Managing Projects to Reduce Delivery Schedule Failures

Ajibade Ayodeji Aibinu
Faculty of Architecture Building and Planning, University of Melbourne, Australia
(email: aaibinu@unimelb.edu.au)

Abstract

The problem of project delivery schedule failure is an old but recurring problem in the construction industry. In this study, the significance of forty-four sources of project delivery schedule failure were examined based on a survey of 35 construction contractors, 46 quantity surveyors, and 19 designers in Nigeria. The results shows that there is agreement between the three 3 groups of respondents regarding the ranking of the 44 sources of schedule failure. Clients' cash flow problems, contractors' financial difficulties, incomplete drawings, equipment problems, late instructions, poor supervision, material shortages, variation/change orders, planning and scheduling problems and price escalations were believed to be among the top significant sources of the problem. Using cost data obtained from 43 private sector- and 17 public sector- procured projects, the impact of variations orders and price escalation on delivery schedule failure were quantified. Simple Linear Regression Analyses show that about 16% percent of project delivery schedule failure can be explained by variations ordered by clients and their consultants while another 16% can be explained by price escalation. In order to lessen project delivery schedule failure, clients and their project management team need to pay greater attention to the most significant factors. In particular, they need to give adequate time for project planning in order to adequately capture client's needs, ensure adequate scoping of project, reduce incompleteness of design, reduce design errors and thereby reduce variations during construction. Clients need to arrange for sufficient finance prior to project award; and during tendering, consultants should conduct thorough due diligence investigation to ensure that the selected contractor is financial capable and has sufficient financial and management capability. The use of management-led procurement approach could also mitigate coordination and decision-making problems. Based on anticipated inevitable changes/variations and price escalation during construction, the regression models developed could assist professionals at the pre-contract stage when estimating projects cost and time.

Keywords: Schedule, Delays, Project delivery, Procurement, Contractors, Designers, Quantity surveyors, Nigeria

1. Background

Project delivery schedule are notorious for their inability to deliver according to plan. In Nigeria the problem is severe and is a major cause of cost overrun. Projects in Nigeria overrun their contract duration by between 50 and 420% [1]. Delivery schedule slippage could have significant effect on the completion cost projects [2]. It often generates conflict between parties when they are unable to determine and allocate responsibility for the problem [3]. Conflict and dispute could lead to further delivery schedule slippage. Factors contributing to schedule slippage are many. In an earlier study, variation order and price escalation were found to be factors significantly influencing schedule failures and cost overrun in Nigeria projects. However, there are few published quantitative studies making use of real life projects on the subject. Understanding of the sources of the problem and quantifying their impact using real life data would provide a better understanding of the problems and how they can be alleviated. The objectives of this study are:

- to understand how quantity surveyors, designers and contractors perceive the significance of the various sources of project delivery schedule failures
- to explore whether there is agreement between the 3 groups regarding the identified sources of delivery schedule failures.
- to quantify the impact of variation orders and price escalation on project delivery schedule failures.
- based on the findings, offer some recommendations on ways of managing projects to reduce delivery schedule failure.

The results provide useful information on ways of managing projects to ensure timely completion.

2. Literature Review

Dlakwa and Culpin found that variation orders, design errors, deficiencies in public agency organizations and deficiencies in contractor organizations, price fluctuation and late payment to contractor were among the most cited reasons for delay in public projects in Nigeria [4]. Mansfield et al found that the problem of financing of and payment for completed works, poor contract management, change in site conditions and shortages of materials are the four most important causes of delays and cost overruns in public highway and building projects [5]. Odeyinka and Yusif classified the causes of delays in Nigeria housing projects into 4 categories namely client-, consultant-, and contractor-caused delays, and extraneous factors [6]: Their findings show that Client-caused delays arise from variation orders, slow decision making and cash flow problems while contractor-caused delays results from financial difficulties, material management problems, planning and scheduling problems, inadequate site inspection, equipment management problems, and shortage of manpower. The

causes of consultant -caused delays identified include: incomplete drawing, slow response by consultant, variation orders, late issuance of instruction, and poor communications. Inclement weather, Acts of God, labor dispute and strikes were found to be extraneous factors responsible for delays.

Elinwa and Joshua surveyed construction practitioners in Northern Nigeria and found that the relative contributions of the client, contractor, and others to time overrun are 62, 32, and 6% respectively [7]. Factors responsible for project delivery schedule slippage have been studied in other countries (see Aibinu and Odeyinka [8] for a detailed review).

Bramble and Callahan classified the causes of delays by looking at the responsibility of major parties to the design and construction process [9]. According to the authors, owner-caused delays could arise from late release of site to the contractor, late approvals, financial difficulties, contract administration responsibilities, change orders and interference while designers-caused delays could arise from design defects, slow correction of design errors, tardy shop drawings review, and delays due to test and inspection. Failure to evaluate the site and design, contractor management problems, inadequate resources and construction defects were listed as potential sources of contractor-related delays while weather, act of God, strikes and labour disputes were identified extraneous factors that could cause delivery schedule slippage.

In this study, the sources of project delivery schedule failure are investigated by looking at the responsibilities of project participants as highlighted by Bramble and Callahan [9]. The level of agreements among contractors, designers, and quantity surveyors regarding the significance of the sources are also tested. Empirical relationship between variation orders and delivery schedule failure, and between price escalation and delivery schedule failure were analysed, which is lacking is previous studies.

3. Research Method

3.1 Data Collection and Sampling

Based on the literature review and a pilot survey of selected construction industry practitioners, 44 sources of delivery schedule failure were identified and developed into a questionnaire (see Table 1). The respondents were asked to rate the extent to which each of the factors contributed to delivery schedule failure on projects they have been involved. They were asked to respond by assigning weights to each factor from 1 to 5 where *'1' is not significant and '5' is extremely significant'1'*. The questionnaire was sent to 60 contracting firms, 90 quantity surveying firms, and 50 design firms (architect/engineers) in South-western Nigeria.

