22]. In contrast to the linear archetype of cause and effect, where dependent and independent variables are clearly defined, system dynamics stresses the importance of feedback by articulating problems systemically [22].

To reflect the complexity and coupling of system components into safety management, the concept of systems thinking i.e. understanding the behavior of an entire system as a result of interactions among individual system components has been applied to accident analysis and investigation [24,25,22]. System dynamics is a method that ranges beyond conservative area of systems approach to large-scale multifaceted engineering problems. SD deals with interface of various elements of a system in time and captures the dynamic feature by integrating concepts such as stock, flows, feedback and delays, and thereby provides an awareness into the dynamic behavior of system over time [21]

Causal loop diagramming, an intrinsic feature of system dynamics, is a qualitative technique used to build models of real world issues [21,22]. A causal loop diagram tries to highlight the feedback and complex relations between variables, where causes and effects are often imperceptible. It can be used to model the effects of inputs on outputs and vice versa [21]. A positive link (arrow with a '+') shows that 'if the cause increases, the effect increases above what it would otherwise have been, and if the cause decreases, the effect decreases below what it would otherwise have been'. A negative link (arrow with a '−') designates that 'if the cause increases, the effect decreases below what it would otherwise have been, and if the cause decreases, the effect increases above what it would otherwise have been'. Furthermore, a set of two parallel lines on an arrow specifies that there is a significant time lag between the cause and effect. A reinforcing loop occurs when an increase/decrease in a variable will lead to an affinity for the variable to be increased/ decreased due to feedback through other variables in the loop. Instead, in a balancing loop, when a variable increases/decreases, there will be a tendency for the same variable to decrease/increase due to feedback through other variables in the loop.

After an extensive literature assessment, safety culture factors affecting safety performance were identified. These factors were further classified into personal, behavioral and situational aspects according to Cooper's Model as per top management, middle management and worker level. After sorting of the factors, the influence diagrams were drawn in the light of causal links referred by several previous studies. These influence diagrams were then converted to causal loop diagrams with the feedback effect. After developing CLD for different hypothesis/problems, these were merged together to get a big picture of how multilevel safety culture affects the safety performance of an organization.

The formulation of a System dynamic model has been designated by many authors as an iterative process e.g. Sterman, 2000, that requires knowledge of the problem area on one hand as well as technical modeling skills and experience of the modeler on the other hand. The model building process involves the following phases as shown in Fig. 2.

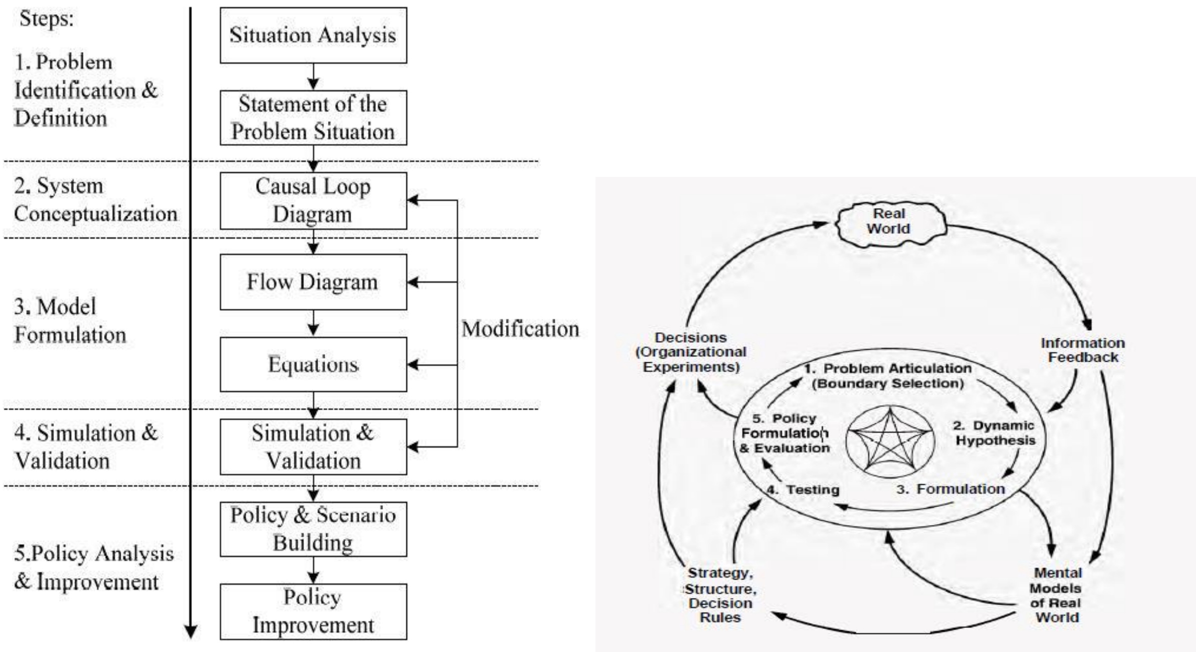

Fig. 2. System dynamics process (Sterman 2000)

