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Whole Life Performance Assessment : Critical Success Factors

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Abstract: Whole life costing (WLC) has become best practice in construction procurement and it is likely to be a major issue in predicting whole life costs of a construction project accurately. However, different expectations from different organisations throughout a project's life and the lack of data, monitoring targets, and long-term interest for many key players are obstacles to be overcome if WLC is to be implemented. A questionnaire survey was undertaken to investigate a set of ten common factors and 188 individual factors. These were grouped into eight critical categories (project scope, time, cost, quality, contract/administration, human resource, risk, and health & safety) by project phase, as perceived by the clients, contractors and sub-contractors in order to identify critical success factors for whole life performance assessment. Using a relative importance index, the top ten critical factors for each category, from the perspective of project participants, were analysed and ranked. Their agreement on those categories and factors were analysed using Spearman's rank correlation. All participants identify “Type of Project” as the most common critical factor in the eight categories for WLPA. Using the relative index ranking technique and weighted average methods, it was found that the most critical individual factors in each category were: "Clarity of Contract" (Scope); "Fixed Construction Period" (Time); "Precise Project Budget Estimate" (Cost); "Material Quality" (Quality); "Mutual/trusting Relationships" (Contract/Administration); "Leadership/Team Management" (Human Resource), and; "Management of Work Safety on Site" (Health and Safety). There was relatively a high agreement on these categories amongst all participants. Obviously, with 80 critical factors of WLPA, there is a stronger positive relationship between client and contactor rather than contractor and sub-contractor, client and sub-contractor. Putting these critical factors into a criteria matrix can facilitate an initial framework of whole life performance assessment in order to aid decision making in the public sector in South Korea for evaluation/selection process of a construction project at the bid stage.

Keywords: Critical factor analysis, Relative importance index, Whole life assessment, Whole life cost, Whole life performance

Introduction

The concept of whole life costing (WLC) is not new. WLC has been used as a tool since the 1960s (Bartlett et al. 2001) and it has recently become best practice in construction procurement (Sorrell 2003). The construction industry has been looking at adopting a framework that allows organisations to consider service life, whole life cost and building component performance data during procurement and throughout the building's life (Al-Hajj 1999; Bartlett and Clift 1999; Hunter 2006)

However, its management is quite new and its accurate prediction is a major issue in the construction industry because it is the goal of the client to estimate as accurately as possible the actual final cost of a project so as not to require funds to be diverted from other projects (Creedy 2006). Any system that produces an increased service life for lower whole life cost should be welcomed (Flanagan et al. 2005). The more whole life costs of constructed assets are reduced, the better the investment performance.

The construction industry has largely acknowledged the benefits that whole life cost based decision-making can bring to the design and operation of building assets (Kirkham and Moores 2005). However, there are some reasons given for not using whole life costing including : 1) not required by the clients; 2) lack of data; 3) lack of monitoring targets; and 4) lack of long-term interest in the building for many key players (Clift and Bourke 1999; Mike Clift 1999), Furthermore, the client may have a limited foreseeable use for the building and different organisations may have different expectations of the constructed asset in the future (Bourke and Davies 1999). Therefore, it is critical to understand the expectations of different project participants throughout a project's life and consider the relevant factors which affect the implementation of whole life costing, and to find more effective collaborative project conditions. Moreover, the early consideration of factors affecting whole life performance could be an important step forward.

Objectives of the Study

The focus of this research is on the critical factors and their relative importance to Whole Life Performance Assessment (WLPA), based on the perspective of the clients, contractors and sub-contractors. The term 'principal industry participants' (PIPs) will be used in this paper to represent the clients, contractors and sub-contractors in South Korea.

A survey was undertaken to investigate how project performance, from pre-design to post-construction, is affected by a number of factors in terms of scope, time, cost, quality, contract/administration, human resource, risk, health and safety. The survey was designed to draw on the expertise and experiences of different practitioners and academics in the construction and engineering industry. The survey reported in this paper aimed to:

- ✓ Identify the critical factors and classified factor categories influencing a holistic project appraisal;

- ✓ Evaluate the relative importance of the identified factors by collecting the group perspectives of three principal industry participants (PIPs), viz. clients, contractors and sub-contractors in South Korea;

- ✓ Develop a criteria matrix of critical factors for better understanding and implementing WLPA from the PIPs' point of view.

Literature Review

Time, cost and quality are typically used as the key criteria for planning and assessing project performance in the construction industry. Many of the processes within project management are iterative because of the existence of, and necessity for, progressive elaboration in a project throughout its life cycle (Project Management Institute. 2004). For example, construction time has always been seen as one of the benchmarks for assessing the performance of a project and the efficiency of the project organisation (Ogunsemi and Jagboro 2006). In order to improve construction time performance of building projects, Chan and Kumaraswamy (1996) evaluated factors which affect the construction time performance in Hong Kong's building industry. Russell, Jaselskis *et al.* (1997) used the continuous or time-dependent variables to predict project cost and schedule outcomes from detailed design through to construction completion.

Due to the increasing complexity and dynamics of construction projects, numerous factors, including time, cost and quality, need to be considered across the whole life of a constructed asset. For example, Creedy (2006) identified construction risk factors in highway projects in order to provide the client with a better guarantee that the final cost of a delivered project would not exceed the risk adjusted project budget estimate. The adoption of an appropriate procurement method can minimize several risks associated with this process, including the selection of an unsuitable design-build team, poor project performance, and owner's expectations not being met (El Wardani et al. 2006). The rate of development and city planning regulations are important factors in determining the life of buildings (Minami 2004).

While there are various factors, such as project organisation, design, construction and quality of materials, which contribute to client satisfaction, the early stages of construction projects are critical for overall project success. These factors need a great level of applicability and value judgement not only to adapt to new project conditions, but also to satisfy the project participants by delivering projects that demonstrate value for money through the whole life of a project. The acknowledged importance of clients as the driving force has led to repeated calls for the construction industry to deliver better value-for-money projects (Kamara et al. 2002). Moreover, the interactions and interrelationships between the project participants including the client, the architect and the contractor, largely determine the overall performance of a construction project (Egan et al. 1998; Soetanto and Proverbs 2002)

A review of the construction industry was undertaken to establish the range and influence of whole life performance issues. Shortcomings were identified and it was argued that, in order to achieve improvement in whole life performance, there is a need to reform the extent of decision-making (Rowe 1999). Hence, a number of published studies have identified time and cost overrun factors related to project performance (Khosrowshahi and Alani 2003; Yu and Lo 2005) and developed forecasting models for whole life costing (Kirkham 2005).

Despite numerous researches into the relevant factors and criteria to improve a project performance, including time delay, cost overrun and risk factors, there has been limited study into categorised factors and simple criteria of whole life performance for a constructed asset. None of the approaches are generic and representative enough to be applied generally. In particular, there is no research to identify and investigate the relative importance of factors, which affect whole life costing, as perceived by the client, contractors and subcontractors in South Korea. Yet, there is an increasing need to take account of the costs, impacts, performance and operation throughout the whole of the planned service life of a constructed asset.

A holistic approach to a project's physical, economic, functional, service and design life enables the client to estimate project costs against the analysis of project functionality and performance characteristics as accurately as possible. This approach allows all relevant project costs to be considered systematically and can lead to a successful project with the right decision at the outset thus avoiding any cost overruns and achieving on-time project completion.

There needs to be a balance of competing demands in terms of: (1) project scope, (2) time, (3) cost, (4) quality, (5) contract/administration, (6) human resource, (7) risk, and (8) health and safety. The specifications, plans and alternative approaches to meet the different expectations of the various participants need to be adapted to improve project performance.

Study approach and Methods

Classification of Factors through a questionnaire survey

The hypothesised factors associated with whole life performance of a constructed asset were explored through a literature review. A set of 10 common factors for each category and 188 individual factors were identified and classified by a series of interviews with the PIPs. These factors were further categorized according to:

- ✓ Project scope (14)
- ✓ Time (23)
- ✓ Cost (38)
- ✓ Quality (18)
- ✓ Contract/administration (20)

- ✓ Human resource (21)
- ✓ Risk (34)
- ✓ Health and safety (20)

NB( ) - the number of individual factors

The factors were used as the basis of a questionnaire and represented the project performance based on WLPA from the PIPs' perspective. The 10 hypothesised common factors identified in this research were, in no particular order: (1) Type of Project; (2) Size of Project; (3) Type of Contract; (4) Project Goals and Milestones; (5) Location of Project; (6) Type of Client; (7) Project Organisation; (8) Project Management Information System; (9) Project Plan & Procedures; and (10) Relevant Law and Regulations.

Firstly, the concept of WLPA was explained to the respondents and they were asked a series of questions in the survey. This established their level of understanding of WLPA, the type of procurement methods and contracts appropriate to WLPA, and in which sector (public or private) its use would be most effective.

Secondly, the opinions of the PIPs were sought to quantify "qualitative" variables. These were recorded, using a scale of 1 to 5, where 1 is the lowest perceived factor, and 5 is the highest perceived factor:

- Extremely Significant (E.S.) 5

- Very Significant (V.S.) 4
- Moderately Significant (M.S.) 3
- Slightly Significant (S.S.) 2
- Not Significant (N.S.) 1

Based upon the data from the PIPs, the rankings of factors were generated by evaluating their relative importance across each group of respondents.

Evaluating factors using the "mean score" and the "relative importance index"

Chan and Kumaraswamy (1996) adopted the "mean score" method with 5-point scale to evaluate construction time performance in the Hong Kong building industry. Assaf et al., (1995) used this approach with 4-point scale to establish the relative importance of the causes of delays in large building projects in Saudi Arabia, from the perspective of the owners, the architects/engineers and contractors.

