

## INDUSTRIALISED BUILDING SYSTEM: THE CRITICAL SUCCESS FACTORS

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### Abstract:

Industrialized Building System (IBS) has been identified as a potential method to improve overall construction performance in term of quality, cost effectiveness, safety and health, waste reduction and productivity. Whereas the advantages are very plausible, the idealism behind the industrialised construction is far from being practical and beneficial to the majority of contractors. This scenario leaves the contractors with noticeable difficulties in implementation while remain to be competitive and profitable. The limited take up is also associated with readiness issues and lack of previous experience in IBS. Thus, the paper reviews literatures conserving Critical Success Factors (CSFs) for contractors in implementing IBS. The paper validates the CSFs using qualitative interview with the practitioners from Manubuild Consortium. In general, the CSFs highlighted from both literatures and interview session are training and education, leadership and organisation structure, cost management, supply chain and procurement, information technology, site management, change management, optimisation, design integration, capital expenditure planning and risk assessment. The CSFs derived from this paper will be used as Benchmarking criteria in a study between IBS and traditional contractors to capture best practices and improve contractor's general readiness. The result is not aim to be conclusive but rather a call for debate and obtains more feedback from the audience.

**Keywords:** *contractor, construction, Critical Success Factors (CSFs, Industrialized Building System (IBS)*

## 1 Introduction

Industrialized Building System (IBS) has been introduced to cope with a growing demand of affordable housing, solving issues associated with foreign labours and improving image, quality and productivity of construction industry. The limited take up on IBS have triggered many research initiatives attempting to scrutinized the barriers and seek the way forward. For contractors, the call to use IBS is less attractive due to cost and risk issues, lack of professional trained in IBS, limited IT adoption and lack of guidance (Pan et al. 2008; Pan et al, 2007 and Blismas, 2007).

The transformation process from traditional practice to IBS has left the contractors with noticeable difficulties in IBS implementation while remain to be competitive and profitable. To date, there has been little discussion about the Critical Success Factors (CSFs) of contractors which transformed from traditional contractor to IBS. Therefore, the paper tends to investigate the CSFs on the perspective of contractors involve in IBS as reported from the literatures. Then, the paper validates the CSFs trough a pilot interview with representatives from the Manubuild Consortium. Manubuild Consortium is a technical group established among key construction organisations across Europe to promote the concept of Open Building Manufacturing (OBM). Manubuild's establishment is also a wake up call for radical paradigm shift from the current 'craft resource based' construction towards 'open building manufacturing' that enable high customised building using manufacturing in open market and assembling them efficiently on site (Eichert & Kazi, 2007).