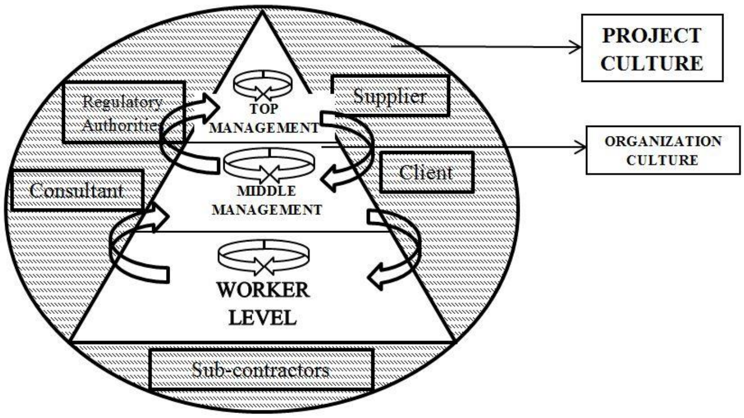

Fig. 3. System boundary

As discussed earlier, this paper is a part of an on-going research. Later the theoretical model shown in fig. 11 will be validated through group model building approach including participants from each level of organization (Top management, Middle management, Worker level). The final cognitive map/mental model will then be converted to stock and flow diagrams. Data from the historical records will be used to develop equations that will be used to simulate the model. Once the quantitative model is developed, policies will be devised for key variables like safety budget, safety trainings, work load, worker turnover etc to see their impact on safety performance like incident rate, worker behavior, and unsafe conditions of the organization.

4.1. Data analysis tools

System Dynamics is an approach to solving problems using different tools, most probably simulation tools. VENSIM is a computer simulation language developed by Ventana Systems that easily solves variable relationship and the structural elements of a model diagram with a model equation. It provides a mutual relation software environment to use for commercial goods and development, exploration, analysis and optimization for simulation models [26]. The equations will be developed using EXEL and SPSS. Those equations will then be the input to each causal link in stock and flow diagram.

5. Results and discussion

After extensive literature review, models were developed for each problem scenario as referred by different researchers. The case scenarios include loop for safety training, rework, work pressure, risk assessment, safety priority, production pressure and worker motivation as shown in Fig. 4,5,6,7,8,9 and 10 respectively.

5.1. Loop for safety training

It is commonly perceived that increasing the safety training will decrease the number of accidents and ultimately improve the safety performance. But in actual practice, it was observed that this scenario does not work in long run. As safety training increases, it will increase the safety instructions which in turn will increase the hazard awareness at worker level [27,28,29,30,31]. Increase in hazard awareness will improve the safety climate and worker perception, attitude towards safety [32,30,33,34,35]. If worker behavior is improved, it will ultimately reduce the number accidents [35,36]. If we look at this in short term, it seems that increasing the safety training will decrease the number of accidents. But, if we consider the feedback of the whole system, if number of accidents decreases, management focus will shift from safety and safety trainings will decrease and it will again increase the number of accidents. The balancing loop is shown in fig. 4

Similarly, feedback loops for each problem statement were developed with literature support. At the end, all the loops were integrated to develop the causal loop diagram for the whole system of the organization as shown in Fig. 11.