The mean score (MS) for each factor is computed by the following formula:

$$MS = \frac{\sum(f \times s)}{N} \qquad (1 \leq MS \leq 5) \qquad (1)$$

Where s is the score given to each factor by the respondents, ranging from 1 to 5 where "1" is "not significant" and "5" is "extremely significant"; f is the frequency of responses to each rating (1-5), for each factor; and N is total number of respondents for that factor.

In addition to the mean score, the five-point scale was transformed to relative importance indices using the relative index ranking technique (A.Shash 1993; Chan and Au 2009; Chinyio et al. 1998; Kometa et al. 1995; Tarawneh 2004), to determine the rankings of the factors and verify the evaluation by the mean score. The relative importance indices (RII) were calculated using the following formula:

$$\mathrm{RII} = \frac{\text{Total point score}}{5 \times N} \qquad (0 \leq \mathrm{RII} \leq 1) \qquad (2)$$

Where total point score is the summation of all the ratings for a given factor, and 5 is the maximum rating possible.

Evaluating the relative importance of factors from the PIPs' perspective by benchmarking "critical success factor analysis"

Critical Success Factor (CSF) analysis, as initially proposed by Rockhart (1979), is a widely used top-down methodology for examining factors affecting technological change (McPherson and Nunes 2006). CSFs are activities required to ensure business success and identify key areas of performance that are essential for the organisation to accomplish its mission (Caralli 2004).

The term "critical success factor" has been adapted for many different uses. For example, CSFs were used to develop a process model for risk management (Dobbins 2002). It was applied to the implementation of quality management in Russia (Tan

2002) and Torp, Austeng et al. (2004) identified CSFs and potential pitfalls in the project performance for large public projects in Norway.

Figure 1 presents the research approach of developing criteria for the evaluation of construction project performance based on the use of critical factors (CFs) for WLPA and CSFs as the process tools. This approach is largely based on Rockhart (1979) and Caralli (2004). However, a sub-structured process is refined and codified for collecting, deriving and analysing data as well as CFs for WLPA.

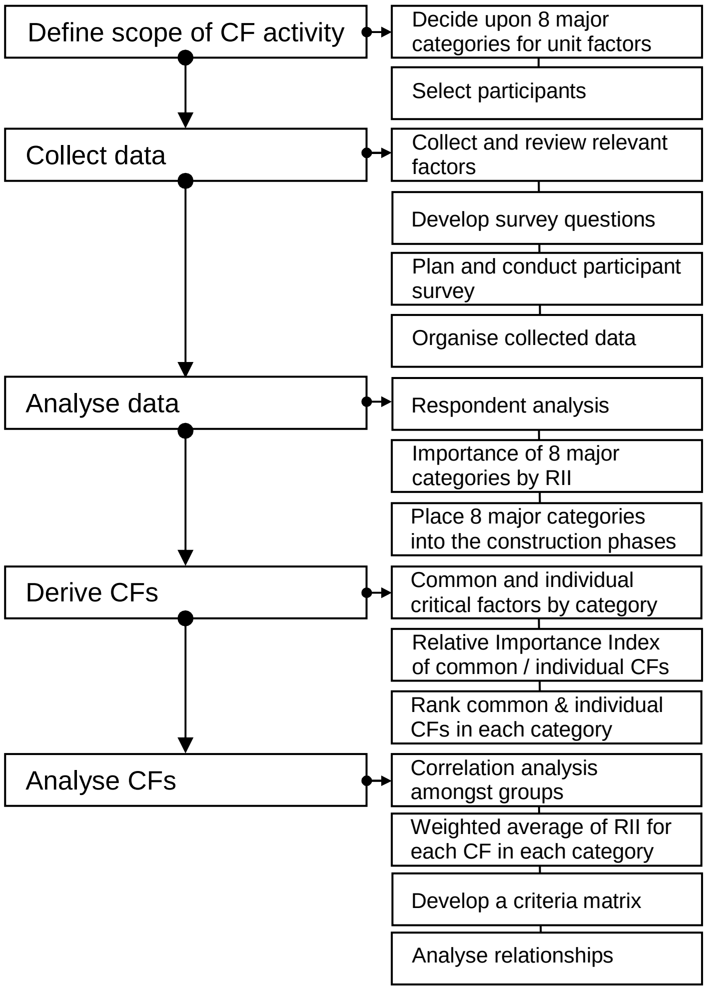

Fig. 1. Critical Factor Method Approach for WLPA

Survey and Analysis

Results for WLPA – through benchmarking of "critical success factor methods", "mean score" and "relative importance index & rank"

Step 1 – Define scope of CF activity for WLPA

In order to determine the critical factors for WLPA, 10 common factors and 188 individual factors were identified through a literature review and a series of interviews. The factors were grouped into eight major categories: project scope, time, cost, quality, contract/administration, human resource, risk and health and safety by the PIP survey respondents. The importance of common and individual factors was clarified and evaluated by the PIPs.

Step 2 – Collect Data

Questionnaire

A questionnaire survey was used to examine the relevant factors and identify their importance in evaluating construction project performance based on WLPA. The survey sought information/opinions in four areas:

1. Information on the distribution profile of respondents
2. Current attitudes of project participants towards WLPA
3. Significant and relative importance of different factors
4. Additional comments and recommendations for applying WLPA to the construction and engineering industry.

Table 1 provides a breakdown of the valid responses by respondent type and shows a response rate of 24.1%.

Table 1 Three groups of survey respondents

Step 3 – Data Analysis

Results analysis – 'mean score, relative importance index & rank'

All the respondents were PIPs from the South Korean construction industry. The client group respondents were from both the private and public sectors, with the split reflecting the ratio of public to private sector outcomes in South Korea; 26.9% to 73.1% in 2006 and 30.7% to 69.3% in 2007 (Korean National Statistical Office, 2008). Their names and addresses were obtained from five main sources: (1) central and local government (such as Ministry of Land, Transport and Maritime Affairs in South Korea); (2) educational authorities; (3) public corporation; (4) private capital inducement corporation; and (5) various organisations such as pension funds.

The contractor and subcontractor group respondents were short-listed from the top 30 Korean construction companies who represent 78% of total construction output in South Korea. The total construction output in South Korea is 91,001 billion KRW and the turnover of the top 30 companies was 70,963 billion KRW in 2006, (1 US$ = 1040.00 KRW). Names and addresses of the appropriate people were mainly obtained from project and cost management departments of those companies. All respondents had been in the industry for between 1.1 years and 31.7 years, with a mean period of 13.1 years. The average number of years' work experience of the clients, contractors and sub-contractors contacted was 10.6, 14.0, and 13.8 respectively. This level of experience meant that their responses on the important factors of whole life performance assessment (WLPA) could be considered reasonably realistic and reliable.

When questioned on the fitness for sector and contract type when using WLPA, all respondents showed that it is slightly more appropriate for the public sector (52.9%) than the private sector (47.1%), and that Design-Build (31.8%) and Turnkey (22.4%) contracts are the most appropriate contract type when WLPA is introduced and applied to a construction project - see Table 2.

Table 2 Type of Contract for WLPA

Table 3 indicates the relative importance of eight major factor categories throughout the life of a construction project according to the survey respondents. The relative importance index ranges from 0 to 1. The indices in Table 3 show that some factors are more important than others. For example, cost, quality, scope and time are more important to all respondents than contract/administration, risk, human resource and health and safety. This is in line with the traditional key factors of time, cost, and quality seen as important for project performance and meeting clients' main needs (Hewitt 1985; Project Management Institute. 2004). Taking the relative indices as a measure of the importance of the eight major factor categories, ‘cost’ is ranked most important with a range of 0.77 to 0.92 over the whole life of a project, except for the post-construction phase in which the relative important indices of all factors except for ‘quality’ were not more than 0.75. The ranking of ‘cost’ should not be at all surprising because there would be no benefit in undertaking a project if it is not completed within project budget nor profitable enough for PIPs.

Contractors and sub-contractors ranked 'cost' first or second in the design, procurement and construction phases in agreement while clients ranked a range of factors as being the most important over the project's life. For example, 'human resource' in the pre-design phase, 'scope' in the design phase, 'contract/administration' in the procurement phase, 'cost' in the construction phase, and 'quality' in the post-construction phase were ranked most important with an overall index of 0.79, 0.81, 0.86, 0.92 and 0.82 respectively.

Table 3 MS and RII of 8 major factor categories by phase

This ranking would seem to indicate that it is necessary for contractors and sub-contractors to consider other factors throughout the project's life in order to satisfy the clients' requirements and to manage the project effectively. All respondents ranked 'health and safety' in the construction phase higher than that in other phases. This supports the findings of Kometa, Olomolaiye et al. (1995). Contractors and sub-contractors are aware that more and more clients are taking safety seriously.

Step 4 – Derive CFs

Tables 4 and 5 summarise the relative importance index (RII) and ranks ten critical common factors over eight major categories from the PIPs' perspective. Out of ten hypothesised common factors, 'type of project' is the most important with relative indices of 0.68 to 0.84 over eight major categories for all participants. This is in contrast to 'type of client', which is relatively less important with relative indices of 0.48 to 0.71 overall. In terms of quality, 'project goals and milestones', 'PMIS' and 'type of project' are the most critical factors with the same relative index of 0.74 for the client, contractor and sub-contractor group respectively. 'Project plan and procedures' is identified by the client group as the most important factor in the health and safety category and is ranked 3rd by the contractor and sub-contractor group.

Table 4 Relative importance index (RII) and ranks (R) of Top 10 critical common factors by scope, time, cost and quality

Table 5 Relative importance index (RII) and ranks (R) of Top 10 critical common factors by con/admin, HR, risk and H/S

Tables 6 to 8 tabulate the top ten critical individual factors in each major category according to the client, contractor and sub-contractor groups. All participants ascribed slightly different degrees of importance to hypothesised individual factors for WLPA. For example, the client group generally perceives 'risk response' in the risk category, with a relative index of 0.86, as paramount to whole life performance (see Table 6); while the contractor and sub-contractor groups view 'defective design' as the most important factor with indices of 0.85 and 0.81 respectively (see Tables 7 and 8). In a similar vein, the client group views 'clarity of contract (0.83)' and 'sustainable project design and construction (0.81)' in the scope category as important determinants. The contractor and sub-contractor groups are more aware of the importance of 'effective pre-planning' and 'design completed before work on site' with indices of 0.84 and 0.82 respectively.

