Factors and criteria influencing the success of sustainable buildings in Hong Kong

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Published in:
Proceedings of the Institution of Civil Engineers: Engineering Sustainability

DOI:
10.1680/jensu.18.00032

The success of sustainable buildings can help ease the adverse impact of climate change. For this reason, sustainable buildings are becoming a worldwide trend. While defining both critical success factors and success criteria is a prerequisite for achieving sustainable building success, very few studies have been conducted to identify the factors and criteria influencing the success of sustainable buildings. In this study, the structured questionnaire survey method was applied to identify the critical success factors for procuring sustainable building projects and success criteria for measuring the success of sustainable building projects in Hong Kong, China. The results show that top success criteria for sustainable buildings can be grouped into 'success of traditional project performance'; 'success of sustainability performance from an environmental, social and economic perspective'; and 'participants' satisfaction'. Meanwhile, a factor analysis reveals five principal component factor groups as 'top management and team competence'; 'project performance, continuous improvement and stakeholder benefits effectiveness'; 'life-cycle process management effectiveness'; 'integrated design and resource management effectiveness'; and 'budget and risk control effectiveness'. The findings of this paper should help improve understanding of the criteria for measuring sustainable building success and the critical factors leading to the success of these criteria.

1. Introduction

The demand for high-performance sustainable buildings has been continually increasing during the past decade (Horman et al., 2006). Sustainable buildings can address many global issues on climate change, human health, social impact and the development of renewable energy resources by the most efficient and least disrupting use of energy, land, water and other resources (Roosa, 2010). The performance of a sustainable building during both the construction and operational stages is critical if clients want to achieve the aforementioned goals. However, sustainable construction projects are often over budget due to unfamiliarity with sustainability during design and construction (Dahl, 2008), encountering more schedule delays than in traditional projects (Hwang and Leong, 2013), as well as increased investment costs and a general lack of life-cycle cost knowledge (Tam et al., 2012). Moreover, the reanalysis by Newsham et al. (2009) of energyconsumption data for 100 Leadership in Energy and Environmental Design (Leed)-certified commercial buildings supplied by the New Buildings Institute and US Green Building Council found that 28–35% of the Leed buildings that they analysed use more energy than their conventional counterparts. Hence, it is important that sustainable buildings can meet the requirements of both clients and end users and achieve project success.

Defining both critical success factors (CSFs) and success criteria (SCs) is a necessity for studying sustainable building success. In this study, a structured questionnaire survey was used to identify the CSFs for procuring the success of sustainable building projects and the criteria for measuring this success in Hong Kong, China.

2. Project success

Project success is an important and frequently discussed project management component (Prabhakar, 2008). Some researchers suggest that project success should be oriented towards long-term goals (Frödell et al., 2008; Munns and Bjeirmi, 1996). Project success should not only consider the benefits to its participants, but should also prepare for the project's future in terms of innovation and continuous performance improvement. The determinants of project success should expand from the project delivery stage to the whole project's life cycle.

The emergence of project success factors and SCs as prerequisites to the study of project success has been discussed in the literature (Ika, 2009). CSFs were first defined by the Sloan School of Management as 'those few key areas of activity in which favourable results are absolutely necessary for a particular manager to reach his or her own goals' or, in other words, 'those limited number of areas where things must go right' (Rockart, 1982: p. 7). SCs are the measures used to judge whether a project is a success or failure, with CSFs as the elements that increase the likelihood of project success (Cooke-Davies, 2002). Typically, research into construction project success examines either CSFs or SCs (Ika, 2009).