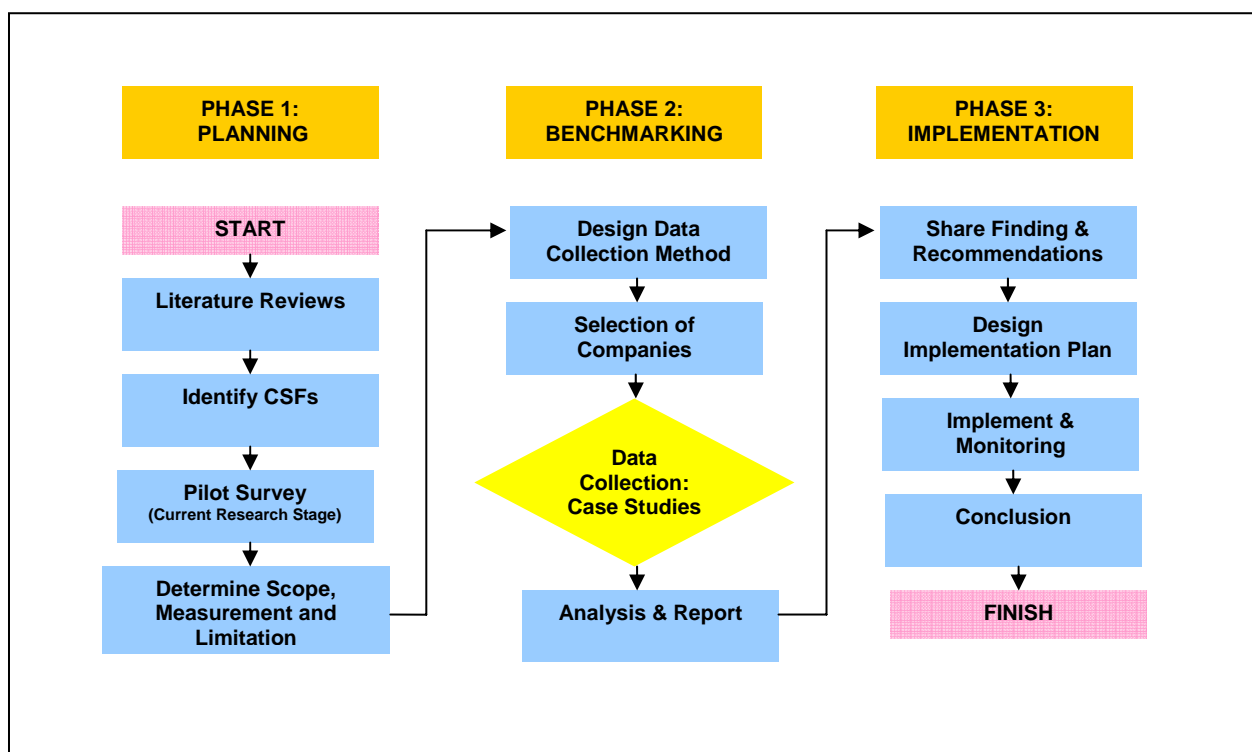
## **2 Research Methodology**

This paper is a preliminary study to a PhD research on IBS implementation among the contractors. This paper has been divided into four parts. The first part deals reviews and analyse the current state of IBS implementation including the barriers, push and pull factors and enabling factors which affected IBS implementation. The second part investigates literatures conserving the CSFs for contractors to embrace into IBS construction. The third part is report on pilot study to validate CSFs and the final part is discussion and conclusion derives from evidence commencing both the literature reviews and the pilot study. First, the paper use literature review to investigate existing evidences conserving CSFs in IBS implementation. Then, the paper applies unstructured interview and open discussion within the pre-determined context to validate the CSFs. The qualitative method permits informal setting that natural reflects the reality of what happen in the real setting. This approach also allows the researcher and the participants to probe each argument in details and obtain rich and more complex data in term of tacit knowledge, perception and human experience in which can not be measured in quantitative approach. The authors imposed a careful selection process of the participants which has need a compulsory high degree of knowledge and direct practice in the area of IBS to construct some validity and robustness of the method. The authors also appointed an experience moderator to lead the discussion and to avoid any 'leading question' which can influence the data validity. In addition, the authors have ensured that the participants are aware of the aims, objectives and methodology of the study. Though the paper make some action to establish validity and reliability in constructivism setting, caution must be applied as the findings might not be representing the whole scenario construction industry thus more data collection need to done. Therefore, the result is inconclusive but rather a call for debate and obtains more feedback from the audience. Further data collection is required to determine exactly how CSFs effect the transformation of IBS contractors.

## **3 Relation of this Paper to Overall PhD Research Study**

The CSFs which have been identified in this paper are the criteria in Benchmarking study in the later stage of the research. The main study involves a comparison analysis between the conventional contractors and IBS contractors in order to identify process and functionality gaps. Multiple case studies and analysis will be conducted between

the Manubuild Consortium’s members and Malaysia G7 contractors. The Benchmarking process is divided into three different phases (planning, benchmarking and implementation) and 12 steps of continues stages as depicted **Figure 1**. At the end of the research, the study will has to propose recommendations to improve readiness among traditional contractors and construct a framework for the transformation process. Hence, the following discussions of this paper are dedicated to map the barriers, drivers and enabling factors, identify the CSFs and validate the result trough a pilot interview.



**Figure 1: The Benchmarking Model**

## 4 Scope of the Research

The contractor is the firm that is in prime contract with the owner for the construction project, either in its entirety or for some designated portion thereof. Contractor responsible to organize, plan, schedules and control the field of work and liable for getting the project completed within the time and cost limitation. Although, IBS implementation involves various parties along the supply chain for instance the manufactures, clients and designers, the paper will only focus on the contractor’s perspective and aim to identify CSFs for contractors to embrace in IBS. The contractor or building contractor deals with project management activities and therefore they are responsible for installation of components (assembler) at site. The term contractor is used throughout this paper to represent building contractor or installer as a matter of simplification.