3.2 Response Rate and Characteristics of Sample

Of the 60 contractors surveyed, 35 responded representing a response rate of 58% while out 90 quantity surveyors 46 completed and return the questionnaire representing 51% response

rate. Of the 50 questionnaire sent to designers 21 were returned representing a response rate of 42%. Overall, the respondents have 22 years of experience, and on the average, they have been involved in 32 projects. The majority are bachelor's degree holders (83%) and are professionally registered (86%). Thus it is understood that the data obtained from the respondents can be relied upon with confidence.

4. Data Analysis and Results

4.1 Sources of Project Delivery Schedule Failure

To address objective 1, the contributions of the 44 factors to delivery schedule failure were determined by transforming the five-point Likert scale into Relative Significance Index (RSI) for each factor [10] using the following expression:

$$\text{RSI} = \frac{A}{B \times C}$$

Where:

A = total Score;

B = highest response option (5 in this study);

C = total number of responses; and

$0 \leq RSI \geq 1$.

The factors are then ranked based on their RSI's. RSIs were computed for quantity surveyors, designers and contractors (Table 1).

According to quantity surveyors (Table 1), the top 15 most significant sources of delivery schedule failure include: client change orders, client slow decision making, client cash flow problem, incomplete architectural drawing, architect late issuance of instruction, incomplete structural drawing, contractor financial difficulties, contractor planning and scheduling problem, contractor shortage of manpower, material shortages, late delivery of ordered materials, equipment breakdown/ maintenance, delays in manufacturer delivery, nominated suppliers cash flow problems, and price escalation.

Table 1: Relative Significant Indices and Ranking of Sources of Delivery Schedule failure

Variable Name	Quantity Surveyors		Designers		Contractors	
	*RSI	*R	*RSI	*R	*RSI	*R
Client variation/change orders	0.66	**13**	0.64	**13**	0.70	**11**
Client slow decision making	0.65	**15**	0.63	**15**	0.68	**15**
Client cash flow problem	0.84	**1**	0.82	**1**	0.81	**3**
Late contract award	0.52	43	0.56	28	0.52	40
Late preparation of interim valuation	0.53	41	0.56	29	0.66	18
Late valuation of variation	0.56	36	0.62	17	0.67	16
Incomplete architectural Drawing	0.78	**3**	0.62	18	0.83	**2**
Architect Late issuance of instruction	0.68	**11**	0.53	37	0.71	**9**
Architect variation/change orders	0.62	19	0.65	**9**	0.70	**12**
Architect inadequate supervision	0.59	27	0.54	35	0.58	31
Poor information dissemination	0.60	26	0.57	25	0.56	34
Architect delays in work approval	0.60	24	0.56	30	0.61	25
Incomplete structural drawing	0.74	**6**	0.56	31	0.76	**4**
Structural engineer change orders	0.59	28	0.49	41	0.62	24
Structural engineer late issuance of instruction	0.63	18	0.55	33	0.65	22
Structural engineer inadequate supervision	0.59	29	0.57	26	0.61	28
Poor structural design information	0.61	21	0.51	39	0.59	29
Incomplete services drawing	0.65	16	0.62	19	0.76	**5**
Services engineer change orders	0.56	37	0.59	21	0.65	23
Services engineer late issuance of instruction	0.59	30	0.56	32	0.66	19
Services engineer inadequate supervision	0.58	32	0.64	**14**	0.61	26
Poor services design information	0.61	22	0.55	34	0.54	36
Contractor financial difficulties	0.84	**2**	0.80	**2**	0.89	**1**
Contractor Planning and Scheduling Problem	0.74	**7**	0.72	**3**	0.66	17
Contractor inadequate preconstruction site inspection	0.58	33	0.59	22	0.53	39
Contractor shortage of manpower	0.66	**14**	0.65	**10**	0.58	32
Material shortages	0.67	**12**	0.65	**11**	0.70	**10**
Change in material specification	0.62	20	0.59	23	0.52	42
Unforeseen material damages	0.54	39	0.52	38	0.76	**6**
Late delivery of ordered materials	0.74	**8**	0.68	**5**	0.61	27
Material delivery not in accordance with specifications	0.55	38	0.63	16	0.54	37
Equipment breakdown/ maintenance	0.77	**4**	0.68	**6**	0.49	43
Equipment shortage	0.64	17	0.66	**8**	0.75	**7**
Equipment delivery problem	0.57	35	0.60	20	0.65	21
Inadequate skill of operators	0.60	25	0.59	24	0.65	20
Delays in manufacturer delivery	0.72	**9**	0.67	**7**	0.72	**8**
Nominated suppliers cash flow problems	0.77	**5**	0.72	**4**	0.57	33
Price escalation	0.70	**10**	0.65	**12**	0.69	**13**
Government regulations	0.59	31	0.54	36	0.54	38
Inclement weather	0.61	23	0.51	40	0.68	**14**
Acts of God	0.46	44	0.37	44	0.42	44
Labour dispute and strikes	0.58	34	0.47	42	0.59	30
Civil disturbances	0.54	40	0.46	43	0.55	35
Slow permit by government agencies	0.53	42	0.57	27	0.52	41

*RSI= Relative Significance Index; R = Rank; (Top 15 sources are highlighted)

According contractors (Table 1), the following are the top 15 significant factors that are responsible for delivery schedule failure on projects: Contractor financial difficulties, incomplete architectural drawing, client cash flow problems, incomplete structural drawings, incomplete services drawing, unforeseen material damages, equipment shortage, delays in manufacturers' delivery, architect late issuance of instruction, material shortages, client change orders, architect change orders, price escalation, inclement weather, and client slow decision making.