Several researchers have carried out studies of the CSFs for sustainable buildings, but there is a paucity of research identifying the SCs of sustainable buildings. Han et al. (2011) developed a theoretical framework for project management success factors for sustainable buildings in Malaysia. They revealed that effective monitoring and control, realistic scheduling, problem-solving abilities, understanding project objectives and the proper allocation of resources are the top five CSFs for ensuring the success of sustainable building construction in that country. Bakar et al. (2010) also combined project management success factors and criteria measuring sustainable housing into a conceptual CSF framework for sustainable housing. However, without SCs as an effective measurement tool, CSFs cannot ensure project success. Both CSFs and SCs need to be considered together as a whole (Han et al., 2011; Ika, 2009). To improve the success level of sustainable buildings, there is a need to identify both the SCs and CSFs that contribute to sustainable buildings.

3. Research design

The quantitative approach is commonly used for soliciting data to examine the relationships between the facts and how these facts and relationships accord with the theories and findings of previous studies (Fellows and Liu, 2008), and surveys are a means of collecting quantitative data to understand people's attitudes, opinions and behaviours (Fellows and Liu, 2008). In this study, the structured questionnaire survey method was applied to identify the CSFs and SCs for procuring sustainable buildings. Twenty-nine potential CSFs and 22 SCs identified from an extensive literature review are listed in Tables 1 and 2. From a life-cycle perspective, a sustainable building is first planned, designed, constructed and then operated, maintained or refurbished, finally demolished and recycled. The SCs for a sustainable building should, therefore, be considered not only at the delivery stage, which includes the planning, design and construction phases, but also at the post-delivery stage, which includes operation, maintenance or refurbishment, demolition and recycling. In the questionnaire, respondents were asked to indicate their level of agreement with the importance of CSFs using a five-point Likert scale and indicate their range of agreement with the importance of SCs at the delivery stage and post-delivery stage. The mean score ranking method was adopted to select the top CSFs and SCs. To determine whether a factor is important, a mean value of 3·45 was used as the cut-off point. Any CSFs or SCs reaching a mean score value of 3·45 or above are considered critical. Factor analysis was then applied to identify the success factor groupings to represent the interrelationships among these factors (Norusis, 1992). The questionnaire content was focused on the problem and was unambiguous and easy for respondents to answer after pilot testing.

The targeted respondents are those who are familiarised with the Building Environmental Assessment Method in Hong Kong (i.e. Beam-Plus – a scheme comparable to the Building Research Establishment Environmental Assessment Method in the UK) with professional credentials and experience in sustainable building projects. As shown on the website of the Hong Kong Green Building Council, there were 2453 accredited Beam professionals and 589 registered Beam projects as of 2015. To increase the representativeness of the samples, 10% of the Beam professionals were first randomly selected. Among the 589 registered Beam projects, 205 were classified as final and provisional. Since each Beam project had been assigned a responsible Beam professional, 205 Beam professionals from the final and provisional Beam projects were also selected as survey samples. After excluding the seven identical Beam professionals, a total sample of 443 Beam professionals were identified.

The questionnaire was sent to the sampled Beam professionals by mail with self-addressed stamped envelopes. Sixty-seven letters were returned due to an incorrect address or departure of the addressee. Of the remaining 376 delivered letters, 106 respondents returned the completed questionnaires, representing a response rate of 28·2%. Three questionnaires with missing data were treated as invalid responses.

4. Survey results

4.1 Ranking of SCs

SPSS 16.0 software was employed to analyse the data obtained from the questionnaire. First, a Cronbach's alpha test was carried out to assess the reliability of the Likert scale in the survey for the CSFs and SCs. The results show that all factors and criteria achieved a Cronbach's alpha value of 0·97, indicating a high level of internal consistency for the five-point scale with this specific sample and the appropriateness of further analysis with no need to delete any factors or criteria. The mean scores were analysed to rank the importance of the 22 SCs at the delivery and postdelivery stages. At the delivery stage, the mean scores range from 4·24 to 3·08, while the mean scores range from 4·26 to 3·4 at the post-delivery stage. The top ten SCs during the two stages are listed in Tables 3 and 4, and they all had mean scores of above 3·45 based on the five-point Likert scale. They are, therefore, regarded as important from the respondents' point of view.