Despite the differences amongst participants, the most critical factors were in the 'time' and 'cost' categories. In particular, 'rapid decision making' and 'fixed construction period' in the time category and 'precise project budget estimate' and 'adequate tender sum' in the cost category were viewed in a similar way by all respondents and scored more than 0.80 on the relative index scale (see Tables 6, 7 and 8). These results indicate that all respondents are interested in speed and have explicitly considered the influence of decision making on project time; they place a much greater emphasis on cost and time than other factors.

The eighty five responses used to evaluate each factor in the survey are sufficient to allow for analysis using the relative index ranking technique, but they may be insufficient to guarantee a definitive conclusion. In spite of this, valuable clues can be found for the evaluation of the relative importance of critical factors and assessing whole life performance in terms of scope, time, cost, quality, contact/administration, human resource, risk and health and safety from inception to completion of a construction project. These factors may be a function of South Korea's distinct construction industry environment as well as cultural traditions and illustrate how whole life performance over project phases can be evaluated by those ranked factors with relative indices in terms of the eight major categories.

Table 6 Top 10 critical individual factors by category – Clients (N=20)

Table 7 Top 10 critical individual factors by category – Contractors (N=27)

Table 8 Top 10 critical individual factors by category – Sub-contractors (N=38)

Step 5 - Analyse CFs

In order to test any agreement on the relative importance of the critical individual factors and to rank them in each category between different participants, the Spearman's rank correlation, which is a non-parametric measure of correlation, is used (Chan and Kumaraswamy 1996; Kometa et al. 1995). The Spearman rank correlation coefficient (r_s) for any two sets of rankings is calculated using the following formula:

$$r_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2 - 1)} \qquad (3)$$

where d_i = the difference between ranks, and n = number of pairs of values in the data

The correlation analysis was performed using the Statistical Package for Social Sciences (SPSS, version 15.0). Table 9 presents the degree of agreement among the respondents on 80 critical factors of WLPA. It can be concluded that all participants have a large positive significance between any two groups, however the value of the correlation coefficient is 0.622 between clients and contractors which indicates a much stronger positive relationship rather than the coefficient of 0.498 between contractors and sub-contractors, and 0.482 between clients and sub-contractors. This reinforces the agreement in perception between clients and contractors on the 80 critical factors.

Table 10 describes the strong agreement between any two groups on the relative importance of the eight major categories by phase: pre-design, design, procurement, construction and post-construction. It is observed that all participants have an overall agreement on eight major categories throughout the whole life of a project, although there is slightly differing perceptions of eight major categories over project phases between client and contractor with a coefficient of 0.646.

Table 9 Correlations between participants on 80 critical factors

Table 10 Correlations between participants on 8 major categories by phase

For the purpose of determining the most critical factors of WLPA in each phase from all participants' perception, and developing a criteria matrix with these factors, the "weighted average" of the relative importance index for the top ten critical factors in each category by each group is calculated and combined with the weighted relative importance index with the remaining groups. The combined three relative importance indices (RII) are obtained from the sum of the outputs of the proportion of the questionnaires received from each group compared to the total number of respondents (n/N) as below:

$$\text{Weighted Average} = \Sigma\ (n/N \times RII)\ (1 \leq WA \leq 5), \qquad (4)$$

Where n=20 for the client group, n=27 for the contractor group and n=28 for the sub-contractor group; N =85.

Table 11 presents the weighted averages of the RIIs of eight major categories by phase as identified in the questionnaire survey. Furthermore, tables 12 and 13 show the "criteria matrix of critical factors by phase for WLPA" as obtained and developed from combining the weighted averages of the relative importance indices of eight major categories by phase, with the weighted averages of the relative importance indices for the top ten critical factors in each category.

This criteria matrix of critical factors for assessing WLP defines the various critical factor category and types across the whole project phases that need to be considered when implementing the relevant project performance. Out of the 80 critical factors in this matrix, the most significant critical factor in each category for WLPA was: “clarity of contract” (in scope), “fixed construction period” (in time), “precise project budget estimate” (in cost), “material quality” (in quality), “mutual and trusting relationships” (in contract/administration), “leadership/team management” (in human resource), “defective design” (in risk), and “management of work safety on site” (in health and safety).

The matrix indicates that some critical factors such as “precise project budget estimate”, “fixed construction period” and “material quality” ought to be considered as being able to achieve best value for a project over the whole life of a construction project. This is due to its considerable importance for whole life performance rather than those critical factors that need careful consideration during a certain construction phase for whole life performance. For example, “clarity of contract” is needed at the beginning of a construction project, in the pre-design and/or design phases. “Defective design” is critical during pre-design and construction due to its relationship between design and construction. In particular, “management of work safety on site” is one of most critical factors during construction.

Table 11 Relative importance indices (RII) of each group and Weighted average(Wa) for 8 major critical category by phase

Table 12 Criteria Matrix of Critical Factors by phase for WLPA – SCOPE, TIME, COST and QUALITY

Table 13 Criteria Matrix of Critical Factors by phases for WLPA– CONTRACT/ADMIN, HUMAN RESOURCE, RISK and HEALTH&SAFETY

Discussion

The following discussion is an attempt to describe the most significant critical factors identified above and understand their relationships with other critical factors.

"Clarity of Contract" in SCOPE

This related to clear terms and conditions of a construction contract between parties. Clarity of contract (S-CCO) in scope is identified as one of the performance attributes which has a significant impact on a project with a relative index of 0.54 to 0.65 (Table 12) and was ranked the most important with an overall index of 0.83 (Table 6). Once an appropriate contract basic form is selected, modified, finalised and agreed between parties, clear terms and conditions of contract would prevent unnecessary claims and disputes, which may occur due to ambiguity in the contract. In relation to this critical factor, the ranking seems to suggest that fair contractual terms for all parties should not be neglected if mutual benefits for all parties are to be gained. Clarity of contract was recently highlighted as an important project success factor by Phua (2004).

"Fixed Construction Period" in TIME

This refers to the project construction period itself, not the life of the project. Clients and sub-contractors ranked this factor the most important with an index of 0.83 and 0.79 respectively (Tables 6 and 8). In particular, “fixed construction period” (T-FCP) during the procurement phase was ranked the most important with an overall relative index of 0.79 (Table 12). However, in order to secure value for money through a holistic approach, whole life performance should be used to represent the securing of efficient long-term value via the appraisal of impacts occurring throughout the project life cycle, including a project service life (Rowe 1999). This life is associated with design life, economic life, functional life, technological life or service life of a constructed asset (Flanagan 2002). Obviously, a fixed construction period is important to contractors and sub-contractors for timely completion. Moreover, they need to understand that clients explicitly consider the influence of time on the costs and returns over the life of a construction project.

"Precise Project Budget Estimate" in COST

This refers to the budget estimate of the project from inception to completion. Out of the 80 critical factors, this was ranked the most important from the pre-design to the procurement phase (Table 12) and all participants showed a strong agreement on the precise project budget (C-PPB) estimate being the most critical factor over all the phases for whole life performance. In the cost category, clients and sub-contractors ranked this factor the most important with an index of 0.86 and 0.87 respectively (Tables 6 and 8). Clients' estimating policies usually focus on the preparation of "unlikely to be exceeded but not excessively conservative" estimates and this means that the estimate prepared at any stage of a project has a 90% confidence factor of the project budget not being exceeded on completion (Creedy, 2006). To make more realistic project cost estimates, project budgets need to be adjusted by other relevant critical factors such as risk, and monitored by feedback from other participants and departments through the budgeting procedures. For example, public clients are expected to spend money wisely as part of their obligation to be accountable. Therefore, a constructed asset by the public sector should be cost-efficient, safe, completed on time and achieve a minimum standard of quality within the budget.

"Material Quality" in QUALITY

The quality category includes the quality of material, design, technology, workmanship and so on. In the quality category, all respondents ranked this factor first or second with an overall index of 0.80 to 0.86 (Tables 6, 7, and 8). Out of the 80 critical factors, material quality (Q-MQU) in the post-construction phase was ranked the most important with a relative index of 0.67 (Table 12). Material quality (Q-MQU) provides a starting point for construction work with the availability of materials, their availability as a bulk commodity, etc.. The material quality category is one of most significant factors affecting labour productivity (Dai et al. 2007). In addition, technical quality gives an indication of the project's quality of materials and finishes (Ling et al. 2006). Clients may prefer a high quality constructed asset but this is costly. Clearly, a constructed asset should have at least a minimum standard of quality and all participants would be encouraged to design buildings with better quality materials that are more compatible with the concept of sustainable and environmental construction in consideration of whole life performance.

"Mutual and trusting Relationships" in CONTRACT/ ADMINISTRATION

With a relative importance index of 0.76 to 0.80, mutual and trusting relationships in contract/administration ranked the most important overall (Tables 6, 7, and 8). It was ranked 61st in the design phase and 68th in the construction phase (Table 13). This low ranking is quite astonishing as this factor is often associated with improving productivity, cost competitiveness and profit margins. One explanation is the relationship between customer and contractor in construction. which constitutes a multilevel complexity in which parties operate simultaneously and collaborate within groups of networks (Karna 2004). Despite its complexity, it is apparent that better mutual and trusting relationships (CA-MTR) lead to mutual satisfaction and benefits for a construction project. In contrast, adversarial relationships can lead to inferior levels of whole life performance. As an alternative approach for integrating the construction process based on those relationships, supply chain management is a win-win business-based approach to the maintenance of relationships among enterprises which has proven potential to improve companies' overall performance (Ofori 2000).