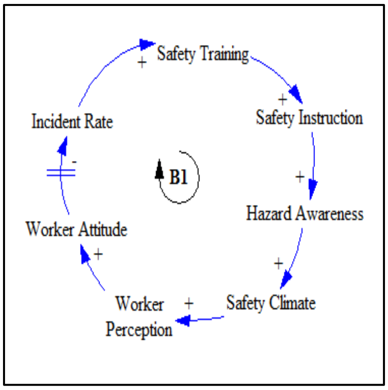

Fig. 4. Loop for safety training

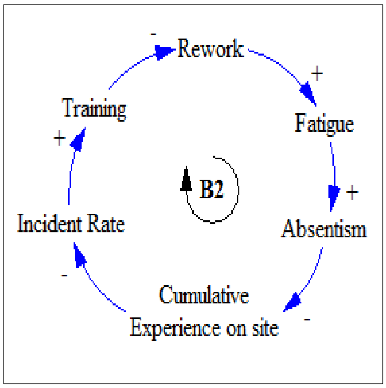

Fig. 5. Loop for rework

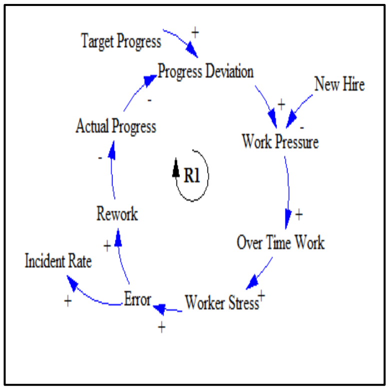

Fig. 6. Loop for work pressure

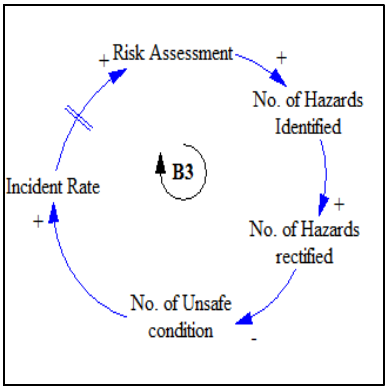

Fig. 7. Loop for risk assessment

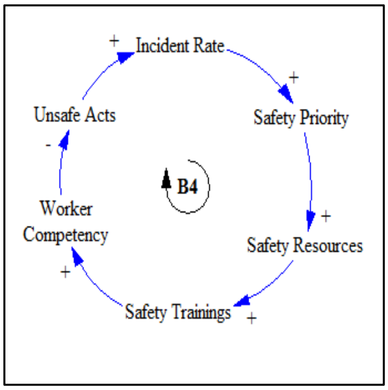

Fig. 8. Loop for safety priority

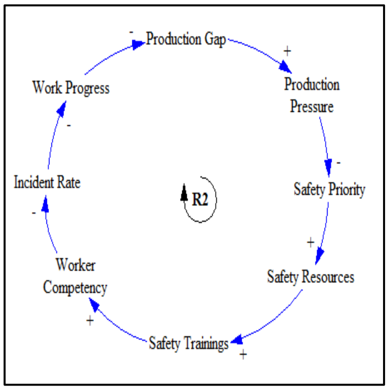

Fig. 9. Loop for production pressure

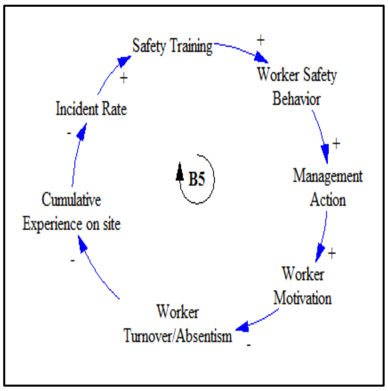

Fig. 10. Loop for worker motivation

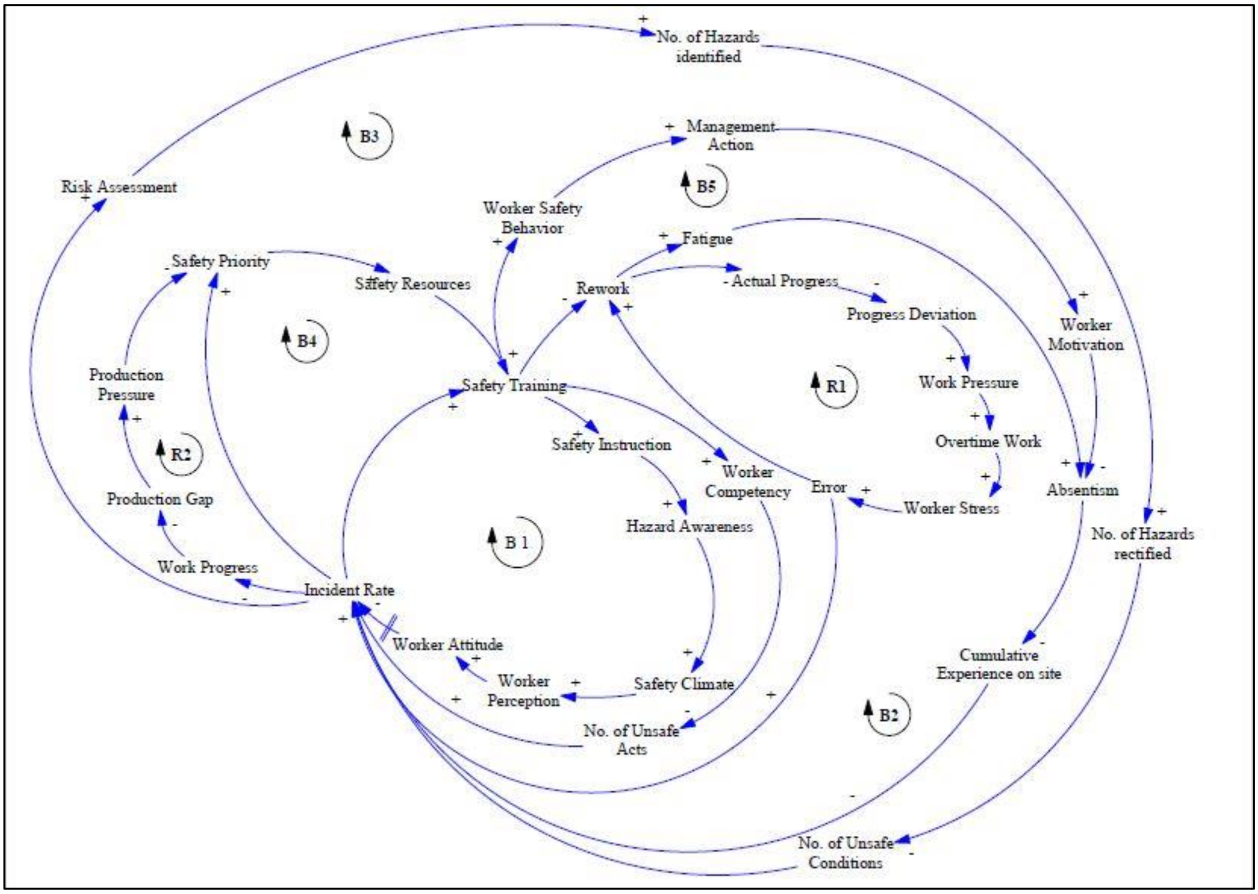

Fig. 11. Integrated theoritical model

6. Conclusion

As pointed out earlier that this article is a part of the ongoing research. From vast literature review, 52 factors of safety culture affecting safety performance were identified (list with references is attached in Appendix-A). As per previous researches influence diagrams amongst the variables were identified and causal loop diagrams were developed for individual case scenario. Later, all causal loops were integrated to get system model of the organization. Although, individual effect of key variables has been studied throughout research but this study has tried to model the whole system. As shown in fig. 11, increasing safety training in balancing loop B1 results in the decrease of incident rate but as the accident rate reaches the satisfaction level (zero accidents), loop B4 dominates and safety priority is decreased which ultimately results in increase of unsafe acts and increases the incident rate again. Similarly, loop B5 shown in fig 10. elaborates the common perception that increasing management actions/commitment/focus on safety will decrease the number of accidents. But if we integrate the scenario in the whole system, production pressure from loop R2 affects the management focus and resultantly increases the accident rate.

So, the basic motive of this research is to develop a system model for the organization which covers almost all the safety culture variables. The CLD will be converted to stock & flow and using past safety record equations will be developed and model will be simulated. Depending on the problems faced by organization, key variables will be decided and policies will be suggested to improve the safety performance of the organization. For example if an organization is having a lot of accidents due to worker turnover, using past records, it can be simulated to see the impact of worker turnover on number of accidents and limits can be set to keep the incident rate within reasonably acceptable limits. Similarly safety budget can be forecasted keeping in view the targeted safety performance.