As shown in Table 3, during the delivery stage, SC-1 'quality/ made as planned', SC-2 'cost/within budget' and SC-3 'time/on time' are ranked as the first, second and fourth SCs, respectively, showing that the traditional 'iron triangle' continues to represent the most important criteria for measuring short-term project success. However, many other studies have suggested that the iron triangle is not exclusive, and other SCs should be considered (e.g. Al-Tmeemy et al., 2011; Atkinson, 1999; Baccarini, 1999). For sustainable buildings, SC-4 'meeting design and planning sustainable goals' ranks third, which echoes Lipovetsky et al.'s (1996) conclusion that meeting design goals and benefits to the customer are the most important success dimensions for all project stakeholders. Shenhar et al. (1997) also propose meeting design goals as one of the three clusters of success. Moreover, for sustainable buildings, it is important for sustainable goals to be achieved during the building project life cycle and not be compromised by such other project SCs such as time and cost.

During the delivery stage, the SC relating to sustainability, namely, SC-19 'environmental impact/performance', SC-20 'energy saving/low carbon' (in this paper, 'low carbon' is taken to mean low carbon dioxide), SC-18 'social impact' and SC-22 'value for money' rank fifth, sixth, eighth and tenth, respectively. In contrast, during the post-delivery stage, SC-19 'environmental impact/performance' ranks third, SC-

20 ‘energy saving/low carbon’ ranks first, SC-18 ‘social impact’ ranks fifth, SC-22 ‘value for money’ ranks fourth and SC-17 ‘low operation/maintenance costs’ ranks second. The results indicate that the success of sustainable building procurement should be measured across the whole life cycle, with emphasis placed on traditional quality, time and cost criteria during the delivery stage, but on the economic, environmental and social triple bottom line during the post-delivery stage.

SC-15 ‘benefit to end user’ and SC-16 ‘benefit to the client/ sponsor’ ranked eighth and tenth, respectively, during the post-delivery stage. Benefits to the end user and client/sponsor as longterm criteria should be measured after project closure and include both tangible and intangible benefits (Bryde and Robinson, 2005). For sustainable building projects, the benefits may include providing a healthy indoor air quality, user-friendliness, conserving the environment, safety, delivering economic value and providing social and cultural value. Furthermore, SC-6 ‘client/sponsor/stakeholder satisfaction’ ranks seventh during the delivery stage and ninth during the post-delivery stage, while SC-7 ‘customer satisfaction/acceptance’ ranks seventh during the post-delivery stage. Jha and Iyer (2006) suggest that, beyond objective iron triangle criteria, such subjective criteria as the overall satisfaction of the customer and other key stakeholders should also be considered. Chan et al. (2002) also include end user, client, design team and construction team satisfaction as subjective measures in their framework for measuring success. Therefore, project participant satisfaction qualifies as a success measure for sustainable building procurement too.

In summary, the top SCs for sustainable building can be grouped into the following categories

■ success of traditional project performance
■ success of sustainability performance from environmental, social and economic perspectives ■ participant satisfaction.

4.2 Factor analysis of CSFs

As all the CSFs received mean scores of above 3·45 and are considered important, factor analysis was carried out to identify the success factor groupings. The sample was first evaluated by the Kaiser–Meyer–Olkin sampling adequacy test and Bartlett’s test of sphericity for its suitability for factor analysis. The results are shown in Table 5. The Kaiser–Meyer–Olkin measure of sampling adequacy is 0·865; a value of 0·80–0·89 is considered appropriate. With an approximate Bartlett’s test of sphericity c^2 of 1899·246 and associated 0·000 significance level, these results support the validity and suitability of the sample responses for factor analysis.

Five components, accounting for 64·3% of the variance, were extracted by principal component analysis and varimax with Kaiser normalisation rotation, which converged in 19 iterations; components 1–5 contribute 17·704, 16·068, 13·888, 11·556 and 5·084% of the variance, respectively. The five principal components can be interpreted as shown in Table 6.

