Critical Success Factors on the Implementation of Industrialized Building System in West Sumatra

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Abstract. The construction industry in West Sumatra, Indonesia is experiencing a serious challenge since the occurrence of the devastating earthquake in September 2009. The Infrastructures including residential housing, government offices, roads and bridges were damaged and destroyed. The major problems facing the construction industry is mostly related to poor planning, lack of standards for quality project implementation and poor processing time. One of the possible solutions to answer these problems is by introducing Industrialized Building System (IBS) in the construction industry. The aim of the study described in this paper is to identify the critical success factors (CSF) for the successful implementation of IBS in West Sumatra. The main methodology involved questionnaire survey to various stakeholders of the construction industry who have had experience dealing with IBS construction methods. The results and findings reveal that there are twenty-two critical success factors that need to be considered by the industry in order to ensure the success of IBS implementation. The factors can be grouped into several distinct classifications. It is expected that the findings form this study serve as a gateway for encouragement towards proper implementation of IBS in West Sumatra.

Keyword: Industrial Building System, West Sumatra Construction Industry, Success Factors

1. Introduction

Industrialised Building System (IBS) can be generally interpreted as the process in which all building components are produced either in a factory or at the site. IBS components are manufactured in accordance with the standard specifications, shapes, and dimensions before being transported to the construction site. IBS may not be a new concept in certain country such as UK or other developed countries. However, in a country like Indonesia IBS is considered a relatively new concept which is yet to be exploited. The history of IBS can be traced dated back since the mid-1900's when in the UK prefabricated construction were used to address the problem of widespread destruction of housing stock during the Second World War.

IBS is an alternative construction approach that changes the scenario of the current traditional construction industry towards a systematic approach of construction materials production. IBS components are conceived, planned, fabricated from factories are transported and erected on the site. With this method, the process involves planning, management and sustained improvement of the production process to eliminate waste. Moreover, the right components are produced and delivered at the right time, in the right order and without defect. IBS therefore, reduce unskilled labours in the country, less wastage, less volume of building materials, increased site cleanliness and better quality control.

In ensuring the success implementation of IBS in the construction industry, the initial step to be taken is to identify the factors that may influence IBS implementation. As the factors are very much dependent on the nature of the construction industry, it is important that a proper investigation is carried out to establish the right factors. In view of the issue, this study has been directed towards identification of the IBS success factors suitable to be implemented in construction projects in West Sumatra.

2. Literature Review

2.1. Definition of IBS

IBS have been defined in many ways by various researchers. Examples of the definitions given by selected researchers can be seen in Table 1. Based on these definitions it can be observed that despite the differences, majority of researches agree that IBS focus on building components that are manufactured and assembled separately.

Table 1. Definitions of IBS.

References	Definition
[1]	An industrialized process which components of a building are conceived, planned, fabricated, transported and erected on site, which includes balance combination between software and hardware component. The software element includes system design, which is complex process of studying the requirement of the end user, the development of standardizing component and market analysis
[2]	A system which uses industrialized production method either in the production of component or assembly of the building or both.
[3]	A system beginning from utilizing craftsmen for every aspect of construction to a system that make use of manufacturing production in order to minimize resource wastage and enhance value end users
[4]	A concept of mass production of the quality building by using new building systems and factory produced building components. Build on-site with elements or components produced in plants then assembled and erected on the site
[5]	A construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and installed into a structure with minimal additional site works
[6]	An approach or process used in making construction less labor-oriented and faster as well as fulfilling quality concern
[7]	A new construction method that can improve the quality and productivity of work through the use of better construction machineries, equipments, materials, and extensive project planning
[8]	An innovative process of building construction using the concept of mass-production of industrialized systems, produced at the factory or on-site within controlled environments, it includes the logistic and installation aspect of it, done in proper coordination with systematic planning and integration
[9]	CIB defined industrialized construction as a generic process of standardization and rationalization of the work processes in the industry to reach cost efficiency, higher productivity and quality

2.2. Charateristics of IBS

Several common characteristics of IBS that have been mentioned by researchers are Standardisation, Transportation, Mass production and Erected on Site. Other characteristics of IBS include Systematic and Organised Plan, Integration, Innovation, Manufacturing and Controlled Environment, and Mechanisation as can be seen Table 2.

Table 2. Characteristics of IBS.