"Leadership and Team Management" in HUMAN RESOURCE

Clients and contractors ranked leadership and team management the most important in human resource with relative indices of 0.86 and 0.87 respectively (Tables 6 and

7). It was highly ranked - 21st in the pre-design phase and 17th in the post-construction phase (Table 13). The ranking would seem to indicate that it is necessary for PIPs to organise appropriate teams and foster good relationships between the teams and their leaders at the beginning of a project. There is no doubt that construction is a people business and thus communication is key to a successful project (CIOB 2002). Leadership and team management (HR-LTM) must be visible and all participants need to provide strategic vision and leadership to encourage teams to collaborate and network to achieve well-developed and co-ordinated communication between parties. This ensures that the project will be well implemented and managed by the experienced teams selected by PIPs.

"Defective Design" in RISK

Taking the relative indices as a measure of the importance of individual factors in risk, defective design (R-DDE) is the most important indication of how design influences a construction project over its life (Table 13). Contractors and sub-contractors ranked this the most important with an index of 0.85 and 0.81 respectively (Tables 7 and 8). Obviously, it is a critical factor and can cause severe project delays (Kartam and Kartam 2001) as defective design can have a serious impact on major changes in output prices, project schedule, minimum standard quality, technical development etc. throughout the life of a project. Therefore, it can be a critical factor that should be dealt with at the pre-design phase to allow control and monitoring over the construction and post-construction phases. Proactive management would help to avoid project participants from performing deficient work, causing serious project delays.

"Management of Work Safety on Site" in HEALTH AND SAFETY

For health and safety, management of work safety on site, hazard identification and cleanliness and order on site are the main critical factors. Of these, management of work safety on site (HS-MWS) was ranked first or second with a relative index of 0.85 by clients, 0.88 by contractors and 0.85 by sub-contractors in the survey. It was ranked 12th in construction phase (Table 13). This high ranking by PIPs is probably because of need to consider the safety of individuals on site and the emphasis placed by health and safety regulations. This importance concurs with previous studies by (Karna 2004; Kometa et al. 1995), who considered this as one of the important attributes for the work environment and safety, with safety during construction as the second fundamental need for clients.

Conclusions and further work

The objective of this study was to identify the critical factors influencing whole life performance of a construction project and evaluate their relative importance from the perspective of PIPs in South Korea. A set of ten common factors and 188 individual factors were identified, which were grouped into eight major categories and ranked into the top 80 critical factors by their relative importance. A questionnaire survey was conducted and its analysis was carried out through a critical factor method approach for whole life performance assessment (WLPA), using the "mean score", “relative importance index” “weighted average” method and “Spearman’s rank correlation coefficients”. From the PIPs' point of view, these analyses revealed that design-build and turnkey contracts are the most appropriate contract types for using WLPA in South Korea and cost, quality, scope and time are more important than contract/administration, risk, human resource and health and safety to all respondents over a project life cycle. In particular, ‘cost’ is the most important factor for all PIPs in South Korea in assessing whole life performance.

The critical factors of whole life performance assessment (WLPA) have been highlighted in a critical matrix throughout the project phases and revealed the following findings. (1) Out of eight key categories, contractors and sub-contractors ranked 'cost' first or second in the design, procurement and construction phases in agreement while clients ranked various factors the most important with a relative index of 0.79 to 0.92 over the project's life. For example, 'human resource (0.79)' in pre-design, 'scope (0.81)' in design, 'contract/ administration (0.86)' in procurement, 'cost (0.92)' in construction, and 'quality (0.82)' in post-construction phase while contractors and sub-contractors obviously ranked 'cost' first or second over phases in agreement. (2) Out of 10 common factors, all participants were of the opinion that “type of project” is the most critical common factor over eight categories for WLPA. (3) Out of the top 80 critical factors, “clarity of contract”, “fixed construction period”, “precise project budget estimate”, “material quality”, “mutual/trusting relationships”, “leadership/team management”, and “management of work safety on site” were the most critical factor in each key category for WLPA. (4) There is a relatively high agreement on eight key categories by phase for WLPA amongst all participants. However, with the top 80 critical factors of WLPA, there is a stronger positive relationship between client and contactor rather than contractor and sub-contractor, or client and sub-contractor (see Tables 9 and 10).

By taking into account these critical factors for assessing whole life performance from inception to completion, some suggestions are provided to help clients, contractors and sub-contractors, whether they have an ongoing construction project or are considering commencing a new project.

- It is preferable to employ whole life performance to evaluate design-build or turnkey project rather than design-bid-build in South Korea. In South Korea, the rate of design build increased rapidly in the mid-2000s, rising to 40.3% in 2005 and 40.5% of total public sector projects in the 1st half of 2006 (Lee et al. 2006), because South Korean government policy and strategy has been continuously oriented towards the activation of design-build in the public sector. Public sector clients in South Korea may shift their attention onto whole life performance from only price competitiveness for evaluating design-build.

- Practitioners in South Korea involved in a construction project may use the findings to get an insight into the critical factors that lead to the holistic planning and management of construction projects in South Korea. For instance, the results indicated which factors the clients ranked as most important over the project's life. The contractor organisations should pay more attention to meeting clients’ needs phase by phase of the project.

- While the criteria matrix of critical factors by phase for WLPA was constructed using South Korea data, it is believed that this matrix would be relevant to clients, contractors and sub-contractors in general. The eighty five responses used to evaluate each factor allows analyses by using the relative index ranking technique, but they may be insufficient to guarantee a definitive conclusion and consistency. In view of this belief and limitation, the findings should be treated with caution, but not be dismissed, since they offer a ray of hope that evaluation criteria for a project can evolve from a criteria matrix of critical factors.

- There is a need to establish an initial framework of whole life performance and proceed with a whole life performance assessment model for the South Korean construction industry (Lee and Lee 2006). The identified critical factors in this study may be incorporated into this framework. The WLPA model based on this framework can be used to aid decision making, appropriate for use by the public and private sectors for evaluation/selection process of a construction project at the bid stage.

The number of huge, complex and long-term projects in South Korea is increasing and a holistic approach from inception to the post-completion of a project may encourage the construction industry to deliver the right construction project at the right time, at the right cost and at the right quality to meet their clients' needs.. In a future study, it would be interesting to ascertain whether the critical factors identified can be generalised across different countries using similar studies. Furthermore, there is a need to expand on this research to establish the critical performance index of eight categories by phase and the model of whole life performance assessment that could be developed from these indices by collecting more data and testing the model.

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Table 1 Three groups of survey respondents

	Client	Contractor	Sub-con	Total
Sent	105	104	143	352*
Response	22	28	38	88
Valid	20	27	38	85
%	19.2	25.7	27.3	24.1

* The primary target population was planned to be 150 PIPs from each group who work as a project and/or cost manager in South Korea. However, the uneven number of respondents in each group was finalised in their lists due to their eligibilities.

Table 2 Type of Contract for WLPA

Type of Contract	Client	Contractor	Sub-con	Total
Design-Bid-Build	-	2	9	11 (12.9%)
Design-Build	10	92	8	27 (31.8%)
Turnkey	-	7	12	19 (22.4%)
Construction Management	3	3	5	11 (12.9%)
JV/Consortium	-	-	2	2 (2.4%)
BOT/BTO/BOO	7	6	2	15 (17.6%)
Size	20	27	38	85 (100.0%)

Table 3 MS and RII of 8 major factor categories by phase

PRE-DESIGN PHASE

Hypothesised 8 major factors	Client Group								Contractor Group								Sub-contractor Group							
	Number of scoring					*MS	**RII	***R	Number of scoring					MS	RII	R	Number of scoring					MS	RII	R
	5	4	3	2	1				5	4	3	2	1				5	4	3	2	1			
SCOPE	4	7	8	0	1	3.65	0.73	4	**16**	**6**	**4**	**0**	**1**	**4.33**	**0.87**	**1**	7	16	11	3	1	3.66	0.73	4
TIME	3	8	4	5	0	3.45	0.69	6	7	12	7	1	0	3.93	0.79	2	10	11	12	4	1	3.66	0.73	3
COST	5	8	6	1	0	3.85	0.77	3	9	9	6	3	0	3.89	0.78	4	**18**	**11**	**6**	**2**	**1**	**4.13**	**0.83**	**1**
QUALITY	3	6	7	2	2	3.30	0.66	7	3	8	11	5	0	3.33	0.67	6	16	9	9	3	1	3.95	0.79	2
CON/ADMIN	3	10	4	2	1	3.60	0.72	5	8	10	5	4	0	3.81	0.76	5	2	13	16	5	2	3.21	0.64	8
HR	**4**	**12**	**3**	**1**	**0**	**3.95**	**0.79**	**1**	2	10	8	7	0	3.26	0.65	7	5	17	8	7	1	3.47	0.69	6
RISK	4	11	5	0	0	3.95	0.79	2	11	7	5	3	1	3.89	0.78	3	8	13	10	6	1	3.55	0.71	5
H/S	2	2	8	5	3	2.75	0.55	8	0	1	10	13	3	2.33	0.47	8	8	12	8	6	4	3.37	0.67	7