5. Discussion

5.1 Component 1: top management and team competence

In contrast to a traditional building, a sustainable building requires more design iteration; more co-operation between stakeholders; additional project participants, such as sustainability consultants; application of new and unfamiliar materials and technologies; additional sustainable site management; and advanced simulation and analyses for energy saving (Pulaski et al., 2006). All these require top management commitment and support to ensure that sufficient resources are provided, authority and power are delegated and the organisational mission and project objectives are linked to achieve project success (Bryde, 2008; Cserháti and Szabó, 2014; Davis, 2014; Jugdev and Müller, 2005). First, a clear understanding of sustainable objectives is a primary success factor for all project stakeholders to enhance the success level of a sustainable building project during the planning, design, construction, operation and demolition stages. In addition, all stakeholders’ objectives should be considered, as stakeholders often interpret project success in different ways and have their own objectives (Eriksson and Westerberg, 2011). Moreover, delivering a sustainable building successfully requires the adoption of promising sustainable strategies and marketing planning to meet the needs and goals of the delivery organisation, senior management and other stakeholders (Turner and Müller, 2005).

In summary, it is important to have senior management support for resource allocation, strategic planning, marketing planning and competent team selection, while sustainable project objectives should be agreed with the main stakeholders before project start and repeatedly fine-tuned according to the real performance level throughout the project life cycle.

5.2 Component 2: project performance, continuous improvement and stakeholder benefit effectiveness

Some studies highlight the need for project success factors to include the benefits for project stakeholder organisations and preparation for the future in terms of innovations and continuous competence improvement (Cserháti and Szabó, 2014; Jugdev and Müller, 2005; Papke-Shields et al., 2010). This focus on stakeholder benefit management can result in authentic project success through trust, teamwork and shared mutual goals (Bryde and Robinson, 2005). In addition, monitoring/evaluating performance and feedback during the project life cycle, communicated and coordinated with the objectives across the stakeholder groups during the project life cycle, is necessary to achieve sustainable building project objectives. Moreover, continuous improvement of project performance is critical to the success of sustainable building delivery (Lapinski et al., 2006). Therefore, innovation, training and education, new knowledge and continuing learning within organisations is required, which also requires communication, coordination and network building (Häkkinen and Belloni, 2011). Special contract conditions should include clauses related to the project sustainability goals, penalties, incentives, innovations, risks and liability allocation (Constructing Excellence, 2008).

5.3 Component 3: life-cycle process management effectiveness

A sustainable building should be planned and controlled from a life-cycle perspective that covers the project processes of planning, design, construction, operation and maintenance, renovation and end of life (Pulaski et al., 2006; Trinius, 2010). Life-cycle costing should be applied to quantify and analyse both the current cost of delivering projects and the future cost of operations, maintenance, refurbishment and disposal (Parrish and Chester, 2014; Trinius, 2010). It is also important for sustainable building project success that the project team engage in effective communication and co-operation from a life-cycle perspective. Meanwhile, green timing, the early adoption of sustainability considerations and early involvement of key project participants are often addressed as critical factors for the success of sustainable building projects (Häkkinen and Belloni, 2011; Korkmaz et al., 2010). The timing accounts for possible sustainable solutions during the project′s early stages and can have a significant effect on meeting sustainability goals that fit the client′s budget and minimise the risk of defects and the need for reworking (Häkkinen and Belloni, 2011; Robichaud and Anantatmula, 2011).