Designers perceived the following as the top 15 significant sources of the problem: Client change orders, client slow decision making, client cash flow problem, architect change orders, services engineer inadequate supervision, contractor financial difficulties, contractor planning and scheduling problem, contractor shortage of manpower, material shortages, late delivery of ordered materials, equipment breakdown/ maintenance, equipment shortage, delays in manufacturer delivery, nominated suppliers cash flow problems, and price escalation.

It is observed that there is almost a perfect agreement between quantity surveyors, contractors and designers regarding the ranking of the following: (1) Client change orders (2) client slow decision making (3) client cash flow problem (4) material shortages (5) price escalation and (6) contractor financial difficulties.

4.2 Test for Agreement between Respondents

The following sub-hypotheses were tested to address objective 2 of the study, which is to statistically determine whether there is agreement between the 3 groups regarding the overall ranking of the 44 sources of project delivery schedule failure:

Hypothesis 1: There agreement between quantity surveyors and designers regarding the ranking of the 44 sources of project delivery schedule failure.

Hypothesis 2: There is agreement between quantity surveyors and contractors regarding the ranking of the 44 sources of project delivery schedule failure.

Hypothesis 3: There is agreement between the designers and contractors regarding the ranking of the 44 sources of project delivery schedule failure.

Spearman's rank correlation analysis was employed to test the hypotheses. Spearman's rank correlation coefficient (r_s) measures the correlation between two sets of rankings and was determined using the expression:

$$r_s = 1 - 6 \sum D^2 / n(n^2 - 1)$$

Where:

D is the difference between the rank given by one group and that given by the second group

N is the numbers of items being evaluated (44 items in this study)

The rank correlation coefficients r_s is from -1 to +1. A correlation of coefficient of +1 suggests a perfect linear correlation while a value of -1 means a negative correlation implying that a high ranking by one group is associated with low ranking by the other group. A zero value indicates that no linear association exists. Since the three groups of respondents are from random samples of population, we may test for true agreement in ranks by using the values of the observed r_s. We may test at a chosen level of significance the null hypothesis that the two groups under comparison differ as regards the ranking of the factors [11] i.e. that the rankings are independent in the population and the observed value of r_s differs from zero only by chance. Table 2 summarize the results. The results support hypotheses 1 (r = 0.612, p = 0.000), hypotheses 2 (r = 0.502, p = 0.001) and hypotheses 3 (r = 0.309, p = 0.041). Thus, we may conclude that there is agreement between contractors, quantity surveyors and designers regarding the contribution of each of the 44 factors to project delivery schedule failure. However, it is observed that agreement between designers and contractors is the weakest (0.309).

Table2: Result of Spearman's Rank Correlation Coefficient

		Designer	**Quantity Surveyor**
Quantity Surveyor	Correlation Coefficient	0.612**	
	Significance probability	0.000	
	n	44	
Contractor	Correlation Coefficient	0.309*	0.502**
	Significance probability	0.041	0.001
	n	44	44

** Correlation is significant at 0.001 level

* Correlation is significant at 0.05 level

4.3 Impact of Variation Orders and Price Escalation on Project Delivery Schedule Failure

Consistent with previous studies, the results from questionnaire analysis show that change order and material price escalation are among the top 15 most significant factors contributing to project delivery schedule failure. Thus a further analysis was conducted to address objective 3, which is to quantify the impact of variation orders and price escalation on project delivery schedule failure. This was achieved by analysing data on 60 completed projects obtained from quantity surveying firms. Two linear regression models (model 1 ad 2) were set up with project delivery schedule failure (Y) as dependent variable in each of the models and variation/change order (A) and price escalation (B) as the independent

variables in model 1 and model 2 respectively. The models are expressed in mathematical form follows:

$$Y = f(A) \ldots\ldots \text{Model 1}$$

$$Y = f(B) \ldots\ldots \text{Model 2}$$

Where:

Y is project delivery schedule failure (measured by the amount of discrepancy between contract and actual project duration.

A is the magnitude of variations/changes ordered by clients and their consultants (measured in terms of the monetary value of variations claims paid to the contractor as reflected by the final account statement of each project); and

B is Price Escalation (measured by the amount of fluctuation claims paid to the contractor as reflected by the final account statement of each project).

The hypotheses are that: significant changes in project delivery schedule failure can be explained by variation orders; and that significant changes in project delivery schedule failure can be explained by price escalation. Prior to data analysis, the monetary values of variation/change order and fluctuation claims for all the projects were brought to same base using the Consumer Price Index Published by the Federal Office of Statistics, Nigeria. The regression results (Table 3) show that about 16% changes in project delivery schedule failure can be explained by variations ordered by clients and their consultants ($R^2 = 0.157$, $F = 11.966$, $p = 0.001$).

Table 4 *Result of Regression Analysis*

Variable	**Predictor**	**β Coefficient**	**Standard Error**	**t value**	**p value**
Project Delivery Schedule Failure (Y)	Constant	5.139	0.698	7.360	0.000
$R^2 = 0.171$	**Variation (A)**	0.423	0.122	3.459	0.001
R^2 Adjusted = 0.157					
Project Delivery Schedule Failure (Y)	Constant	5.324	0.688	7.740	0.000
$R^2 = 0.168$	**Price Escalation (B)**	0.410	0.178	3.424	0.001
R^2 Adjusted = 0.154					

*Variables are significant at 5% level ($p < 0.05$)

Also, 16% of the changes in discrepancy between contract and actual project duration (projects delays) can be explained by price escalation ($R^2 = 0.154$, $F = 11.724$, $p = 0.001$). The result suggest that variations ordered by project owners and or their representatives and

price escalation both accounted for a significant change (about 32%) in delivery schedule failure. The following are the regression models of the relationships:

Estimated Regression model 1 (for Variation orders): $Y = 5.139 + 0.414A$

Estimated Regression model 2 (for Price Escalation): $Y = 5.324 + 0.410B$

Where: Y is project delivery schedule failure

A is Variation or changes ordered by clients and their consultants

B is Price Escalation

5. Discussion

This study shows that variation orders, price escalation, poor planning and scheduling, client slow decision-making, client cash flow problems, contractor financial difficulties, incomplete design, design errors inadequate supervision, and late issuance of instructions are the top most significant sources of project delivery schedule failure in Nigeria building projects. Variations ordered by clients and their consultants, and price escalation accounts for 32% of the problem.