Characteristics		References
Mass Production	Mass Production, Methods of Production, Production Output, Industrialized Production, Production Process	[4], [10]
Systematic and Organized Plan	Centrally Organized, Systematic Organizational Process, Organization Structure, Systematic planning, Extensive Project Planning	[8], [11], [12]
Innovative	Innovative Process, Investment in Innovation	[4], [8], [9]
Industrialization	Industrialization, Industrialized Production	[2], [13]
Standardization	Standardization, Optimizing Standardization	[1], [9], [10], [11], [12]
Integration Integration	Integrated Manufacturing, Systematic Planning and Integration	[11], [12]
Mechanization	Mechanization, Better Construction Machineries, Mechanization and Automation	[7], [9], [11], [12]
Transportation	Transportation	[5], [10]
Manufacturing and Factory controlled	Manufacturing, Factory Production, Factory Controlled Environments, Integrated Manufacturing	[3], [4], [14]
Positioned, Assembled and Erected on the site	Assembled and Erected on the site, positioned and Installed	[1], [5]

2.3. Critical factors on IBS implementation

According to Carali (2004) the concept of Critical Success Factors (CSFs) originated back in 1960's [15]. Méndez et al. (2008) define CSFs as carry out certain activities in the right way to meet intended objectives [16]. On the other hand Austin (2002) describes CSFs as critical areas that need to perform so that the organisation can achieve its goals [17]. There many other researchers that describe CSF in different styles but the intention is similar which is important elements to be addressed in order to achieve targeted goals.

In ensuring IBS is successfully implemented in the construction industry, this study has reviewed and compiled all relevant critical success factors mentioned by previous researchers. Various sources of information were used to establish the list of factors. Alltogether there are eleven success factors which can be expanded into forty-five sub-factors or elements. Table 3 provides an overview of the factors and sub-factors that have been compiled based on available literatures.

Table 3. Critical success factors on IBS implementation.

No.	Element Critical Success Factor	References	Code
1	Training & Education	[18]	CSF-1
2	Labour skill	[19]	CSF-2
3	Skill and Expertise	[20]	CSF-3
4	Effective Cost Planning, Control & Management	[21]	CSF-4
5	Cost of Management, Training, Process & Technology	[22]	CSF-5
6	Cost of Factory	[23]	CSF-6
7	Cost of Transportation	[24]	CSF-7
8	Cost of Material	[19]	CSF-8
9	Cost of Human Resource	[19]	CSF-9
10	Price stability of building materials	[21]	CSF-10
11	Operational costs	[25]	CSF-11

12	Machinery and Equipment	[23]	CSF-12
13	Material Selection	[23]	CSF-13
14	Facilities	[23]	CSF-14
15	Standardisation system	[21]	CSF-15
16	Information Technology	[23]	CSF-16
17	Logistic & Transportation	[19]	CSF-17
18	Management of Supply Chain & Logistic	[26]	CSF-18
19	Coordination of Design, Manufacturing & Construction	[27]	CSF-19
20	Collaboration between/within organization	[19]	CSF-20
21	Teamwork	[25]	CSF-21
22	Communication channel	[25]	CSF-22
23	Time Management	[26]	CSF-23
24	Guideline	[23]	CSF-24
25	Business and Marketing	[18]	CSF-25
26	Risk Management	[26]	CSF-26
27	Top-Down Commitment	[26]	CSF-27
28	Key Decisions	[23]	CSF-28
29	Procurement System	[19]	CSF-29
30	Factory suitability	[23]	CSF-30
31	Production Capacity	[19]	CSF-31
32	Health & Safety	[22]	CSF-32
33	Marketing Strategy	[26]	CSF-33
34	Environmentally friendly	[19]	CSF-34
35	Leadership and Organisation	[25]	CSF-35
36	Contractor Management	[21]	CSF-36
37	Site Management & Process	[28]	CSF-37
38	Quality Expectation	[28]	CSF-38
39	Economies of scales/ Quantity of components Ordered	[21]	CSF-39
40	Comprehensiveness of IBS principles in the design	[21]	CSF-40
41	Advance planning and project management	[18]	CSF-41
42	Roles and in-house capability	[18]	CSF-42
43	Development Role	[27]	CSF-43
44	QA / QC	[23]	CSF-44
45	Regulation	[27]	CSF-45

3. Research Methodology

In the first stage this study all relevant literatures on CSFs as mentioned by various researchers were reviewed. The review did not only limit to articles published in peer-reviewed and prestige journals, but also include theses and books. The search date was within year 1990 to 2018 in order to cover a broad range and at the same time capturing new findings. In the second stage, questionnaires were distributed to professionals who have experience involving in IBS related projects. The questionnaire consisted two main parts. Part A targeted to collect some general information and background of the respondents, followed by part B which aimed to collect data on the level of importance of the critical success factors that have been identified through literature as shown in Table 4. The questionnaires were handed over to the respondents by means of self-administrated questionnaire. A total of 25 responses were fully received. The respondents comprised of contractors, consultants and project owners. A five point Likert scales was used to measure the level of importance of the success factors. The data obtained was analyzed using

descriptive statistics. The qquestionnaire data was analysed using Statistical Package for the Social Sciences (SPSS). The results of the reliability values were calculated and found to above 0.70 (Cronbach's Alpha) while validity ("r" table) will be the CSFs that determines in the implementation of IBS in West Sumatra - Indonesia.