Due to limited time, budget and availability of data, the study is limited to oil and gas projects in Pakistan but the methodology can be used to larger scope of work to develop a generalized model for construction industry.
It would be a great tool to enhance the safety performance of the organization as this methodology is a proactive approach to limit the accident rate and improve the worker behavior.

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Appendix A.

			Factors	**References**	
External/Exogenous			Government Safety Standards	Lin etal 2001; Khan M.I 2013	1
			Stakeholder Focus on Safety	Ng & R.M.Skitmore etal 2005; Farooqui 2007	2
			Target Work Progress	Hinze & Parker 1978; Hinze 1997; Goldenhar etal 2003; Mitopoulos & Cupido 2009	3
			Change Order	Rodrigues & William 1998; Love etal 1999; Park & Pena Mora 2003	4
Top Management	Person	Personality (Alertness, Responsibility)	Top Management Commitment to Safety	Mohammad 2003;Khan M.I 2013;	5
		Attitude & Perception towards Safety	Safety Priority	Leveson 2012; Goh etal 2012	6
			Top Management Focus on Safety	Goh etal 2012; Khan M.I 2013;	7
	Behavior	Participation	Top Management Involvement in Safety	Mohammad 2003; Khan M.I 2013;	8
		Performance Evaluation	Safety Audit	Sawacha etal 1999; Ng & R.M.Skitmore etal 2005;	9
		Leadership Style	Workers' Care & Concern	Sawacha etal 1999; Aksorn & Hadikusumo 2008; Khan M.I 2013;	10
	Situation	Policy	Safety Policy	Sawacha etal 1999	11
			Safety Goals/Targets	Aksorn & Hadikusumo 2008;	12
		Resource Allocation	Safety Budget	Hinze etal 1988; ; Aksorn & Hadikusumo 2008;	13
		Personal Selection	New Hiring	Rodrigues & William 1998; Love etal 1999; Park & Pena Mora 2003	14
		Environment	Work Pressure	Leveson 2012; Hinze & Parker 1978; Hinze 1997; Goldenhar etal 2003; Mitopoulos & Cupido 2009;Rodrigues & William 1998; Love etal 1999; Park & Pena Mora 2003; Rundmo 1998; Brown 2000; Mohammad 2000; Seo 2005; Mitropoulos etal 2005	15
			Schedule Pressure	Leveson 2012; Rodrigues & William 1998; Love etal 1999; Park & Pena Mora 2003; Rundmo 1998; Brown 2000; Mohammad 2000; Seo 2005; Mitropoulos etal 2005	16
Middle Management	Person	Personality (Alertness, Responsibility)	Safety Implementation	Mohammad 2003;	17
		Attitude & Perception towards Safety	Attitude & Perception towards Safety		18
		Abilities (Decision Making)	Risk Assessment	Bena etal 2009; Cohen etal 1999; Goh etal 2012	19