## 5 IBS Definition

To date there has been no one commonly-accepted or agreed definition on IBS. However, there are a few definitions by researchers who studied into this area

previously emphasizing on the concept on pre-fabrication, off-site production, manufacturing and mass production of building components (Rahman & Omar, 2006; Lessing *et al.* 2005; Thanoon *et al.*, 2003 and Warszawski, 1999). The paper selects definition of IBS as a construction technique in which components are manufactured in a controlled environment (on or off site), transported, positioned and assembled into a structure with minimal additional site works (IBS Roadmap, 2003).

## **6 The Critical Success Factors (CSFs) Definition**

The CSFs first appeared in the literature in the 1980s when there was interest in why some organizations seemed to be more successful than others and research was carried out to investigate the success components and also those things that must be done if a company is to be successful (Ingram *et al.*, 2000). While a variety of definitions of the term CSFs have been suggested, this paper will use the definition first suggested by Bullen & Rockhart (1981) who saw it as the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department, or organization. They added that, CSFs is the few key areas where things must go right for the business to flourish and for the goal to be attained. The CSF approach to identifying and measuring an organization's performance was developed and became well-established under the work of Bullen & Rockhart (1981) and Rockhart & Crescenzi (1984). In the context of this paper, the CSFs is identified and will be used as criteria for a Benchmarking study as proposed by Camp (1989) and other researchers.

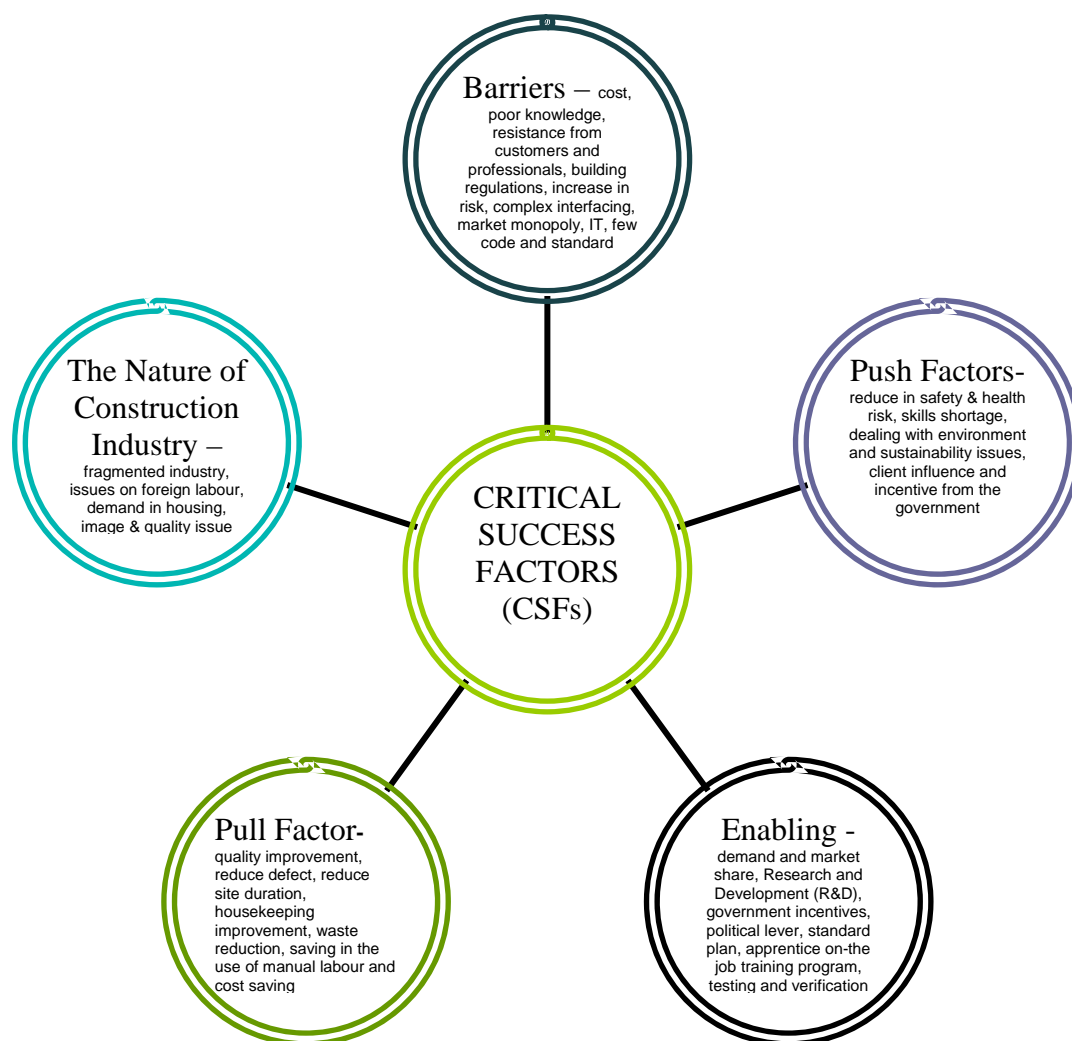
## **7 Pull and Push Factor of IBS Implementation**