DESIGN PHASE

Hypothesised 8 major factors	Number of scoring					MS	RII	R	Number of scoring					MS	RII	R	Number of scoring					MS	RII	R
	5	4	3	2	1				5	4	3	2	1				5	4	3	2	1			
SCOPE	**7**	**9**	**2**	**2**	**0**	**4.05**	**0.81**	**1**	13	6	7	1	0	4.15	0.83	2	12	13	12	1	0	3.95	0.79	3
TIME	3	11	4	1	1	3.70	0.74	5	8	11	8	0	0	4.00	0.80	3	9	17	9	3	0	3.84	0.77	4
COST	6	7	6	1	0	3.90	0.78	3	**14**	**6**	**7**	**0**	**0**	**4.26**	**0.85**	**1**	**20**	**14**	**4**	**0**	**0**	**4.42**	**0.88**	**1**
QUALITY	6	6	4	4	0	3.70	0.74	6	8	12	5	2	0	3.96	0.79	4	18	16	3	1	0	4.34	0.87	2
CON/ADMIN	4	8	6	1	1	3.65	0.73	7	7	5	12	3	0	3.59	0.72	6	2	14	16	6	0	3.32	0.66	7
HR	6	8	5	1	0	3.95	0.79	2	4	7	12	4	0	3.41	0.68	7	5	15	13	5	0	3.53	0.71	6
RISK	5	8	5	2	0	3.80	0.76	4	6	9	9	3	0	3.67	0.73	5	8	16	8	6	0	3.68	0.74	5
H/S	2	2	7	7	2	2.75	0.55	8	1	1	9	14	2	2.44	0.49	8	6	9	12	10	1	3.24	0.65	8

PROCUREMENT PHASE

Hypothesised 8 major factors	Number of scoring					MS	RII	R	Number of scoring					MS	RII	R	Number of scoring					MS	RII	R
	5	4	3	2	1				5	4	3	2	1				5	4	3	2	1			
SCOPE	7	3	8	2	0	3.75	0.75	4	10	9	8	0	0	4.07	0.81	3	8	13	14	2	1	3.66	0.73	5
TIME	3	4	10	2	1	3.30	0.66	7	8	6	12	1	0	3.78	0.76	5	7	16	13	2	0	3.74	0.75	4
COST	9	7	4	0	0	4.25	0.85	2	**16**	**7**	**4**	**0**	**0**	**4.44**	**0.89**	**1**	**27**	**9**	**2**	**0**	**0**	**4.66**	**0.93**	**1**
QUALITY	3	8	6	1	2	3.45	0.69	6	7	12	8	0	0	3.96	0.79	4	14	17	6	1	0	4.16	0.83	2
CON/ADMIN	**10**	**7**	**2**	**1**	**0**	**4.30**	**0.86**	**1**	11	9	5	2	0	4.07	0.81	2	6	9	18	5	0	3.42	0.68	8
HR	3	7	8	2	0	3.55	0.71	5	3	8	10	6	0	3.30	0.66	7	4	11	21	2	0	3.45	0.69	7
RISK	5	8	6	1	0	3.85	0.77	3	5	12	8	2	0	3.74	0.75	6	8	19	7	4	0	3.82	0.76	3
H/S	2	2	8	5	3	2.75	0.55	8	0	2	9	15	1	2.44	0.49	8	6	12	14	6	0	3.47	0.69	6

CONSTRUCTION PHASE

Hypothesised 8 major factors	Number of scoring					MS	RII	R	Number of scoring					MS	RII	R	Number of scoring					MS	RII	R
	5	4	3	2	1				5	4	3	2	1				5	4	3	2	1			
SCOPE	5	6	9	0	0	3.80	0.76	7	9	10	8	0	0	4.04	0.81	4	11	13	12	2	0	3.87	0.77	7
TIME	10	9	1	0	0	4.45	0.89	3	13	13	1	0	0	4.44	0.89	3	20	14	4	0	0	4.42	0.88	4
COST	**13**	**6**	**1**	**0**	**0**	**4.60**	**0.92**	**1**	18	6	2	1	0	4.52	0.90	2	26	8	4	0	0	4.58	0.92	2
QUALITY	15	3	1	1	0	4.60	0.92	2	**21**	**5**	**0**	**1**	**0**	**4.70**	**0.94**	**1**	**29**	**6**	**3**	**0**	**0**	**4.68**	**0.94**	**1**
CON/ADMIN	4	7	9	0	0	3.75	0.75	8	5	10	9	3	0	3.63	0.73	7	4	12	18	3	1	3.39	0.68	8
HR	2	2	8	5	3	3.90	0.78	6	5	13	9	0	0	3.85	0.77	5	19	9	10	0	0	4.24	0.85	5
RISK	7	9	3	1	0	4.10	0.82	5	6	8	10	3	0	3.63	0.73	8	15	17	5	1	0	4.21	0.84	6
H/S	10	6	3	1	0	4.25	0.85	4	7	9	8	3	0	3.74	0.75	6	26	8	4	0	0	4.58	0.92	2

POST-CONSTRUCTION PHASE

Hypothesised 8 major factors	Number of scoring					MS	RII	R	Number of scoring					MS	RII	R	Number of scoring					MS	RII	R
	5	4	3	2	1				5	4	3	2	1				5	4	3	2	1			
SCOPE	3	4	8	5	0	3.25	0.65	7	6	6	13	1	1	3.56	0.71	2	6	7	20	4	1	3.34	0.67	4
TIME	0	3	12	5	0	2.90	0.58	8	1	6	12	7	1	2.96	0.59	6	3	9	19	6	1	3.18	0.64	6
COST	2	8	3	7	0	3.25	0.65	6	3	6	13	4	1	3.22	0.64	4	3	18	11	5	1	3.45	0.69	2
QUALITY	**9**	**6**	**3**	**2**	**0**	**4.10**	**0.82**	**1**	5	11	6	4	1	3.56	0.71	3	**21**	**11**	**5**	**1**	**0**	**4.37**	**0.87**	**1**
CON/ADMIN	3	3	12	2	0	3.35	0.67	4	**9**	**8**	**5**	**4**	**1**	**3.74**	**0.75**	**1**	5	6	19	5	3	3.13	0.63	7
HR	4	5	10	1	0	3.60	0.72	2	3	5	10	8	1	3.04	0.61	5	0	11	19	7	1	3.05	0.61	8
RISK	4	3	8	5	0	3.30	0.66	5	4	4	6	10	3	2.85	0.57	7	6	14	9	8	1	3.42	0.68	3
H/S	4	7	5	4	0	3.55	0.71	3	2	3	9	10	3	2.67	0.53	8	4	12	13	5	4	3.18	0.64	5

* RII – Relative importance index: if individual factors are equal, they are ranked according to the number of respondents scoring 4 or more, **R - Rank

Table 4 Relative importance index (RII) and ranks (R) of Top 10 critical common factors by scope, time, cost and quality

Hypothesised factors	Scope						Time						Cost						Quality					
	CL		CO		SU		CL		CO		SU		CL		CO		SU		CL		CO		SU	
	RII*	R**	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R
Type of Project	**0.80**	**1**	**0.79**	**1**	**0.76**	**1**	**0.75**	**1**	**0.81**	**1**	0.69	3	0.82	2	0.79	2	**0.75**	**1**	0.68	4	0.73	3	**0.74**	**1**
Size of Project	0.73	4	0.75	3	0.74	3	0.73	3	0.79	2	**0.80**	**1**	**0.83**	**1**	**0.83**	**1**	0.74	2	0.64	7	0.67	5	0.64	5
Type of Contract	0.73	3	0.73	4	0.66	6	0.67	7	0.71	5	0.64	7	0.71	5	0.76	3	0.67	4	0.66	6	0.63	8	0.60	7
Project Goals/ Milestones	0.77	2	0.70	6	0.68	5	0.71	4	0.76	3	0.70	2	0.69	6	0.72	5	0.62	8	**0.74**	**1**	0.70	4	0.64	4
Location of Project	0.63	9	0.62	10	0.63	8	0.58	9	0.65	7	0.65	6	0.65	7	0.70	6	0.67	5	0.63	9	0.56	10	0.55	9
Type of Client	0.58	10	0.62	9	0.60	10	0.54	10	0.59	10	0.54	10	0.55	10	0.63	10	0.62	7	0.57	10	0.59	9	0.54	10
Project Organisation	0.70	6	0.69	8	0.66	7	0.61	8	0.64	8	0.63	8	0.59	9	0.67	8	0.60	9	0.63	8	0.65	6	0.62	6
PMIS***	0.71	5	0.70	7	0.75	2	0.71	5	0.72	4	0.68	5	0.72	4	0.73	4	0.68	3	0.73	2	**0.74**	**1**	0.66	3
Project Plan/Procedures	0.68	8	0.70	5	0.73	4	0.75	2	0.70	6	0.69	4	0.63	8	0.69	7	0.66	6	0.71	3	0.74	2	0.67	2
Relevant Law/Regulation	0.70	7	0.76	2	0.63	9	0.69	6	0.63	9	0.57	9	0.72	3	0.64	9	0.59	10	0.67	5	0.64	7	0.59	8

* RII - Relative importance index: if individual factors are equal, they are ranked according to the number of respondents scoring 4 or more, **R – Rank, ***PMIS – Project Management Information System

Table 5 Relative importance index (RII) and ranks (R) of Top 10 critical common factors by con/admin, HR, risk and H/S