			Working Hours/Day		20
		Safety Knowledge	Safety Trainings	Mohammad 2003;Bena etal 2009; Goldeberg etal 1999; Cohen etal 1998; Sawacha etal 1999; Lingard 2002; Goh etal 2012	21
	Behavior	Communication	Safety Trainings	Mohammad 2003;Bena etal 2009; Goldeberg etal 1999; Cohen etal 1998; Sawacha etal 1999; Lingard 2002; Goh etal 2012	22
		Participation	Safety Inspection	Sawacha etal 1999;Ng & R.M.Skitmore etal 2005;	23
		Organization Learning	Safety Documentation	Mohammad 2003; Khan M.I 2013;	24
		Leadership Style	Worker Empowerment	Hechanova etal 2001;	25
			Worker Motivation	Mohammad 2003; Goldeberg etal 1999; Cohen etal 1998; Sawacha etal 1999; Lingard 2002; Goh etal 2012	26
		Performance Evaluation	Safety Management System	Mearns etal 2003; Hinze etal 2003	27
	Situation	Resource Allocation	Safety Resources	Goh etal 2012	28
			Safety Incentives	Goh etal 2012	29
		Environment	Actual Work Progress	Hinze & Parker 1978; Hinze 1997; Goldenhar etal 2003; Mitopoulos & Cupido 2009	30
			Safety Climate	Tomas etal 1999; Brown etal 2000; Lingard 2000; Mohammad 2002; Seo 2005; Choudhry etal 2007; Zohar 1980	31
			Overtime Work	Rodrigues & William 1998; Love etal 1999; Park & Pena Mora 2003; Nguyen & Ogunlana 2005	32
Worker Level	Person	Personality (Alertness, Responsibility)	Worker Stress	Hinze & Parker 1978; Hinze 1997; Goldenhar etal 2003; Mitopoulos & Cupido 2009	33
			Error	Rodrigues & William 1998; Love etal 1999; Park & Pena Mora 2003	34
			Fatigue	Rodrigues & William 1998; Love etal 1999; Park & Pena Mora 2003; Nguyen & Ogunlana 2005; Love & Edward 2004;	35
			Use of PPE		36
		Attitude & Perception towards Safety	Worker Perception towards Safety	Tomas etal 1999; Brown etal 2000; Lingard 2000; Mohammad 2002; Seo 2005; Choudhry etal 2007; Zohar 1980; Khan M.I 2013;	37
			Worker Attitude towards Safety	Tomas etal 1999; Brown etal 2000; Lingard 2000; Mohammad 2002; Seo 2005; Choudhry etal 2007; Zohar 1980; Khan M.I 2013;	38
			Worker Safety Behavior	Tomas etal 1999; Choudhry etal 2007; Goh etal 2012	39
			Worker Satisfaction	Mohammad 2003;	40
		Safety Knowledge	Supervisor Competency		41
			Cumulative Experience on Site	Nguyen & Ogunlana 2005; Love & Edward 2004;	42
			Awareness of Safety Rules	Goldeberg etal 1991;	43

		& Procedures		
		Workers' Competency	Goh etal 2012	44
Behavior	Communication	Safety Communication/Instructions	Mearns etal 2003; Siu etal 2004; Sawacha etal 1999	45
	Participation	Worker Feedback	Goldeberg etal 1999; Cohen etal 1998; Sawacha etal 1999; Lingard 2002	46
	Performance Evaluation	No. of Unsafe Acts	Sawacha etal 1999; Jones etal 1999; Siu etal 2004	47
		Accident Rate	Leveson 2012; Mohammad 2003;Hinze & Parker 1978; Hinze 1997; Goldenhar etal 2003; Mitopoulos & Cupido 2009; Nguyen & Ogunlana 2005; Love & Edward 2004;	48
		No. of Accidents	Mohammad 2003;Leveson 2012; Goh etal 2012	49
Situation	Site Environment	No. of Unsafe Conditions	Goh etal 2012; Abdelhamid 2000; Sawacha etal 1999; Jones etal 1999	50
		Workers' Turnover/Absentism	Rodrigues & William 1998; Love etal 1999; Park & Pena Mora 2003; Nguyen & Ogunlana 2005; Love & Edward 2004; Goh etal 2012	51
		Rework	Leveson 2012;Rodrigues & William 1998; Love etal 1999; Park & Pena Mora 2003; Nguyen & Ogunlana 2005; Love & Edward 2004;	52

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Sustainable Civil Engineering Structures and Construction Materials, SCESCM 2016

Model of the maturity of pre-construction safety planning

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Abstract

Across the world, construction safety still has poor performance. The construction accident rate is higher than in other industries. Construction safety is not only about worker, but also about public, property, and environment. In the line of safety of property, accident can damage construction elements, construction materials, equipments, and may generate delayed construction time. Therefore, accident prevention is an important aspect in a construction project. According to the old theory, accident prevention based on downstream approach and only the contractor responsibility, whereas the recent theory more based on upstream approach (needs a good/mature planning which conducted since pre-construction stage), and all participants in a construction project are responsible to develop the mature Pre-Construction Safety Planning (PCSP). The problems of this research are how the good (mature) of PCSP and how to evaluate/assess the maturity of PCSP. This research started by literature study, and then created the model of PCSP. This research use questionnaire, interview and focus group discussion (FGD) to identify and measure as well as validate the contribution of all project participants in PCSP. The Structural Equation Modeling (SEM) employed to generate aggregation model. Finally, the results of research, are: (1) the model for evaluating the maturity of PCSP in radar diagram, and (2) the results of evaluation to the several medium high rise building projects in Indonesia.

Peer-review under responsibility of the organizing committee of SCESCM 2016.