Several studies investigating pull and push factors in IBS implantation (Pan *et al.*, 2007; Pan *et al.*, 2008; Blismas *et al.*, 2006; Thanoon *et al.*, 2003 and Warszawski, 1999). The pull factors that encouraged the use of IBS are quality improvement, reduce defect, reduce site duration, housekeeping improvement, waste reduction, saving in the use of manual labour, incentive from government and cost saving. On the other hand, the push factors that encourage the adoption are reduce in safety & health risk, addressing skills shortage, dealing with environment and sustainability issues, client influence and government policy.

## **8 Barriers and Enabling Factors**

Despite the plausible advantages, IBS implementation had to face shortcomings as highlighted by recent literatures and reports (Hamid *et al.* 2008; Pan *et al.*, 2008; Hussein, 2007; IBS Review, 2007; Pan *et al.*, 2007; Blismas *et al.*, 2006 and CIMP, 2007). The barriers for the adoption are cost issues, poor knowledge, resistance from customers and professionals, misunderstand of building regulations, increase in risk, complex interfacing between systems, market monopoly, IT integration, few code and standard, lack of integration in design stage, manufacturing capability, legal and cultural issues. Nevertheless, several enabling factors has been identified to improve the adoption mainly come from government initiatives. The enabling factors are the demand and market share (Goodier & Gibb, 2006), Research and Development (R&D) (Hamid *et al.*, 2008), government promotion and incentives (Pan *et al.*, 2007 and CIMP, 2007), political lever (Pan *et al.*, 2008) and standard plan, apprentice on-the job training program, testing and verification program and vendor developing

program (Hussein, 2007). **Figure 2** depicted an overview of IBS implementation in the perspective of contractors.



**Figure 2: An overview of IBS implementation of the perspective of contractors**

## 9 The Critical Success Factor (CSFs)

In most of construction contract both using IBS or traditional, the contractor is given an opportunity to set the price which is in tender or bidding phase. From that point, the profits are determined from the contractor's abilities through the project management team to save money from project sequences. As such, the only way a profit can be generated is through better planning and the skill to make good and prudent decision. Putting this argument into perspective, the transformation from conventional to IBS required tremendous focus to several critical areas which are important to achieve a transformation goal and at the same time gain benefit and profit from it. While variety of definitions of the term CSFs have been suggested, this paper will use the definition first suggested by Bullen & Rockhart (1981) who defined it as the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department, or organization and as the few key areas where things must go right for the business to flourish and for the goal

to be attained. The CSFs for contractors to embrace in IBS construction are highlighted as follows:

a) Training and Education

Historically, the construction industry had a poor record at investing into training and education (Ball, 1996). The large proportion of construction industry workforce are general labourers with narrow skill based and limited training. Although IBS is used to address the skill shortage in construction industry, some evidence suggests that a skilled workforce in specific skill areas like integration, coordination and assembly are become more important to IBS due to a different undertaken roles and project methods. Therefore, a broader and comprehensive training program must be taken on board to cater vast demand in these specialised skills (Clark, 2002; Palmer *et al*, 2003 and Goodier & Gibb, 2004). (Pan *et al*, 2008) and (Housing Forum, 2001) claim that IBS required a high level of technique and precision compared to traditional method. Evidently, the high level of specialities is derived from high level of training and professional education. By taking the above mention points and arguments, an investment in training to master IBS skills is inevitable and critical to contractors to succeed in IBS. According to Goodier & Gibb (2006), developed training program should have focus in adopting the role as system integrator at site with a full amount of responsibility in coordination and integration activities. Thus, the training equipped the workers with a clear understanding on issues related to implementation, monitoring, handling and installation of building components.