Hypothesised factors	Con/Admin						HR						Risk						H/S					
	CL		CO		SU		CL		CO		SU		CL		CO		SU		CL		CO		SU	
	RII*	R**	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R	RII	R
Type of Project	0.72	5	**0.84**	**1**	0.69	2	**0.78**	**1**	**0.81**	**1**	**0.77**	**1**	**0.76**	**1**	**0.83**	**1**	**0.73**	**1**	0.63	2	**0.72**	**1**	**0.69**	**1**
Size of Project	0.72	6	0.74	5	0.67	3	0.73	2	0.72	3	0.74	2	0.74	3	0.78	3	0.69	2	0.65	4	0.68	2	0.64	4
Type of Contract	**0.80**	**1**	0.82	2	**0.74**	**1**	0.60	9	0.62	7	0.59	10	0.75	2	0.79	2	0.66	4	0.51	9	0.53	9	0.57	9
Project Goals/ Milestones	0.78	3	0.76	4	0.66	6	0.63	7	0.71	4	0.64	7	0.70	6	0.65	7	0.65	6	0.55	8	0.56	8	0.59	8
Location of Project	0.61	10	0.61	10	0.54	10	0.60	8	0.56	10	0.64	6	0.65	8	0.62	10	0.63	8	0.61	6	0.63	6	0.61	6
Type of Client	0.71	8	0.71	8	0.62	7	0.56	10	0.56	9	0.60	8	0.63	9	0.63	9	0.58	10	0.48	10	0.53	10	0.56	10
Project Organisation	0.66	9	0.67	9	0.60	9	0.64	6	0.76	2	0.69	4	0.61	10	0.64	8	0.59	9	0.56	7	0.61	7	0.60	7
PMIS***	0.74	4	0.73	6	0.66	8	0.72	3	0.69	5	0.70	3	0.69	7	0.67	6	0.67	3	0.65	3	0.67	4	0.66	2
Project Plan/Procedures	0.72	7	0.72	7	0.62	4	0.67	4	0.66	6	0.66	5	0.72	4	0.68	4	0.63	7	**0.68**	**1**	0.67	3	0.65	3
Relevant Law/Regulation	0.79	2	0.79	3	0.66	5	0.64	5	0.59	8	0.60	9	0.72	5	0.67	5	0.65	5	0.62	5	0.64	5	0.64	5

* RII - Relative importance index: if individual factors are equal, they are ranked according to the number of respondents scoring 4 or more, **R – Rank, ***PMIS – Project Management Information System

Table 6 Top 10 critical individual factors by category – Clients (N=20)

Hypothesised factors

SCOPE	MS*	RII**	R***	TIME	MS	RII	R
Clarity of Contract	4.150	0.83	1	Fixed Construction Period	4.150	0.83	1
Sustainable Project Design & Construction	4.050	0.81	2	Rapid Decision Making	4.000	0.80	2
Reliability Engineering Techniques	3.950	0.79	3	Overrun Duration	3.950	0.79	3
Effective Pre-Planning	3.750	0.75	4	Project Time Constraints	3.950	0.79	4
Understanding of Project Requirements	3.650	0.73	5	Adequacy of Time	3.900	0.78	5
Construction Complexity	3.650	0.73	6	Constraint by Government Regulations	3.900	0.78	6
Project Levels of Decision-Making	3.650	0.73	7	Lack of Time	3.850	0.77	7
Economic Evaluation of Socio-Environmental Effects	3.600	0.72	8	Service Life Planning	3.800	0.76	8
Integrated Functional Requirement	3.500	0.70	9	Constraint by Ground Conditions	3.800	0.76	9
Design Completed Before Work On Site	3.450	0.69	10	Severity of Variations	3.750	0.75	10
COST	**MS**	**RII**	**R**	**QUALITY**	**MS**	**RII**	**R**
Adequate Tender Sum	4.300	0.86	1	Design Quality Plan	4.250	0.85	1
Precise Project Budget Estimate	4.150	0.83	2	Material Quality	4.200	0.84	2
Cost Effectiveness	4.050	0.81	3	Construction Quality Plan	4.050	0.81	3
Competition On Price	4.000	0.80	4	Contracted Work Quality	4.050	0.81	4
Long-term Profitability	3.950	0.79	5	Durability of Building Assemblies	4.000	0.80	5
Overbudget Possibility	3.950	0.79	6	Determining Quality in Construction	3.950	0.79	6
Eliminating Waste	3.950	0.79	7	Durability of Building Components	3.900	0.78	7
Rapid Decision Making	3.950	0.79	8	Level of Technology	3.900	0.78	8
Cash Flow Certainty	3.800	0.76	9	Conformance to Requirement	3.800	0.76	9
Severity of Variations	3.800	0.76	10	Inadequate Labour Skills	3.700	0.74	10
CONTRACT/ADMIN	**MS**	**RII**	**R**	**HUMAN RESOURCE**	**MS**	**RII**	**R**
Disputes Resolution Procedure	3.950	0.79	1	Leadership / Team Management	4.300	0.86	1
Mutual/trusting Relationships	3.850	0.77	2	Team communication	4.250	0.85	2
Changes in Contact	3.850	0.77	3	Motivation for Project	4.200	0.84	3
City Planning Regulations	3.800	0.76	4	Skilled Personnel	4.150	0.83	4
Threat of Litigation	3.750	0.75	5	Monitoring and Feedback	4.050	0.81	5
Inclusion of All Risks	3.700	0.74	6	Labour productivity	3.950	0.79	6
Implement of Partnering	3.500	0.70	7	Capture of Organisation's Mission/Vision	3.900	0.78	7
Procured Similar Projects Within 5 years	3.400	0.68	8	Spirit of Cooperation	3.900	0.78	8
Long and Short Form	3.400	0.68	9	Centralised Decision-making	3.900	0.78	9
Commercial Bid Evaluation	3.350	0.67	10	Need for Collaboration	3.850	0.77	10
RISK	**MS**	**RII**	**R**	**HEALTH & SAFETY**	**MS**	**RII**	**R**
Risk Response	4.300	0.86	1	Hazard Identification	4.350	0.87	1
Defective Materials	4.100	0.82	2	Management of Work Safety on Site	4.250	0.85	2
Risk Management Techniques	4.100	0.82	3	Health and Safety Records	4.150	0.83	3
Defective Design	4.100	0.82	4	Personal Protective Equipment	4.000	0.80	4
Ignorance of Risk	3.950	0.79	5	Management Responsibility	4.000	0.80	5
Cash Flow Reliability of Project	3.900	0.78	6	Teaching of Accident Prevention	3.950	0.79	6
Risk Identification	3.900	0.78	7	Cleanliness and Order on Site	3.950	0.79	7
Labour Disputes	3.900	0.78	8	Teaching of First Aid Skills	3.900	0.78	8
Financial Stability of Client	3.850	0.77	9	Safety Consideration (Operative ratings)	3.900	0.78	9
Coordination with Subcontractors	3.850	0.77	10	Management of Environmental Issues on Site	3.900	0.78	10

* MS – Mean score : if the individual factors are equal, they are ranked according to the number of respondents scoring 4 or more.

** RII – Relative importance index: if individual factors are equal, they are ranked according to the number of respondents scoring 4 or more,

*** R – Rank.

Table 7 Top 10 critical individual factors by category – Contractors (N=27)

Hypothesised factors

SCOPE	MS*	RII**	R***	TIME	MS	RII	R
Effective Pre-Planning	4.185	0.84	1	Rapid Decision Making	4.148	0.83	1
Clarity of Contract	4.074	0.81	2	Fixed Construction Period	4.111	0.82	2
Understanding of Project Requirements	3.667	0.73	3	Adequacy of Time	4.074	0.81	3
Reliability Engineering Techniques	3.667	0.73	4	Overrun Duration	4.074	0.81	4
Sustainable Project Design & Construction	3.593	0.72	5	Severity of Variations	3.963	0.79	5
Construction Complexity	3.519	0.70	6	Approval of Shop Drawings	3.926	0.79	6
Integrated Functional Requirement	3.481	0.70	7	Project Time Constraints	3.889	0.78	7
Design Completed Before Work On Site	3.407	0.68	8	Frequency of Variations	3.778	0.76	8
Understanding Contractor Difficulties	3.370	0.67	9	Slow Decision Making Process	3.741	0.75	9
Project Levels of Decision-Making	3.333	0.67	10	Lack of Time	3.741	0.75	10
COST	MS	RII	R	QUALITY	MS	RII	R
Precise Project Budget Estimate	4.296	0.86	1	Material Quality	4.296	0.86	1
Competition On Price	4.148	0.83	2	Level of Technology	4.259	0.85	2
Adequate Tender Sum	3.926	0.79	3	Design Quality Plan	4.185	0.84	3
Competitive Tendering Process	3.815	0.76	4	Contracted Work Quality	4.148	0.83	4
Overbudget Possibility	3.741	0.75	5	Construction Quality Plan	4.074	0.81	5
Application of Value Management	3.704	0.74	6	Determining Quality in Construction	4.000	0.80	6
Frequency of Variations	3.667	0.73	7	Agreed Quality Assurance Procedures	3.852	0.77	7
Cost Effectiveness	3.630	0.73	8	Inadequate Labour Skills	3.815	0.76	8
Target Costing	3.593	0.72	9	Conformance to Requirement	3.815	0.76	9
Cash Flow Certainty	3.556	0.71	10	Durability of Building Assemblies	3.815	0.76	10
CONTRACT/ADMIN	MS	RII	R	HUMAN RESOURCE	MS	RII	R
Changes in Contact	3.963	0.79	1	Leadership / Team Management	4.370	0.87	1
Disputes Resolution Procedure	3.815	0.76	2	Skilled Personnel	4.148	0.83	2
Inclusion of All Risks	3.815	0.76	3	Team communication	4.074	0.81	3
Mutual/trusting Relationships	3.778	0.76	4	Centralised Decision-making	4.000	0.80	4
City Planning Regulations	3.741	0.75	5	Efficiency of Project Organisation	4.000	0.80	5
Procurement Arrangements	3.741	0.75	6	Motivation for Project	3.926	0.79	6
Procured Similar Projects Within 5 years	3.667	0.73	7	Labour productivity	3.926	0.79	7
Implement of Partnering	3.519	0.70	8	Pride in Their Work	3.852	0.77	8
Threat of Litigation	3.407	0.68	9	Monitoring and Feedback	3.778	0.76	9
Frequency of Negotiation	3.407	0.68	10	Integrity and Honesty	3.778	0.76	10
RISK	MS	RII	R	HEALTH & SAFETY	MS	RII	R
Defective Design	4.259	0.85	1	Management of Work Safety on Site	4.407	0.88	1
Defective Materials	4.222	0.84	2	Cleanliness and Order on Site	4.259	0.85	2
Risk Response	4.222	0.84	3	Hazard Identification	4.259	0.85	3
Financial Stability of Client	4.148	0.83	4	Personal Protective Equipment	3.815	0.76	4
Risk Management Techniques	4.037	0.81	5	Skilled Personnel	3.815	0.76	5
Accuracy of Project Program	3.963	0.79	6	Teaching of Accident Prevention	3.815	0.76	6
Differing Site Condition	3.963	0.79	7	Management Responsibility	3.741	0.75	7
Ignorance of Risk	3.926	0.79	8	Site Safety Resources	3.741	0.75	8
Risk Identification	3.889	0.78	9	Teaching of First Aid Skills	3.704	0.74	9
Site Risk Access	3.852	0.77	10	Safety Consideration (Operative ratings)	3.704	0.74	10

* MS - Mean score : if the individual factors are equal, they are ranked according to the number of respondents scoring 4 or more.