Keywords: safety; pre-construction; planning; maturity; upstream approach

1. Introduction

The rate of fatal accidents in the construction industry in many countries is higher than other industries [1]. In USA, accident data in 2009 show that the rate of fatal accidents was 3.3 per 100,000 workers and in the construction

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Peer-review under responsibility ofthe organizing committee of SCESCM 2016.

industry was 9.7 per 100,000 workers [2]. In UK, at 2010, the average fatal accident rate was 0.5 per 100,000 workers and in the construction industry was 2 per 100,000 workers [3]. In the developing countries, the rate was even worse [4]. Rate of fatal accidents in developing countries were about three times of developed countries [5]. These data reflect that construction projects are a risky place of accidents, while they are increasingly complex in design and construction. Johnson mentioned that difficult design may increase the risk of accidents [6]. Furthermore, Barrie [7], Hinze [8], and Oberlender [9] recommend that construction safety should be planed as early as possible. Koehn describes that the implementation of safety plan must be monitored and evaluated thoroughly [4]. Oberlender points out that although the construction safety on site was the contractors' responsibility, a closed cooperation among project participants is required to improve safety [9]. Mohamed argues in the traditional view that safety is the responsibility of the contractor is not valid [10]. Suraji stated clearly that safety is the responsibility of all people of project participants involved in the construction process from project conception, project design and throughout project construction [1]. However, there is no evidence to show a collaborative convergence effort of those project participants from clients, consulting engineers and contractors in providing a comprehensive planning in the pre-construction stage in order to eliminate, reduce and avoid any risks of accidents during construction on site. Safety in construction are not only related to safety for worker but also safety for public, safety for property and safety for environment [11].

This paper is to report findings of the research aiming at the assessment model of maturity of pre-construction safety planning. The assessment involving the role of all participant project (clients, consulting engineers and contractors as well as stakeholders such as governments and society). This paper also report the result of evaluations to the medium high rise building projects at several towns in Indonesia.

2. Safety Planning in Pre-Construction Stage

In the last decade, construction accident causation is not only viewed as individual worker issues but also project organization as a whole [12], [13]. Only downstream approach (construction stage approach) to deal with safety in the construction industry is not enough and therefore upstream approach (pre-construction stage approach) is of important path. Furthermore Suraji considers that the construction accident at work is actually comes from many factors, not just workers and site management factors by contractors but also the planning factors by designers and project management factors by clients [12]. Any project participants involved in a construction project may generate the potential factors leading to the increased risks of accident. Construction safety is no longer only contractor's duties but all participants' duties. Under the Construction Design Management (CDM) regulation of UK, construction safety is treated since in the pre-construction. CDM was introduced in 1994 [14], and then revised in year 2007 and replaced in year 2015 [16]. In the CDM, clients has strong role to evaluate safety plan proposed by contractors during tender stage and a planning supervisor is appointed to assess safety plan in the planning and design of construction projects. In the regulation, the designer should be responsible for the safety of the design and the main contractor is responsible to plan organize and coordinate safety and health during construction [12], [13]. Furthermore, safety is also a key issue in the process protocol developed by the University of Sanford since 1998 to improve the design and construction process [17]. In this protocol, safety is considered since very early project development.

3. Research Method

The research started by a thorough literature study to some theory of accident causation regarding upstream approach, to investigate project participant's role during pre-construction stage. Some theories are: Constraint-Response Theory (CRT) of construction accidents [10], Construction Design Management (CDM) Regulation in UK [16], and the Process Protocol (Pp) developed by Salford University [17]. The project participant's roles then be verified by practitioners and academics through Delphi method. The Delphi method is a method that uncovers the subjective consideration regarding the possibility of future event occurrence based on the related events [18]. First, postal survey targeted to the practitioners and academics, and continued with two rotation of focus group discussion (FGD). FGD would obtain some indicators roles of project participant's contributions to the maturity of safety planning during pre-construction stage. All indicators role then be sent to the middle-level practitioners who had been implementing in the daily project activities, and the returned questionnaire awaited.

Furthermore, practitioners need an instrument for evaluating a maturity of pre-construction safety planning, in this research called MIPSAP (Maturity Index of Pre-construction Safety Planning). MIPSAP was developed to model how mature is safety planning carried out by clients, designers, contractors, and stakeholders during pre-construction stage. In this case, the SEM (Structural Equation Modeling) employed to analyzed data of returned questionnaire, an then examine validity of their necessary rate and reliability required in the safety planning. The indicator roles would be considered valid if its loading value above to 0.5 and the instrument is reliable if have Cronbach Alpha value above to 0.7 [19]. Finally, researchers obtain 27 indicators role of pre-construction safety planning which adequate in validity and reliability. The MIPSAP will be drawn in a “radar diagram” under EXEL Microsoft Office.

4. The Result and Discussion

Through seventy and four returned questionnaire, respondents state the role of participants project are: the role of Owner is 27%; the role of consultant is 27.5%; the role of contractor is 31.5%; and the role of stakeholder is 14%, total 100%. Furthermore, based on the results of SEM-PLSsmart calculation, from 40 roles of project participant’s contributions to the maturity of safety planning in the pre-construction stage, 27 roles was valid. The validation score of each role are described at the next paragraphs. The results of PLS smart also indicated that the instrument was reliable, by the composite reliability of the role of owner’s (OW) = 0.856; the role of consultant’s (KS) = 0.867; the role of Contractor’s (KN) = 0.892 and the role of Stakeholder’s (ST) = 0.891.