The findings are not unexpected. Variations could disrupt the progress of work and prolong the contract period. Also, when not sufficiently provided for in the contract (by way of management reserve or contingency), price escalation could to lead to financial difficulties and clients putting aside projects for months before they are continued. It may also lead to contractor's financial difficulties when domestic sub-contractor and suppliers' price upon which tender estimates are based becomes outdated. These problems could further generate tension and conflict at all levels of the supply chain hence disruption to progress on site and further delivery schedule problems.

Price escalation is a serious problem in Nigeria. Over the last 2 decades the Nigeria economy has witnessed a high and fluctuating level of inflation rising from 4.1% in March 1991 to 78.2% in August 1995 and 16.8% in September 2005 (Federal; Office of Statistics, Nigeria) and 10.5% in 2006 (CIA World Fact Book). This puts Nigeria in number 32 out of 211 countries on inflation rate ranking (CIA World Fact Book). It is likely that the impact of price escalation on project delivery schedule failure is exponential rather than arithmetical in that during the period when projects are delayed due to price escalation, there could be further price escalation leading to further delays. To exacerbate the problem, contingencies included in contract sum are often based on 5 – 10% rule of thumb and often inadequate [2]. Regarding poor planning and scheduling, a most recent survey of the impact of ICT on professional practice in Nigeria shows that less than half of the respondents use project planning software [12].

Also, client's slow decision-making is serious problem in public sector projects. The structure of most public clients' organization is such that independent consultants engaged on projects are cut off from client's top executives. In the author's experience while monitoring a major public sector project in Nigeria, sometimes decisions on matters affecting time and cost of projects are made in the absence of the responsible professionals. The inputs of independent consultant project managers and professionals in the client's decision-making are often frustrated by lack of independence and the bureaucratic nature of public clients' organisations. Contractors sometimes openly disregard and despise directives of the independent project manager and professionals on believe that there will be no penalty enforced by the client (government departments or authorities) for lack of performance. It would appear that political ties dictate the tune.

Further, while integrated procurement method such as design and build; and management-led procurement such as management contracting and construction management are well known among stakeholders in Nigeria, the use of traditional method procurement method is still dominant [13]. In fact, all the projects analysed in this study were completed using traditional method of procurement. This may explain the problem of late instruction and slow decision-making.

6. Conclusion and Recommendations

Based on the findings of this study, it is apparent that clients and their project management team (quantity surveyors, designers, and other consultants) need to take responsibility for timely delivery of projects by paying greater attention to how projects are managed at the conception, planning and construction stage. The following recommendations are proposed for managing projects to reduce delivery schedule failure:

Building Capability in Project Management and Promoting Project Management Climate

Clients and construction practitioners need to build capability for managing projects and to promote project management culture. This is essential as there is now an unprecedented increase in size and complexity of projects, which cannot be ignored. To build project management capabilities, professional bodies in Nigeria need to mandate project management training and competence as core aspect of continuous professional development and criteria for registration of professionals.

When procuring projects, clients and their consultants need to give sufficient time for client's briefing to understand client's needs and clarify project objectives at project inception in order to reduce future variations to project scope. They need to spend more time on planning and design of project to reduce design errors and incomplete drawings. Poor planning and scheduling could be reduced by the use relevant information technology tools. Promoting project management culture and coordinating with the client could reduce late instruction, poor supervision, and slow decision-making.

Further, professionals are considered to be of superior knowledge and they owe a duty of care to their clients. In their advisory role, clients' project management team need to ensure that clients obtain sufficient finance prior to project commencement, conduct due diligent investigation to ensure that capable contractor with appropriate financial and management expertise is selected at the tender stage. In this regard, following due process in project procurement (especially in the public sector) and during tendering is a way forward.

Improving Clients Project's- and In-house Organisational Structure

The problem of client's slow decision-making (especially in the public sector) could be addressed by reforming public sector procurement policy to ensure due process, transparency and reduce bureaucracy. Such reform needs to provide for-, guarantee-, and protect- the independence of construction professionals in project procurement. While the new Public Procurement Act, 2007 (developed on behalf of the Federal government of Nigeria by World Bank and in collaboration by some Nigeria private specialist) passed by senate in June 2007 is a step forward in improving the performance of public project delivery, there is still a lot to be done regarding the provisions of the Act which are beyond the scope of this study.

Using Appropriate Procurement Strategy and Project Governance

There is need to consider the use of design- and management-led procurement approach for projects procurement in order to reduce project delivery schedule failure. However, choice of procurement arrangement option for each project should be subject to other project peculiarities such as risk, complexity of project, quality requirements and cost. The advisory role of Nigeria professionals who act as clients advisers is critical in this regard. Optimum procurement arrangement option should be chosen based on consideration of relevant criteria. A mismatch of procurement method and project peculiarities will certainly lead to failed project (delivered beyond budget cost and schedule and with poor quality). Thus professionals need to build capability in procurement management and project governance.