5.4 Component 4: integrated design and resource management effectiveness

The successful procurement of a sustainable building requires intense collaboration from different disciplines, integrated design and careful material and system selection, particularly in the early project stages (Häkkinen and Belloni, 2011). While traditional projects seldom involve other project participants during the design stage, sustainable building projects need an integrated design process, which may include the client, the developer, designers, contractors, suppliers, facility managers and end users throughout the building′s life cycle (Häkkinen and Belloni, 2011; Westerveld, 2003). The construction organisation can provide valuable advice in terms of estimating services and evaluating the feasibility of sustainable technical tasks. The suppliers can provide suitable sustainable materials and equipment price information, as well as embodied energy information. The facility management organisation is able to provide information and feedback for designers and contractors in the operational stage to avoid long-term risks (Robichaud and Anantatmula, 2011). With interdisciplinary collaboration, sustainable alternatives can be evaluated, and adjustments and communication in the integrated design stage can ensure that sustainable building goals are clarified and agreed in the early project phase, which can help realise the mutual success of different stakeholders throughout the project life cycle.

5.5 Component 5: budget and risk control effectiveness

Budget control is one of the most important traditional iron triangle success factors for construction projects (Cserháti and Szabó, 2014; Frödell et al., 2008; Garbharran et al., 2013). Developing budget estimates that include sustainable features and potential risks and helping to keep within budget during the life cycle are also critical for sustainable building success (Yates, 2014). Budget control for sustainable building needs to be carried out from the planning stage to design, construction, operation and demolition.

Risk management for sustainable building projects involves considering such additional aspects as unfamiliar or unavailable materials and innovative building practices (Robichaud and Anantatmula, 2011). In addition, if a sustainable building certificate is desired, additional documentation and reporting work may extend the project schedule. Facility managers and end users may lack experience and comprehensive information for new sustainable facilities to realise the designer′s objectives. Therefore, long-term consideration of risks and precautions is necessary to avoid misunderstandings and failure to achieve design goals.

6. Conclusion

The rapidly increasing demand for sustainable buildings over the past decade has prompted the question of how sustainable building projects can be judged as successes and what CSFs influence project performance. A questionnaire was designed to identify the CSFs and SCs for procuring sustainable building. A mean score ranking method was applied to identify the top SCs. A mean value of 3·45 was used as the cut-off point to delineate whether a factor or criterion is important, and the results show that the top ten SCs during the delivery stage include 'quality/ made as planned', 'cost/within budget', 'meeting design and planning sustainable goals', 'time/on time', 'environmentalimpact/performance', 'energy saving/low carbon', 'client/ sponsors/stakeholders' satisfaction', 'social impact' and 'safety and value for money'. The top SCs during the post-delivery stage include 'energy saving/low carbon', 'low operation/maintenance costs', 'environmental-impact/performance', 'value for money', 'social impact', 'life-cycle cost', 'customer satisfaction/ acceptance', 'benefit to end user', 'client/sponsor/stakeholder satisfaction' and 'benefit to the client/sponsor'. Top SCs during both the delivery stage and post-delivery stage can be grouped into 'success of traditional project performance'; 'success of sustainable performance from environmental, social and economic perspectives'; and 'participants' satisfaction'. The main differences between SCs for sustainable and traditional building are sustainability-related criteria from the environmental, social and economic perspectives, such as energy savings, environmental impact/performance, value for money and social impact. In addition, sustainable building SCs should distinguish between the delivery and post-delivery stages. In the delivery stage, the traditional iron triangle criteria remain the top SCs for measuring project success, while in the post-delivery stage, sustainability performance criteria are the most important.

Five principal component factor groups of CSFs are identified through factor analysis, comprising (a) top management and team competence; (b) project performance, continuous improvement and stakeholder benefit effectiveness; (c) life-cycle process management effectiveness; (d) integrated design and resource management effectiveness; and (e) budget and risk control effectiveness. The results show that successfully procuring sustainable buildings not only requires new technologies, sustainable materials, energy savings, waste management and sustainable process management, but also involves top management commitment and support, changing participants' perceptions and behaviours, alignment of project objectives, integration of project teams, transferring and sharing knowledge and more training and innovation opportunities from a life-cycle perspective.

The findings of this study should help confirm the most relevant SCs for measuring sustainable building success and delineate the CSFs that could help achieve success from the SC perspectives. The results should facilitate decision makers drawing up a set of policies related to procurement in order to maximise the success of a sustainable building.

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