b) Leadership and Organisation Structure

A strong leadership in both institutional and management level are important in order to convince the decision makers, customers, clients and own organisational hierarchy on the lead to use innovative technology such as IBS. In strategic point of view, the leadership with high level of technical competence will ensure prudent risk taking, targeting specific target market (Bleyse & Manley, 2004) and therefore ensure the contractor firm will sustain in a competitive market of construction industry. Good leadership attribute is also important to deal with cultural issues, internal resistance towards IBS and introducing collaborative work at site and design office. Previous studies have reported that organizational rigidity is a barrier to innovation adoption in construction organisation (Nam & Tatum, 1997). An organisation structure which is more open and supportive to innovation will has more tendency to be successful in adopting new construction method and more likely to be an organisation that are favourable and supportive to IBS implementation

c) Information Technology

IT has proved to be an important key enabler in product design and much likely to be implemented in the construction industry. In manufacturing, a large scale and complex engineering projects as the development of the 'Airbus A380' aircraft are only feasible by using simultaneous and concurrent engineering interwoven with suitable 3D design toolkits (Jaeger, 2007). Similarity to an advance and more complex construction technology for instance the modular houses and mass-customisation can only be developed and produced using an extensive and interwoven IT tools. Eichert & Kazi (2007) and Hervas & Ruiz (2007) point out that IT improve tendering, planning, monitoring, distribution, logistic and cost comparison process by

establishing collaborative design integration, accurate data and effective dealing with project documents. Verweij & Voorbij (2007) and Oostra & Jonson (2007) identifies the role of IT tools which are to establish communication between project team and suppliers and as a medium for quality control of overall project deliveries. The communication channel and integration enable effective 'feedback-respond' activities between design and production where errors are discovered early and problems in the manufacturing and assembly phases can be avoided (Lessing *et al.* 2005). InPro system is one of the IT tool developed to improve design integration. InPro system is an advanced system of integrated design, analysis processes and decision-support developed based on existing IT tool. The tool will radically improve collaboration and integration between design, manufacturing and assembly process (Jaeger, 2007). One of major the drawback to IT implementation is higher initial cost. Moreover, the development and implementation of the system required highly skilled personnel which eventually discouraged some contractors due to the cost issues (Abderrahim *et al.* 2008)

#### d) Cost Management

Evidently, cost impact is the major barrier to IBS implementation (Goodier & Gibb, 2004; Vanables *et al.*, 2004 and Pan *et al.*, 2007). In general, contractors are likely to maintain tight control over the budget and schedule to guarantee profit margin. Therefore, the use of IBS demands careful and detailed cost planning and management at all stages (Sanderson, 2003). Good cost comparison analysis tools are critical to support decision making in choosing IBS over the conventional method. The contractors need a framework for comparing costing solution in more holistic manners (Blismas *et al.*, 2003). Pan *et al.* (2007) also draw attention to balance and transparent comparative costing framework for IBS project. Tool such as IMPREST (Interactive Model for Measuring Preassembly and Standardisation Benefit in Construction) toolkit describing details the measurement of risks and benefits of using prefabrication (Blismas *et al.*, 2003). Better cost data lead the contractor in pursuit of systematic costing and estimating tools for tendering phase.

#### e) Supply Chain & Procurement

Historically, the industry relationship between the main contractors and its suppliers is comparable to 'master to servant' relationship where there are lacks of togetherness and the information protectionism is widespread over the industry (Faizul, 2006). To worsen this situation, current state of supply chain in the construction industry are fragmented and underpinned by poor communication, adversely relationship and lack of trust, commitment (Hong-Minh *et al.*, 2001) and relationship between parties has been driven by the cost agenda (Wood & Ellis, 2005). The suggestion to improve procurement system and supply chain to enhance IBS adoption was proposed by Hong-Minh *et al.* (2001), Vanables *et al.* (2004) and Goodier & Gibb (2004). One of the plausible recommendations is partnering and strategic alliance approaches to project delivery in creating a shared project vision and developing complementary objectives between project participants. In his analysis on Supply Chain Management (SCM) of IBS, Faizul (2006) identifies good supply chain characteristics consist planning and management of all activities including procurement, conversion, logistic and coordination between contractor, suppliers, intermediaries and third party solution providers within and across the company structure. Partnering with suppliers and component's manufactures from the early stages of project sequence is significant to

ensure efficient and timely delivery of supply and specialised work with high quality of products. Nevertheless, partnering has not escaped criticism from observers. Although good partnering with suppliers and subcontractors is important, the competitive tendering system mean, the contractors must see price as overriding feature and frequently it mean inability to offer repeat business (Gray & Flanagan, 1989). It make contractors tend to be independent and choosing the lower tender bid to archive competitiveness.