Improving the Accuracy of Project Time and Cost Estimates

Turning to the problem of price escalation, this study discovered that price escalation could explain a significant amount of project delivery schedule failure. While the problem of price escalation is national issue, professionals such as quantity surveyors have an important role to play. The challenge is to find ways of improving the accuracy of cost and time estimates of projects. Contingency estimate based on 5 – 10% rule of thumb is certainly inadequate in Nigeria. There would be need to improve methods for quantifying risks, including price escalation, and taking them into proper account when estimating project cost and time. This may be achieved by the use of appropriate risk management and modeling tools. Also, the practice where public sector clients in-house executives and professionals reduces project budget to get their favourite project approved need to be discouraged as it could be a major

source of cash flow problems resulting from unrealistic and inadequate budget and time estimates.

In this study, 2 regression models were developed representing the relationship between variation orders and project delivery schedule slippage; and between price escalation and project delivery schedule slippage. The models could be used by professionals to predict the likely time overrun on projects based on anticipated uncontrollable changes to project scope and based on anticipated price escalation during construction period. The assessment could be factored into project time and cost estimate thereby increasing price and cost certainty prior to project commencement. It is likely that certainty of project cost and time could reduce lending institutions perceived risk of construction projects financing in Nigeria. This could increase their confidence in construction business thus increase in construction industry access to capital and inadvertently may reduce contractors and clients financial difficulties which are top ranked sources of project delivery schedule failure.

7. Significance of the Findings

This study provides useful information to stakeholders and foreign architectural engineering and consultancy (AEC) firms in Nigerian construction industry and to those contemplating venturing into Nigeria construction market on some of the forces that could influence project delivery schedule failure on their projects. It provides information that could support project planning and bid preparation. It also indicates areas in which firms could add value to project execution in Nigeria and thus increase their market share. It also provides vital information to pubic policy-makers in Nigeria and those who have control over the procurement of projects. While the new Public Procurement Act, 2007 is a step forward for improving the performance of public project delivery, the understanding gained from this study would assist when implementing the Act. The findings of this study also could assist in amending the Act in the future. Other levels of government proposing to develop procurement policies may also find the results useful. Although the data for this study is from Nigeria, the findings are applicable to other developing countries as they are faced with similar situation. This study is useful to international organizations such as World Bank, who are providing aid and supporting capacity building in developing economies. It provides them with independent knowledge of some of the problems and challenges of project procurement in Nigeria and developing economies. The findings are critical for poverty reduction in that a huge amount of public sector spending in developing countries and loans provided by international organizations as loans are expended on programs with huge construction element. Thus by improving public sector procurement policies to reduce project failure will be most beneficial to the common people in developing economies.

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The contractor–subcontractor relationship: the general contractor's view

Adnan Enshassi,
School of Civil Engineering, IUG, Palestine
(email: enshassi@ iugaza.edu.ps.)
Zohair Medoukh,
Consultant, Universal Group, Gaza

Abstract

Subcontractors play a significant role in the Palestinian construction industry. The relationship between the general contractor and subcontractors is one of the keys to any successful construction project. Despite this importance, little information is available about the actual working relationship which exists between general contractors and subcontractors. Subcontractors are specialist agents in the execution of a specific job, supplying manpower, equipment, tools, and designs. They respond only for the executed part of the workmanship, acting as agents of the production system of the contracting company. The aim of this paper is to explore the actual working relationship between contractors and subcontractors. This study was based on a questionnaire survey of general contractors in the Gaza Strip. Information was obtained on reason, for subcontracting, communication process, selection criteria, negotiation with subcontractors, commitment, type of contract, and control tools. The results indicate that more than 90 percent of the work is performed by subcontractors. General contractors select subcontractors according to the complexity of the work and previous experience with subcontractors.

Keywords: Contractors, subcontractors, relationship, construction, development.

1. Introduction

The contribution of subcontractors to the total construction process can account for 80-90% of the total value of the project [1; 2; 3; 4]. This large involvement of subcontractors can be attributed to the shift from the traditional craft base, to a greater reliance on increasingly sophisticated technology-based products [2]. This has resulted in general contractors concentrating their effort, on managing construction site operations rather than employing direct labor to undertake construction work [3]. Arditi et al [5] has also attributed the increased use of subcontractors to the increased complexity of both the construction of buildings and the organizational relationship.

Subcontractors contribute significantly to the capital risk, resources, managerial effort, and business expertise supporting the largest industry in the country. The trend toward more subcontracted work accelerated as the technical development of building materials and methods escalated the requirement for craft skill and knowledge. Quality control and labor management problems on construction projects became less complicated for general

contractors utilizing specialty trade subcontractors in lieu for furnishing all craft labor themselves [6]. Hinze and Tracy [1] have studied the working relationship between subcontractors, and contractors in the United States from the subcontractor's perspective. They put forward a series of recommendations to improve the subcontractor-main contractor relationship. The purpose of this study is to explore the actual working relationship between general contractors and subcontractors in the Gaza Strip for the main contractors' perspective.

2. Overview of the construction sector

Construction sector is one of the key economic sectors and is the main force motivating the Palestinian national economy. Upon the establishment of the Palestinian National Authority and the assumption of its powers over the Palestinian territories in 1994, the construction sector has witnessed noticeable expansion and activities. The contribution of the construction sector to the GDP is currently rising in real terms and as a percentage of the total labor force. Construction sector contributes 33% to the Palestinian GDP. This is a large proportion covered by this sector, thus positively affecting various economic, social, educational and vocational sectors in addition to other Palestinian institutions. Construction is one of the most important sectors in the assimilation of labor force throughout Palestinian cities and towns. Construction sector employs an average of 22.3% of Palestinian labor force volume. It employs about 10.8% of laborers directly, and 30% indirectly in factories related to the construction sector and other service and productive sectors. Construction sector contributes largely to different sectors of investment, such as manufacturing of construction materials. In addition, it provides materials needed for construction, such as stone, marble, brick, floor tiles, etc. Further, the sector is one of the main resources of the commercial sector in Palestine [7].