Table 4. Critical success factor of IBS implementation

No.	Critical Success Factor (CSF)	No.	Critical Success Factor (CSF)
1	Training & Education (CSF-1)	24	Guideline (CSF-24)
2	Labour skill (CSF-2)	25	Business and Marketing (CSF-25)
3	Skill and Expertise (CSF-3)	26	Risk Management (CSF-26)
4	Effective Cost Planning, Control & Management (CSF-4)	27	Top-Down Commitment (CSF-27)
5	Cost of Management, Training, Process & Technology (CSF-5)	28	Key Decisions (CSF-28)
6	Cost of Factory (CSF-6)	29	Procurement System (CSF-29)
7	Cost of Transportation (CSF-7)	30	Factory suitability (CSF-30)
8	Cost of Material (CSF-8)	31	Production Capacity (CSF-31)
9	Cost of Human Resource (CSF-9)	32	Health & Safety (CSF-32)
10	Price stability of building materials (CSF-10)	33	Marketing Strategy (CSF-33)
11	Operational costs (CSF-11)	34	Environmentally friendly (CSF-34)
12	Machinery and Equipment (CSF-12)	35	Leadership and Organisation (CSF-35)
13	Material Selection (CSF-13)	36	Contractor Management (CSF-36)
14	Facilities (CSF-14)	37	Site Management & Process (CSF-37)
15	Standardisation system (CSF-15)	38	Quality Expectation (CSF-38)
16	Information Technology (CSF-16)	39	Economies of scales/ Quantity of components Ordered (CSF-39)
17	Logistic & Transportation (CSF-17)	40	Comprehensiveness of IBS principles in the design (CSF-40)
18	Management of Supply Chain & Logistic (CSF-18)	41	Advance planning and project management (CSF-41)
19	Coordination of Design, Manufacturing & Construction (CSF-19)	42	Roles and in-house capability (CSF-42)
20	Good working collaboration between/within organization (CSF-20)	43	Development Role (CSF-43)
21	Teamwork (CSF-21)	44	Quality Assurance & Quality Control (CSF-44)
22	Communication Channel (CSF-22)	45	Regulation (CSF-45)
23	Time Management (CSF-23)		

4. Data Analysis

Data from the demographics of the respondents were collected and made their respective classifications, to see the background of the respondents whether they met the requirements as respondents or not.
All of the respondents came from 3 groups of parties who will be involved in implementing IBS going forward in West Sumatra. They come from Project Owners, Consultants and Contractors for Multi-storey Building Works in West Sumatra. The demographic data of respondents is as shown in Figure 1.

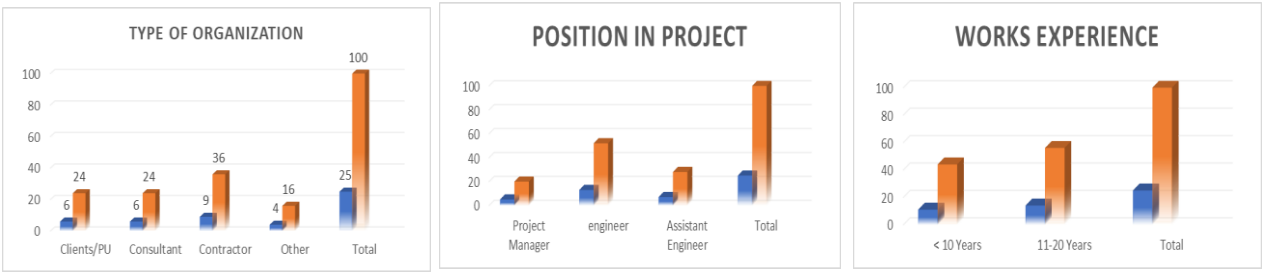

Figure 1. Demographic.

Looking at the critical success factors, the data collected from the survey were analysed using SPSS for determining the reliability and validity scores as shown in Table 5.

Table 5. Item total statistic.