#### f) Site Management & Process

In contras to the traditional method, the design, manufacture, assembly and other related processes in IBS project requires more coherent structure of process planning and control in order to reduce defects and errors (Gibb, 2001) (Warszawski, 1999). In general, the contractor was responsible to organize, plan, schedules and control the field of work and become the system integrator of whole construction process at site. Therefore, contractors equipped with systematic planning to manage complexity in transportation, logistic and interface between systems (Pan et al. 2008; Hamid *et al.* 2008 and Blissmas, 2007). One of the important aspects in planning and monitoring internal process is standardisation. Standardization as observed by Voorbij (2007) reduced project costs by process simplification, increase efficiency, simplifies communication, reduced time to align business processes and systems and improved utilisation of human resources. However, some of notable drawback to standardisation is argument that it more concern about the process or way in which the organisation goes about their work but not the end result. It contributes to a lack of focus on result orientation process and it will not encourage innovation adoption (Ranns & Ranns, 2005).

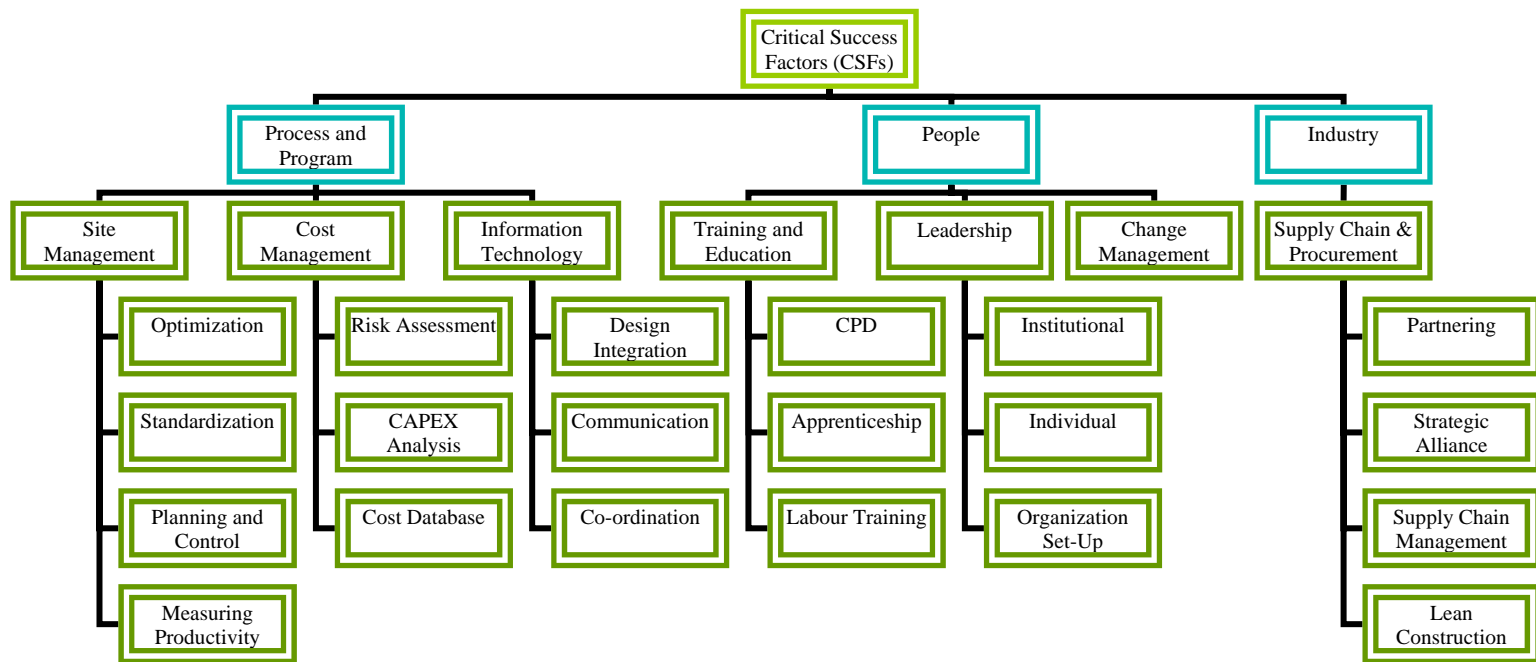
## 10 Pilot Interview to Validate the CSFs