This has resulted in the recovery of the construction contracting profession and subsidiary industries, encouraged the investment of the Palestinian expatriates' capital in the local construction sector, and contributed to the creation of jobs for thousands of Palestinians. Therefore, the construction sector has occupied the foremost position among the rest of sectors, mainly in the attraction of investments and creation of new jobs. In addition to subsidiary industrial and productive sectors, construction sector is the largest and most important of all other sectors. As such, the construction sector has been crucially significant, mainly in the past two years, for the role it plays in reconstruction, road rehabilitation and construction of infrastructure.

The typical image of the construction contracting profession, whether in the Arab World or in Palestine does not match the role active contractors' play in the building of their societies. Contractors are effective entities involved in all professions subsidiary to the construction sector through a complementary relationship. Further, contractors possess the skills necessary for financial management and project administration. Taking into account that a large number of Palestinian contractors are engineers, contractors' professional experience is also consolidated by Palestinian expatriates. Such status has led to the upgrading of the construction contracting profession in Palestine as regards quality, specialty and professionalism.

Construction contracting is considered the hub for construction sector in Palestine. Hence, Palestinian contractors have proved their national role and outstanding ability in construction and reconstruction. In addition, construction sector proficiency been enhanced following the establishment of the Palestinian National Authority in 1994. According to recent figures, contractors registered as members at the PCU have amounted to (1180) throughout Palestinian cities and towns in July 2003. Contractors registered as members in the West Bank have been (800), and those registered in the Gaza Strip have reached (380).

3. Previous studies

Subcontracting has been defined as a legal-economic relationship between two agents, in which the characteristic criteria are substitution and subordination. The substitution criterion means that the subcontractor executes the operation with technical and financial risks, instead of the job assignor; the subordination criterion means the subcontractor must follow the direction given by the contractor (Pagnani, cited in [5]. Another definition was given by Hinze and Tracy [4] who stated that the subcontractors are specialty contractors who are hired to perform specific tasks on a project. Subcontracting can be classified as volume subcontracting and specialist subcontracting. Volume subcontracting can be used when an enterprise commission a subcontractor because, while technically able to carry out the operation, it is overloaded and has to obtain additional capacity from another source. Specialist subcontracting can be used, when the main contractor obtains goods or services, which he does not produce or is not able to produce himself.

Beardsworth et al [8] pointed out that subcontracting could be seen as an organizational alternative for some economic activities. Firms are decentralizing their jobs more and more, allowing subcontracting to become a basic part of the work organization. Firm does not need to have the control of all the value string, being able to externalize non-strategical activities, aiming to reduce costs. The subcontractor's typical source of work is the general contractors that assume responsibility for complete construction of the project. At any point of time, the subcontractor is providing specialty construction services to a number of general contractors with varying expertise in subcontract development, subcontractor management and relations; project management, coordination, and control; and project cash-flow reliability. Decisions on individual projects are often influenced by the objective of sustaining an on-going relationship. Both the short-term (project) and long-term relationship with the general contractors are essential to the success of all specialty contractors [6].

Bennett and Ferry [9] described building firms as organized into a consistent operating core based on their individual capabilities. Construction companies are becoming construction managers or contractor managers, transferring construction work to specialists. Subcontractors are specialists' agents in the execution of a specific job, supplying work force, besides materials, equipment, tools or designs. They respond only for the executed part of the workmanship, acting as agents of the production system of the contractor company. Specialty contractors are construction

"job shops", performing construction work that requires skilled labor from one or at most a few specific trades and for which they have acquired special-purpose tools and equipment as well as process know-how [10].

Chung and Ng [11] have studied the practice of subcontractor appraisal in the construction of Hong Kong. They have developed a common standard to monitor the performance of suncontractors and to uplift the quality standard of construction works eventually. Russell and Mcgowan [12] stated that up to 95% of the total project value was entrusted to subcontractors in Canada. The trends was similar in Asia countries like Japan [13] and Singapore [14]. Adriti and Chotibhongs [1] investigated a number of issues in subcontracting practice such as: safety issues, productivity issues, construction insurance, and subcontracting bonding.

4. Method

This study was based on a questionnaire survey of general contractors in the Gaza Strip. The questionnaire design was based on previous related literature [1. 3, 5, 6, 15] and contractors' expert. The content and understanding of the questionnaire have been reviewed and tested. 100 questionnaires have been sent to general contractors randomly. 53 (53%) completed questionnaire have been returned and descriptive analysis has been used.

5. Results

The results indicated that the majority of the general contractors' respondents stated that it is a common practice to use subcontractor to execute specific operation in the project. They added that more than 90% of the works are performed by subcontractors. This result is similar to previous researches results in USA, UK, Hong Kong, and Brazil. The main reasons behind using subcontractors were found to be shortages of skilled labor, maximizing profit, reducing overhead costs, and reducing the work pressure on the main contractors. In addition, monitoring and controlling quality control, safety management, and labor management problem, on construction projects become less complicated for general contractors.

Concerning communication process between major contractors and subcontractors, 50% of respondents indicated that informal, face to face communication was the main mean for communication. The results indicated that 33% of respondents communicate with subcontractors by telephone. Only 6% of the respondents have mentioned that they have formal communication (using letters) with subcontractors. This result reflects the informal characteristics relationship between general contractors and subcontractors. This type of relationship (litte documentation) can be a source of problems which may affect the progress and the quality of the work.