** RII - Relative importance index: if individual factors are equal, they are ranked according to the number of respondents scoring 4 or more,

*** R - Rank.

Table 8 Top 10 critical individual factors by category – Sub-contractors (N=38)

Hypothesised factors

SCOPE	MS*	RII**	R***	TIME	MS	RII	R
Design Completed Before Work On Site	4.079	0.82	1	Fixed Construction Period	4.868	0.97	1
Effective Pre-Planning	3.921	0.78	2	Rapid Decision Making	4.316	0.86	2
Reliability Engineering Techniques	3.921	0.78	3	Overrun Duration	4.158	0.83	3
Clarity of Contract	3.895	0.78	4	Severity of Variations	4.026	0.81	4
Construction Complexity	3.868	0.77	5	Lack of Time	3.895	0.78	5
Sustainable Project Design & Construction	3.789	0.76	6	Project Time Constraints	3.842	0.77	6
Understanding of Project Requirements	3.605	0.72	7	Approval of Shop Drawings	3.816	0.76	7
Understanding Contractor Difficulties	3.579	0.72	8	Late Delivery of Materials/Equipment	3.816	0.76	8
Integrated Functional Requirement	3.421	0.68	9	Adequacy of Time	3.789	0.76	9
Design Complexity	3.395	0.68	10	Slow Decision Making Process	3.711	0.74	10
COST	**MS**	**RII**	**R**	**QUALITY**	**MS**	**RII**	**R**
Precise Project Budget Estimate	4.368	0.87	1	Determining Quality in Construction	4.053	0.81	1
Adequate Tender Sum	4.368	0.87	2	Material Quality	4.000	0.80	2
Competition On Price	4.158	0.83	3	Construction Quality Plan	3.974	0.79	3
Severity of Variation	4.105	0.82	4	Level of Technology	3.974	0.79	4
Overbudget Possibility	4.026	0.81	5	Design Quality Plan	3.921	0.78	5
Rapid Decision Making	4.000	0.80	6	Contracted Work Quality	3.921	0.78	6
Long-term Profitability	3.921	0.78	7	Conformance to Requirement	3.895	0.78	7
Different Per Diem Rate	3.895	0.78	8	Agreed Quality Assurance Procedures	3.789	0.76	8
Cost Effectiveness	3.868	0.77	9	Significance of Customer Satisfaction	3.737	0.75	9
Competitive Tendering Process	3.789	0.76	10	Durability of Building Assemblies	3.711	0.74	10
CONTRACT/ADMIN	**MS**	**RII**	**R**	**HUMAN RESOURCE**	**MS**	**RII**	**R**
Mutual/trusting Relationships	4.000	0.80	1	Skilled Personnel	4.316	0.86	1
Disputes Resolution Procedure	3.763	0.75	2	Labour productivity	4.211	0.84	2
Conformity of Supplier's Subcontracting to Contract	3.763	0.75	3	Leadership / Team Management	4.079	0.82	3
Changes in Contact	3.711	0.74	4	Team communication	4.053	0.81	4
Implement of Partnering	3.632	0.73	5	Integrity and Honesty	4.000	0.80	5
Technical Bid Evaluation	3.605	0.72	6	Availability of Skill Training	3.974	0.79	6
Procured Similar Projects Within 5 years	3.579	0.72	7	Pride in Their Work	3.947	0.79	7
Greater Responsibility for the Contractor	3.579	0.72	8	Need for Collaboration	3.947	0.79	8
Over-design and Oversized Equipment	3.553	0.71	9	Top-down Decision-Making	3.868	0.77	9
Inclusion of All Risks	3.526	0.71	10	Efficiency of Project Organisation	3.842	0.77	10
RISK	**MS**	**RII**	**R**	**HEALTH & SAFETY**	**MS**	**RII**	**R**
Defective Design	4.026	0.81	1	Hazard Identification	4.316	0.86	1
Accuracy of Project Program	3.974	0.79	2	Management of Work Safety on Site	4.263	0.85	2
Contractor Competence	3.974	0.79	3	Teaching of Accident Prevention	4.263	0.85	3
Change Order Negotiations	3.921	0.78	4	Personal Protective Equipment	4.158	0.83	4
Financial Stability of Client	3.895	0.78	5	Teaching of First Aid Skills	4.026	0.81	5
Defective Materials	3.868	0.77	6	Cleanliness and Order on Site	4.000	0.80	6
Risk Response	3.737	0.75	7	Health and Safety Record	4.000	0.80	7
Changes in Work	3.737	0.75	8	Skilled Personnel	3.842	0.77	8
Coordination with Subcontractors	3.658	0.73	9	Site Safety Resources	3.842	0.77	9
Cash Flow Reliability of Project	3.658	0.73	10	Subcontractor Safety Meeting	3.816	0.76	10

* MS - Mean score : if the individual factors are equal, they are ranked according to the number of respondents scoring 4 or more.

** RII - Relative importance index: if individual factors are equal, they are ranked according to the number of respondents scoring 4 or more,

*** R - Rank.

Table 9 Correlations between participants on 80 critical factors

Participants	Spearman's rank Correlation coefficient	t	Reject H_0?	p-value
Client and Contractor	0.622	-.155	Yes	Significant, < 0.05
Contractor and Sub-Contractor	0.498	-.819	Yes	Significant, < 0.05
Client and Sub-Contractor	0.482	-.921	Yes	Significant, < 0.05

t = t-statistics; H_0=null hypothesis; p= probability that rejects the null hypothesis wrongly.

Table 10 Correlations between participants on 8 major categories by phase

Participants	Spearman's rank Correlation coefficient	t	Reject H_0?	p-value
Client and Contractor	0.646	-.741	Yes	Significant, < 0.05
Contractor and Sub-Contractor	0.660	-1.614	Yes	Significant, < 0.05
Client and Sub-Contractor	0.659	-1.169	Yes	Significant, < 0.05

t = t-statistics; H_0=null hypothesis; p= probability that rejects the null hypothesis wrongly.

Table 11 Relative importance indices (RII) of each group and Weighted average(Wa) for 8 major critical category by phase

Critical Category	Pre-Design				Design				Procurement				Construction				Post-Construction			
	CL	CO	SU	Wa	CL	CO	SU	Wa	CL	CO	SU	Wa	CL	CO	SU	Wa	CL	CO	SU	Wa
SCOPE	0.73	0.87	0.73	0.77	0.81	0.83	0.79	0.81	0.75	0.81	0.73	0.76	0.76	0.81	0.77	0.78	0.65	0.71	0.67	0.68
TIME	0.69	0.79	0.73	0.74	0.74	0.80	0.77	0.77	0.66	0.76	0.75	0.73	0.89	0.89	0.88	0.89	0.58	0.59	0.64	0.61
COST	0.77	0.78	0.83	<u>0.80</u>	0.78	0.85	0.88	0.85	0.85	0.89	0.93	<u>0.90</u>	0.92	0.90	0.92	0.91	0.65	0.64	0.69	0.66
QUALIT	0.66	0.67	0.79	0.72	0.74	0.79	0.87	<u>0.81</u>	0.69	0.79	0.83	0.78	0.92	0.94	0.94	<u>0.94</u>	0.82	0.71	0.87	<u>0.81</u>
CON/ADMIN	0.72	0.76	0.64	0.70	0.73	0.72	0.66	0.70	0.86	0.81	0.68	0.76	0.75	0.73	0.68	0.71	0.67	0.75	0.63	0.68
HR	0.79	0.65	0.69	0.70	0.79	0.68	0.71	0.72	0.71	0.66	0.69	0.69	0.78	0.77	0.85	0.81	0.72	0.61	0.61	0.64
RISK	0.79	0.78	0.71	0.75	0.76	0.73	0.74	0.74	0.77	0.75	0.76	0.76	0.82	0.73	0.84	0.80	0.66	0.57	0.68	0.64
H&S	0.55	0.47	0.67	0.58	0.55	0.49	0.65	0.58	0.55	0.49	0.69	0.59	0.85	0.75	0.92	0.85	0.71	0.53	0.64	0.62

The number of respondents (N=85) : n=20 for client group (CL), n=27 for contractor group (CO) and n=28 for sub-contractor group (SU)., Wa :“Weighted Average”

Table 12 Criteria Matrix of Critical Factors by phase for WLPA – SCOPE, TIME, COST and QUALITY