The owner/client’s indicator roles in safety planning during pre-construction stage are: OW1: Providing data analysis of construction accidents for each type of construction activities (loading value = 0.707>0.50/valid) ; OW2: Providing sufficient funds to pay the cost of construction project (0.843/valid); OW3: Selecting a professional consultant which make safe design by using the principles of risk management (0.759/valid) ; OW4 : Controlling every level of safety planning through the bid documents proposed by contractors (0.608/valid) ; OW5: Having a list of consultants and contractors who have been carrying out a proper construction safety (0.599/valid) ; OW6 : Appointing consultants and contractors who have a proper construction safety plan (0.684/valid).

The consultant’s indicator roles in safety planning during pre-construction stage are: KS1: Providing data analysis of construction accidents for each type of construction activities (0.545/valid) ; KS2: Incorporating construction safety requirements in the tender documents (0.513/valid); KS3: Making a proper planning and safe design by using risk management principles (hazard identification, risk assessment and risk management) (0.640 /valid) ; KS4: Having planner/designer who holds a certified safety expertise for design and planning (0.762/valid) ; KS5: Proposing project supervision plan including the implementation of the project safety plan (0.700/valid); KS6: Setting up the format for reporting findings of safety monitoring in the project implementation (0.691/valid) ; KS7: Setting up the format for reporting findings of safety monitoring in the project implementation (0.700 /valid); KS8: Assigning a safety engineer as the supervisor in the implementation of the construction safety plan (0.679/valid).

The contractor’s indicator roles in pre-construction safety planning are: KN1: Adopting rules and regulations that are applicable for the construction safety (0.706/valid ; KN2:Proposing Construction Safety Plan in a bid proposal in accordance with the method of statements which will be used (0.728/valid); KN3: Maintaining knowledge and experiences in similar projects (0.648/valid); KN4:Providing evidences in implementing construction safety plan (0.826/valid) ; KN5::Providing safety engineers and safety managers in its project organization (0.833/valid) ; KN6: Providing a system to control safety implementation by sub-contractors (0.852/valid) ; KN7 Implementing safety according to safety codes and regulations (0.620/valid); KN8: Subcontractor has an operation methods which will be implemented, including the safety plan (0.632/valid); KN9: Subcontractor has experiences on the similar project (0.535/valid).

The stakeholder’s indicator roles in pre-construction safety planning are: ST1: Local governments and related institutions require to project participants to fulfill a building permit and licensing requirements and to supervise the implementation of construction safety codes and standards (0.720/valid); ST2: Government institutions enforce any law and regulations related to safety matters and take actions towards breach of safety code and regulations by any project participants (0.943/valid) : ST3: Society knows about the construction projects to be built, including the hazard(s) (0.716/valid) ; ST4: Society particularly workers are aware of standards and practices of construction safety (0.883/valid).

The maturity of pre-construction safety planning (namely MIPSAP) can be expressed in mathematical model.

Each valid indicator role, (OW1 – OW6; KS1 –KS8; KN1 – KN9; and ST1 – ST4) measured in five scale score, score 1 for low, and up to score 5 for very high. The maturity index is the sum of score of all indicator roles multiplied by role of participants' project respectively. The MIPSAP illustrated in Equation 1 and Equation 2.

$$MIPSAP = \frac{Cow}{n1.a}\sum_{i=1}^{n1} OWi + \frac{Cks}{n2.a}\sum_{i=1}^{n2} KSi + \frac{Ckn}{n3.a}\sum_{i=1}^{n3} KNi + \frac{Cst}{n4.a}\sum_{i=1}^{n4} STi \quad \ldots\ldots\ldots\ (1)$$

$$MIPSAP = 0.9\sum_{n=1}^{6} OWi + 0.6875\sum_{n=1}^{8} KSi + 0.7\sum_{n=1}^{9} KNi + 0.7\sum_{n=1}^{4} STi \quad \ldots\ldots\ldots\ (2)$$

Where:
MIPSAP= The maturity of safety planning in the pre-construction stage ($0 \leq$ MISAP ≤ 100)
OW = The Owner's role, consisting of 6 variables, score each variable $0 \leq OWi \leq 5$
KS = The Consultant 's role, consisting of 8 variables, score each variable $0 \leq KSi \leq 5$
KN = The Contractor's role, consisting of 9 variables, score each variable $0 \leq KNi \leq 5$
ST = The Stakeholder's role, consisting of 4 variables, score each variable $0 \leq STi \leq 5$
Cow, Cks, Ckn, Cst = Percentage role of Owner, Consultant, Contractor, Stakeholder, respectively.

For illustrating the maturity of pre-construction safety planning (MIPSAP), researcher used radar diagram under EXEL Microsoft Office. In the radar diagram, the indicator roles as "fingers" of diagram with its score respectively. The area fenced by line connecting each score (coloured area) illustrate a MIPSAP. The maturity of safety planning is categorized into: very not mature (MIPSAP < 20), not mature (20 < MIPSAP < 40), nearly mature (40 < MIPSAP < 60), mature (60 < MIPSAP < 80) and very mature (80< MIPSAP < 100).