The majority of respondents (60%) have stated that they select subcontractors according to the required specific activity and to the nature and complexity of the work. It has been noticed from the results that 13% of general contractors' select subcontractors according to their previous experience with them. Surprisingly, 7% of the respondents select subcontractors based on their reputation. This can be traced to the trend of the major contractors in the local industry in selecting the lowest bid regardless of the safety and quality of work.

It has been found that 70 % of the respondents gave all necessary drawings and bill of quantities to subcontractors in order to estimate their costs for the required operations. It was noticed that only 7% of subcontractors have visited the construction sites during the estimation process. This has led, in many cases, to inaccurate cost estimation which affected the quality of the work as subcontractors are interested to make profit without enough attention to the quality of the work being implemented (this has increased the probability of a conflict and claims after construction work has begin). The general contractor required from subcontractors to submit in addition to bid price, method of execution, past experience in similar works, time schedule, expected obstruction, and any other special conditions.

The majority of general contractors' respondent committed with the selected subcontractors during the tendering stage when they awarded the contract. However, most respondents (87%) practiced negotiation with the subcontractors after winning the contract in order to reduce the agreed costs in the tendering stage. This may be due to the sever competition between contractors that enforce them to reduce the tender price, and thus asked the subcontractors to reduce their previously estimated cost. Regarding contract type between general contractor and subcontractor, it was noticed that more than 60% of the respondents used contracts similar to the one between owners and contractors. The other respondents used a simplified contract.

Regarding methods of measuring the performance level of the subcontractors, it was noticed that contractors (87%) have used bar chart and s-curve in monitoring the progress of the subcontractors. This reflects the formal procedures and gives a good tool to the management body of the project to correct any defaults that may occure by the subcontractors. Concerning the safety measures of the subcontractors, the majority of general contractors (93%) stated that subcontractors are obliged to adopt the safety measures as specified in the contract between the owner and the general contractor. This is a crucial point in the local construction industry as almost all works are implemented by subcontractors and general contractors.

The majority of the respondents have agreed that there is a close cooperation and a good flow of information exchange between general contractors and subcontractors. In general, the main contractors' respondents were satisfied with the performance of subcontractors.

6. Conclusion

This study has explored the working relationship between general contractors and subcontractors from the general contractors' perspective. A decision to subcontract part of the process should be a strategic decision, and not one driven solely by resource problems. It may involve long-term strategic views related to the core skills required for the company's future, as well as consideration of the importance of design re-use and internal control of the design and manufacture of the product. The general contractors have stated that, it is a common practice to use subcontractors to execute specific operation in the project.

There are many benefits to be gained from working with subcontractors. It provides skilled labore, reducing overhead costs, and reducing the pressure on the main contractors. Monitoring and controlling, quality control, safety management, and labor management problems on construction projects become less complicated for general contractors. It is apparent from the results that informal communication is practiced between general contractors and subcontractors. General contractors have indicated that they select the subcontractors according to the complexity of the work and previous experience with subcontractors.

Some subcontractors have failed to exercise the proper diligence and care when submitting their bids; even they do not have the time to visit construction sites during the estimating process. General contractors committed to the selected subcontractors during the tendering stage; they negotiate with subcontractors after winning the contract in orders to reduce the agreed costs in the tendering stage. This is due to the sever competition between contractors which enforce them to reduce the tenders price, and thus asked the subcontractors to review and reduce their previously estimated costs. Overall, general contractors indicated that they have good relationship with subcontractors and they satisfied with their performance.

Further in-depth study concerning all aspects of the relationship between general contractors and subcontractors is recommended. It is imperative to improve and develop the subcontractors position towards the general contractor, by upgrading the understanding of all contract terms such as; wording and potential for negotiations of conditions including indemnity, payment and retention terms, warranties and call backs, schedule of work, delays and liquidated damages, lien and bond rights, and of curse scope of work. It is advisable to establish a Palestinian subcontractors union for better networking improves the quality and conditions of work, improving the terms of contracting and place subcontractors in a good position in the local market.

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Developing Relational Approaches to Contracting: The Sri Lankan Context

Sachie Gunathilake,
Department of Building Economics, University of Moratuwa
(email: sachie.21@gmail.com)
Himal Suranga Jayasena,
Department of Building Economics, University of Moratuwa
(email: suranga@becon.mrt.ac.lk)

Abstract

The traditional construction procurement systems have come under constant scrutiny in the past decades for their numerous drawbacks, resulting in under-performance of the industry. International research in this area showed that the adaptation of approaches such as, partnering and alliances, which are based upon relational contracting (RC) principles, could lead to numerous benefits to all parties and uplift the industry performance. However, these practices still have not proliferated into the Sri Lankan construction industry, which continues to use the traditional system as the most popular procurement approach. Therefore, the need to identify the potential to develop RC cultures in the Sri Lankan construction industry was identified. Through the literature review, thirty factors facilitating RC and thirty-nine factors impeding RC was identified. A questionnaire survey was conducted among project team members of construction projects with Design-Bid-Build (DBB) and Design and Build (D&B) type arrangements, to gather the perceptions of the respondents in relation to the applicability and validity of these factors in the Sri Lankan context. The study revealed that overall, there is an environment conducive to the development of relationship-based procurement approaches in the Sri Lankan construction industry. It was identified that in general, the contractors were much more supportive towards adaptation of such practices and thereby shifting away from the traditional system than the consultants. In addition, it was revealed that as the level of integration within the project team improved, the project environment became more conducive towards RC approaches.