Critical Factor			Weighted Critical Factor for Whole Life Performance Assessment									
			Pre-Design		Design		Procurement		Construction		Post-Construction	
R*	**SCOPE**	Code	RII	R**	RII	R**	RII	R**	RII	R**	RII	R**
1	Clarity of Contract	S-CCO	0.62	6	0.65	13	0.61	22	0.63	52	0.54	14
2	Effective Pre-Planning	S-EPP	0.61	9	0.64	18	0.60	24	0.62	57	0.54	16
3	Reliability Engineering Techniques	S-RET	0.60	19	0.62	23	0.58	32	0.60	61	0.52	24
4	Sustainable Project Design & Construction	S-SPC	0.59	26	0.61	26	0.58	39	0.59	64	0.51	31
5	Design Completed Before Work On Site	S-DCB	0.58	33	0.60	33	0.57	46	0.58	65	0.50	37
6	Construction Complexity	S-COC	0.57	37	0.60	36	0.56	47	0.58	66	0.50	42
7	Understanding of Project Requirements	S-UPR	0.56	42	0.59	41	0.55	52	0.57	67	0.49	49
8	Integrated Functional Requirement	S-IFR	0.54	59	0.56	49	0.53	66	0.54	71	0.47	73
9	Understanding Contractor Difficulties	S-UCD	0.53	62	0.55	59	0.52	69	0.53	72	0.46	76
10	Project Levels of Decision-Making	S-PLD	0.52	63	0.55	60	0.51	70	0.53	73	0.46	78
R*	**TIME**											
1	Fixed Construction Period	T-FCP	0.66	3	0.69	4	0.65	11	0.79	1	0.54	15
2	Rapid Decision Making	T-RDM	0.62	7	0.65	15	0.61	19	0.74	11	0.51	32
3	Overrun Duration	T-ODU	0.60	16	0.63	20	0.60	27	0.72	14	0.50	44
4	Severity of Variations	T-SOV	0.58	28	0.61	29	0.58	38	0.70	22	0.48	63
5	Adequacy of Time	T-AOT	0.58	32	0.60	32	0.57	40	0.69	25	0.48	69
6	Project Time Constraints	T-PTC	0.57	36	0.60	34	0.57	43	0.69	28	0.47	72
7	Lack of Time	T-LOT	0.57	39	0.59	38	0.56	49	0.68	33	0.47	75
8	Late Delivery of Materials/Equipment	T-LDM	0.56	45	0.58	44	0.55	53	0.66	36	0.46	77
9	Approval of Shop Drawings	T-ASD	0.55	48	0.57	45	0.54	58	0.65	41	0.45	79
10	Slow Decision Making Process	T-SDM	0.55	49	0.57	46	0.54	59	0.65	42	0.45	80
R*	**COST**											
1	Precise Project Budget Estimate	C-PPB	0.69	1	0.73	1	0.77	1	0.78	2	0.57	11
2	Adequate Tender Sum	C-ATS	0.67	2	0.71	2	0.76	2	0.77	4	0.56	12
3	Competition On Price	C-COP	0.66	4	0.70	3	0.74	3	0.75	9	0.55	13
4	Overbudget Possibility	C-OPO	0.63	5	0.66	7	0.70	4	0.72	16	0.52	25
5	Cost Effectiveness	C-CEF	0.61	10	0.65	12	0.69	5	0.70	20	0.51	33
6	Severity of Variations	C-SOV	0.61	11	0.65	14	0.69	6	0.70	21	0.51	34
7	Long-term Profitability	C-CTP	0.61	13	0.64	16	0.68	7	0.69	23	0.50	38
8	Rapid Decision Making	C-RDM	0.61	14	0.64	17	0.68	8	0.69	24	0.50	39
9	Competitive Tendering Process	C-CTP	0.60	17	0.63	19	0.67	9	0.68	29	0.50	45
10	Cash Flow Certainty	C-CFC	0.59	23	0.63	22	0.66	10	0.68	34	0.49	50
R*	**QUALITY**											
1	Material Quality	Q-MQU	0.60	18	0.67	5	0.65	12	0.77	3	0.67	1
2	Design Quality Plan	Q-DQP	0.59	25	0.66	6	0.64	13	0.76	5	0.66	2
3	Level of Technology	Q-LOT	0.58	27	0.66	8	0.63	14	0.76	6	0.65	3
4	Construction Quality Plan	Q-CQP	0.58	29	0.66	9	0.63	15	0.75	7	0.65	4
5	Contracted Work Quality	Q-CWQ	0.58	30	0.66	10	0.63	16	0.75	8	0.65	5
6	Determining Quality in Construction	Q-DQC	0.58	31	0.65	11	0.63	17	0.75	10	0.65	6
7	Conformance to Requirement	Q-CTR	0.55	46	0.63	21	0.60	23	0.72	15	0.62	7
8	Durability of Building Assemblies	Q-DBA	0.55	47	0.62	24	0.60	26	0.71	17	0.62	8
9	Durability of Building Components	Q-DBC	0.54	52	0.61	25	0.59	30	0.70	18	0.61	9
10	Agreed Quality Assurance Procedures	Q-AQA	0.54	54	0.61	27	0.59	31	0.70	19	0.61	10

* RII - Relative importance index: if individual factors are equal, they are ranked according to the number of respondents scoring 4 or more, R** - Rank of 80 critical factor in each category and phase

Table 13 Criteria Matrix of Critical Factors by phases for WLPA– CONTRACT/ADMIN, HUMAN RESOURCE, RISK and HEALTH&SAFETY

Critical Factor			Weighted Critical Factor for Whole Life Performance Assessment									
			Pre-Design		Design		Procurement		Construction		Post-Construction	
R*	**CONTRACT/ADMINISTRATION**	Code	RII	R**	RII	R**	RII	R**	RII	R**	RII	R**
1	Mutual/trusting Relationships	CA-MTR	0.54	53	0.54	61	0.59	29	0.55	68	0.53	21
2	Disputes Resolution Procedure	CA-DRP	0.53	60	0.53	62	0.58	33	0.54	69	0.52	26
3	Changes in Contact	CA-CCO	0.53	61	0.53	63	0.58	34	0.54	70	0.52	27
4	Inclusion of All Risks	CA-IAR	0.51	64	0.51	64	0.56	50	0.52	74	0.50	46
5	Implement of Partnering	CA-IOP	0.50	67	0.50	65	0.54	54	0.51	75	0.48	58
6	City Planning Regulations	CA-CPR	0.50	68	0.50	66	0.54	55	0.51	76	0.48	59
7	Procured Similar Projects Within 5 year	CA-PSP	0.50	69	0.50	67	0.54	56	0.51	77	0.48	60
8	Conformity of Supplier's Subcontracting to Contract	CA-CSS	0.49	70	0.49	70	0.54	57	0.50	78	0.48	64
9	Procurement Arrangements	CA-PAR	0.49	71	0.49	71	0.54	60	0.50	79	0.48	68
10	Technical Bid Evaluation	CA-TBE	0.48	72	0.48	72	0.53	63	0.49	80	0.47	74
R	HUMAN RESOURCE											
1	Leadership / Team Management	HR-LTM	0.59	21	0.61	30	0.58	36	0.68	30	0.54	17
2	Skilled Personnel	HR-SPE	0.59	22	0.61	31	0.58	37	0.68	31	0.54	18
3	Team communication	HR-TCO	0.58	34	0.59	39	0.56	48	0.66	37	0.52	23
4	Labour productivity	HR-LPR	0.57	38	0.58	42	0.56	51	0.66	40	0.52	29
5	Efficiency of Project Organisation	HR-EPO	0.55	50	0.56	48	0.53	61	0.63	49	0.50	47
6	Pride in Their Work	HR-PRW	0.54	51	0.56	50	0.53	62	0.63	51	0.49	48
7	Need for Collaboration	HR-NCO	0.54	55	0.55	54	0.53	64	0.62	53	0.49	52
8	Integrity and Honesty	HR-IAH	0.54	56	0.55	55	0.53	65	0.62	54	0.49	53
9	Motivation for Project	HR-MFP	0.54	57	0.55	57	0.53	67	0.62	55	0.49	55
10	Monitoring and Feedback	HR-MAF	0.54	58	0.55	58	0.53	68	0.62	56	0.49	56
R	RISK											
1	Defective Design	R-DDE	0.62	8	0.61	28	0.63	18	0.66	39	0.53	22
2	Defective Materials	R-DMA	0.61	12	0.60	35	0.61	20	0.65	46	0.52	28
3	Risk Response	R-RRE	0.60	15	0.60	37	0.61	21	0.64	47	0.52	30
4	Financial Stability of Client	R-FSC	0.60	20	0.59	40	0.60	25	0.63	48	0.51	35
5	Accuracy of Project Program	R-APP	0.59	24	0.58	43	0.60	28	0.63	50	0.50	40
6	Change Order Negotiations	R-CON	0.57	35	0.57	47	0.58	35	0.61	58	0.49	51
7	Contractor Competence	R-CCO	0.57	40	0.56	51	0.57	41	0.60	59	0.48	61
8	Cash Flow Reliability of Project	R- CFR	0.57	41	0.56	52	0.57	42	0.60	60	0.48	62
9	Risk Management Techniques	R-RMT	0.56	43	0.55	53	0.57	44	0.60	62	0.48	65
10	Risk Identification	R-RID	0.56	44	0.55	56	0.57	45	0.60	63	0.48	66
R	HEALTH&SAFETY											
1	Management of Work Safety on Site	HS-MWS	0.50	65	0.50	68	0.51	71	0.73	12	0.54	19
2	Hazard Identification	HS-HID	0.50	66	0.50	69	0.51	72	0.73	13	0.54	20
3	Cleanliness and Order on Site	HS-COS	0.47	73	0.47	73	0.48	73	0.69	26	0.51	36
4	Teaching of Accident Prevention	HS-TAP	0.47	74	0.47	74	0.48	74	0.69	27	0.50	41
5	Personal Protective Equipment	HS-PPE	0.46	75	0.46	75	0.48	75	0.68	32	0.50	43
6	Health and Safety Records	HS-HSR	0.45	76	0.45	76	0.47	76	0.67	35	0.49	54
7	Teaching of First Aid Skills	HS-TFA	0.45	77	0.45	77	0.46	77	0.66	38	0.48	57
8	Skilled Personnel	HS-SPE	0.44	78	0.44	78	0.46	78	0.65	43	0.48	67
9	Management Responsibility	HS-MRE	0.44	79	0.44	79	0.45	79	0.65	44	0.47	70
10	Site Safety Resources	HS-SSR	0.44	80	0.44	80	0.45	80	0.65	45	0.47	71

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