Assessment model of the maturity of pre-construction safety planning (equation 2) then applied for case study by observe several medium rise building projects in Indonesia with DBB (Design-Bid-Build) delivery system of procurement. The medium rise building projects in developing country still need more attention in safety management/ organization. There are seven projects that were observed in five cities, two of which are projects that had construction accident. Through observation and documentation toward the project administration, researchers measured each indicator of the maturity of the pre-construction safety planning The result of observation be drawn on radar diagram under EXEL, and then the diagram will appear automatically, for example Fig 1 for project A and Fig 2 for project E. The result of the observation of seven projects illustrated in Fig 3, show that the potencial of fatality accident tend occur in the project having low MIPSAP score, for example Project B and also Project E.

Furthermore, according to the result, "the radar diagram" can be used for evaluating the maturity of pre-construction safety planning to one project which will be built. If the score of MIPSAP is high (mature and very mature), the project may go on to construction stage. But if the score of MIPSAP is low (very not mature and not mature), better make re-planning of construction safety before starting the project to construction stage. The boundary between low and high score (about 50 MIPSAP score) still need further studied with observe some medium high rise building as sample as much as possible.

MIPSAP (Maturity Index of Pre-construction Safety Planning)
Findings:
The Owner's role :46.67 x 27% = 12.60
The Consultant's role :40.00 x 27.5% = 11.00
The Contractor's role :80.00 x 31.5% = 25.20
The Stakeholder's role :47.50 x 14% = 6.65
Total score = 55.45
Maturity Criteria: **nearly mature**
No acciden**t.**

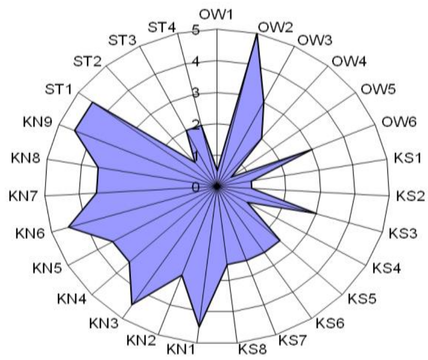

Fig 1. Maturity Index of pre-construction safety planning (MIPSAP) of Project A

MIPSAP (Maturity Index of Pre-construction Safety Planning)
Findings:
The Owner's role : 33.33 x 27% = 9.00
The Consultant's role : 14.50 x 27.5% = 3.9875
The Contractor's role :16.70 x 31.5% = 5.25
The Stakeholder's role : 30.00 x 14% = 4.20
Total score =22.4375
Maturity Criteria : **not mature**
There was an accident, minor injuries =10 workers and major injuries = 4 workers.

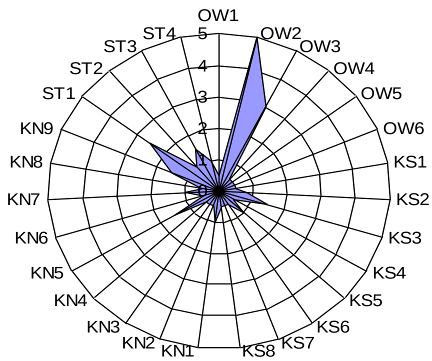

Fig 2. Maturity Index of pre-construction safety planning (MIPSAP) of Project E

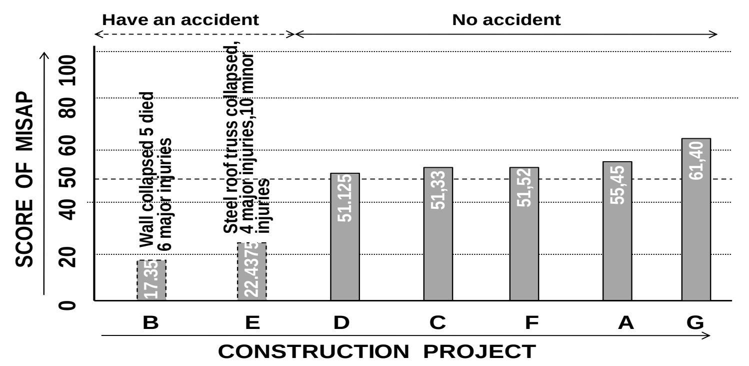

Fig 3. MIPSAP score of several project in Indonesia

6. Conclusion

The research found that according to the organizational/management theory of accident causation with upstream approach, all participants of the project have a role to the project safety. Owner, consultant, and contractor had majority roles in safety planning, and stakeholder had minority roles. A mature pre-construction safety planning should be created before project execution. For evaluating the maturity of pre-construction safety planning, a assessment instrument is needed. Furthermore, MIPSAP can be used to measure the maturity of safety planning in the building project especially the medium rise building projects with DBB (Design-Bid-Build) delivery system of procurement. This research also uncovered that the building projects with the low score of MIPSAP (very not mature and not mature), better make re-planning of construction safety before starting the project to the construction stage. If the score of MIPSAP is high (mature, and very mature), the project may go on to the construction stage.

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