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
CSF-1	166.7692	44.359	.000	.758
CSF-2	166.1538	47.641	-.413	.785
CSF-3	167.3077	43.897	.028	.761
CSF-4	165.1538	46.308	-.320	.775
CSF-5	165.6154	38.756	.767	.728
CSF-6	165.6154	38.923	.741	.729
CSF-7	166.2308	37.359	.674	.725
CSF-8	166.8462	41.641	.218	.755
CSF-9	166.0000	42.000	.155	.760
CSF-10	167.2308	38.526	.363	.747
CSF-11	166.4615	38.936	.639	.731
CSF-12	165.8462	42.808	.406	.750
CSF-13	165.9231	42.244	.404	.748
CSF-14	167.3846	43.423	.060	.762
CSF-15	167.2308	40.526	.327	.748
CSF-16	165.6923	39.731	.705	.733
CSF-17	165.6154	40.090	.868	.733
CSF-18	165.8462	42.808	.406	.750
CSF-19	165.2308	47.192	-.435	.780
CSF-20	166.3846	40.423	.571	.739
CSF-21	165.6154	44.256	-.008	.761
CSF-22	165.5385	40.603	.638	.738
CSF-23	165.7692	44.359	.000	.758
CSF-24	165.8462	42.808	.406	.750
CSF-25	166.3846	40.423	.571	.739
CSF-26	166.5385	40.603	.638	.738
CSF-27	165.6923	46.064	-.473	.770
CSF-28	165.7692	44.359	.000	.758
CSF-29	165.7692	44.359	.000	.758
CSF-30	165.7692	44.359	.000	.758
CSF-31	165.6923	38.564	.906	.725
CSF-32	165.4615	38.936	.639	.731

CSF-33	165.5385	44.769	-.103	.765
CSF-34	165.7692	47.026	-.506	.777
CSF-35	166.6923	44.897	-.166	.763
CSF-36	165.9231	43.244	.111	.758
CSF-37	165.7692	45.692	-.272	.769
CSF-38	165.8462	42.808	.406	.750
CSF-39	165.7692	44.359	.000	.758
CSF-40	165.6923	38.564	.906	.725
CSF-41	165.7692	45.526	-.242	.769
CSF-42	165.9231	44.744	-.105	.763
CSF-43	165.9231	44.744	-.105	.763
CSF-44	165.6154	38.090	.682	.727
CSF-45	165.2308	47.192	-.322	.787

5. Results And Discussion

Looking at the results of data processing from Table 2 above, it can be seen that several factors do not meet the reliability and validity threshold values where the required reliability value is greater than 0.70 and the validity for df = N-2 is "r" table = 0.2483 .

From the factor analysis from the table it was found that 23 factors had a value of r <0.283 and there were 22 factors that had a value of r> 0.283. This means that there are only 22 factors that are closely related to the implementation of IBS in West Sumatra.

From these results, the factors that determine of the IBS implementation in West Sumatra are:

- Cost of Management, Training, Process & Technology (CSF-5)
- Cost of Factory (CSF-6)
- Cost of Transportation (CSF-7)
- Price stability of building materials (CSF-10)
- Operational costs (CSF-11)
- Machinery and Equipment (CSF-12)
- Material Selection (CSF-13)
- Standardisation system (CSF-15)
- Information Technology (CSF-16)
- Logistic & Transportation (CSF-17)
- Management of Supply Chain & Logistic (CSF-18)
- Good working collaboration between/within organization (CSF-20)
- Communication Channel (CSF-22)
- Guideline (CSF-24)
- Business and Marketing (CSF-25)
- Risk Management (CSF-26)
- Top-Down Commitment (CSF-27)
- Production Capacity (CSF-31)
- Health & Safety (CSF-32)
- Quality Expectation (CSF-38)
- Comprehensiveness of IBS principles in the design (CSF-40)
- Quality Assurance & Quality Control (CSF-44)
- Regulation (CSF-45)

6. Conclusion

A survey that had been carried out to determine the critical success factors of IBS implementation in West Sumatra revealed that there are twenty-two (22) critical factors of IBS that determine its implementation in West Sumatra. The identification of the critical success factors will help the stakeholders to plan and implement a more systematic approach of implementation of IBS in West Sumatra. Even though, the use of IBS in Indonesian Construction Industry is still low, the early efforts of the Government to encourage the use of IBS in the construction sector is commendable. It cannot be disputed to be competitive at the international level, it is important for the Indonesian Construction Industry and especially in West Sumatera to evolve and be ready for the globalisation era where an increase in productivity, quality and safety is a must.

7. References

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