This paper aims to validate and cross-reference the CSFs with the practitioner's perspectives and point of view. Thus, the pilot interview was conducted with representatives from the Manubuild Consortium using unstructured interview approach and open ended discussion to the context related to IBS. After a lengthy deliberation, the paper suggests the CSFs from the practitioner's point of view are:

1. Risk assessment and risk mitigation to deal with 'trail and error' stages normally at the early phase of the transformation process
2. Strategic alliances and partnering in supply chain procurement including strong connection and support from mother company in some cases
3. Design integration to deal with changes in design and improve construction buildability
4. Change Management and 'occupational physiologist' approach to deal with cultural issues and reluctant professional
5. Measuring productivity in both off-site and on-site project sequences
6. Institutional and management leadership to convince clients to use IBS
7. Prudent cost management and financial with detail calculation on cost and investment projection
8. Optimization on design, process and project sequences by having a detail program and understand the complex process
9. The need to have specialised skills in certain areas
10. Identify market prospect and capital expenditure (CAPEX) requirement

11. Long term planning and realistic time frame
12. New procedure, business approach, investment planning

A comparison between data conserving CSFs in literatures and results from pilot interview reveals the significant relation. Thus, the pilot interview validates findings which highlight the importance of training and education, site management, IT, supply chain and cost management. For the purpose of this paper, the CSFs identified in both the literatures and pilot interview were classified into three categories which are process and program, people and industry. An overview of CSFs for contractor to embrace in IBS is depicted in **Figure 3**.



**Figure 3: The Critical Success Factors (CSFs) of Contractor to Embrace in IBS**

## 11 Discussion and Conclusion

Industrialised Building System (IBS) has been identified as a potential method to improve overall construction performance in term of quality, cost effectiveness, safety and health, productivity and waste reduction. Nevertheless, the large numbers of building contractors are reluctant to use IBS due to cost factor, lack of previous experience, increase in project risk and lack of professional trained in IBS. The paper investigates the CSFs which are limited numbers of areas that ensure successful competitive performance and IBS adoption. First, the paper depicted an overview of IBS implementation including the barriers, pull and push factors and enabling factors. Second, the paper presents the literature review conserving the CSFs of IBS implementation in perspective of contractors. The CSFs highlighted in this paper are training and education, leadership and organisation structure, cost management, supply chain and procurement, Information Technology, site management and cost management. Third, the pilot interview was conducted to validate CSFs derived from the literature reviews. In general, pilot study report reveals a significant relation between factors highlighted from the literature and the data obtained from the interview thus the paper concludes that the CSFs were accepted and validated at some

point. However, with only one interview conducted in the pilot study, caution must be applied as the findings might not be representing the whole scenario construction industry. Nevertheless, the authors have taken several actions to improve validity and reliability according to methodology in constructive epistemology. The pilot interview also reveals additional factors to be considered as CSFs which are risk management, business planning, optimisation, measuring productivity and Capital Expenditure (CAPEX) analysis. The respondents are even suggesting the appointment of 'occupational psychologist' to deal with cultural issues involving professionals. Finally, the CSFs were classified into three categories which are process and program, people and industry. Apart from identifying and validating the CSFs, the paper also concludes two things; first, the adoption of IBS required focus in both hard and soft issues. Second, contractors play different roles in IBS which is more towards assembling or system integrating role which requires careful attention to critical area both in process, people and its relation to the industry. The CSFs will assist in our understanding of the role of contractors in IBS project and therefore improve overall readiness among the traditional contractors. The CSFs derived from this paper will be used as criteria to benchmark a process gaps between IBS and traditional contractors, capture the success elements and improve general readiness among the traditional contractors.

## **12 Acknowledgment**

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