Keywords: Procurement, Relational Contracting, Facilitators, Impediments, Sri Lanka

1. Background

Most traditional forms of construction procurement rely upon segregated teams, fragmenting the construction process. The numerous drawbacks of this system such as, adversarial relationships, unhealthy competition, purely price-based selections, numerous change orders and improper risk-shedding tactics [1], creates a general atmosphere of poor co-operation, limited trust and ineffective communication in project teams, ultimately resulting in unsatisfactory project

performance. In recent years, a number of studies and industry reports around the world have addressed these issues. Industry reports in Hong Kong [2], Singapore [3] and UK [4] have highlighted limited co-operation and fragmentation as impediments for proper consideration of issues such as, buildability, safety and life cycle costs in their respective construction industries [5]. Further, other studies, (for e.g. in Canada), have found that the cost of mistrust generated by confrontational situations inherent in the traditional contracts to amount to 8 – 20% of contract value [6]. All these have created an urgent need for new procurement approaches encouraging better relationships and team working within project teams, which has influenced a global shift towards "relational contracting (RC)" practices, such as partnering, alliancing, joint venturing, relationship contracting etc.

Recent local surveys have shown the dominance of traditional procurement systems in the Sri Lankan construction industry [7] and the stated weaknesses of these systems are quite common in the Sri Lankan context as well. Further, the future construction demands of the country are likely to call for increased efficiencies and performance from the industry. Therefore, considering all these, development of RC cultures in project delivery teams in the Sri Lankan construction industry, seems sensible and appropriate in the out set. However, RC is not a "one-size-fits-all" guaranteed fix, but rather a philosophy that must be tailored for each situation for which it is applied [8]. The successful implementation of a RC culture will undoubtedly present hard work, especially in an industry full of individuals well conditioned in working in adversarial climates.

Although, many countries around the world are quite advanced in the practice of RC approaches, it remains an unexplored area for research in the Sri Lankan context. The aim of this paper is to explore the potential for building a successful relationship-based procurement culture in the Sri Lankan construction industry. Specific objectives have been set to identify the factors (1) facilitating and (2) impeding the development of a RC culture in the Sri Lankan context and (3) to assess the capacity to adopt RC practices in the Sri Lankan construction industry.

2. Limitations of the traditional procurement system

Construction industry in any country is a complex, high-risk sector, dominated by contracts. It has strong backward and forward linkages with a large number of other industries such as, manufacturing, finance, labour etc. The construction industry has a direct impact on the national economy and is generally used as an indicator of economic well being of the country. It can influence a country's national economy in four aspects namely, production of specific and national basic needs, provision of fixed capital assets and infrastructure of a country, direct contribution to the Gross Domestic Product (GDP) and employment generation [9].

Despite its significance, the industry has and continues to suffer consistently from many weaknesses. There is a deep concern that the industry as a whole is under achieving [4]. The profitability and productivity levels in the construction industry are frequently acknowledged extremely poor in comparison to other industries. Studies have shown growing dissatisfaction

among clients about the performance of the construction industry [4], indicating a rise in the demand for greater efficiencies and client focus. The industry is criticised for failing to meet the demands of the modern business environment, which require the ability to be competitive in the international market and provide best value for clients. Much of the blame has been placed on the traditional procurement systems and their limitations, which prevents the industry from performing up to its full potential.

It is the general view that the traditional Design-Bid-Build procurement approach provides a measure of protection to less informed developers and other clients, who lack faith in the professionalism of their contractors [8]. Fragmentation of the industry has been identified as one of the major disadvantages of the traditional system. A large part of the low performance of the UK construction industry has been blamed on fragmented teams over the past few decades [4]. The lack of co-operation, limited trust and ineffective communications between these fragmented parties lead to adversarial relationships, which often result in project delays, difficulties in claim resolution, cost overruns, litigation and win-lose mentality among parties. The traditional procurement environments are ineffective in managing interdependencies between design, construction and supply activities [10], thus affecting the quality and buildability of the design. Lack of communication and cooperation and fear of opening up claims exclude valuable contributions from parties. Furthermore, fragmented teams result in extra transaction costs being incurred between fragmented functions [11], which have a direct impact on the value of production. The transaction costs of competitive tendering may constitute 15-20% of the total project value [12] and includes, costs of negotiation, monitoring contractual performance, enforcing contractual promises and costs associated with breaches of contractual promises etc [13].

These limitations of the traditional procurement systems, makes such systems inappropriate in dealing with the changing market conditions, adapting new technological developments and meeting rising clients' expectations. This has lead many researchers to stress the importance of shifting away from the traditional procurement culture to improve the industry performance. Emphasis on Relational Contracting practices has been one of the most significant developments in this context.

3. Relational contracting

3.1 Concepts of relational contracting

The phrase "relationship contracting or RC" is intended to describe a spectrum of project delivery methods that emphasize and focus upon the relationship between parties to a construction project [14]. Relational contracts are regarded as informal agreements and codes of conduct between parties, sustained by the value of the future relationships that powerfully affect their behaviour [15]. In contrast to the traditional forms of construction contract, relational contracts are flexible in nature and provide a flexible response to information problems. It acts as a safe guarding mechanism designed to smoothen transactional friction and make provisions for "incomplete contract" in complex scenarios [16]. Relational Contracting (RC) defines the

relationship of parties, who do not always govern themselves bounded by the strict legal framework of the contracts. They provide the relationship among the project participants the same level of importance as the project itself. The prominence given to the terms of the contract is less compared to that given to the relationship between parties. Practices such as, partnering, alliancing, joint venturing etc; are based upon these RC principles. RC approaches are useful in achieving the overall project objective of reducing the total of production and transaction costs. It offers a cost effective means of encouraging mutually beneficial behaviour, overcoming most of the limitations of the traditional procurement systems.

3.2 Benefits of relational contracting

A number of studies around the world have reported on the benefits of RC practices such as, partnering, alliancing etc. According to Thompson and Sanders [17], benefits achieved through partnering are in direct proportion to the risk assumed and dramatically increase as the relationship is unified and developed through the acceptance of uncertainty and a willingness to be vulnerable.

Most of the authors [17; 18; 19] have emphasised the lowering of the risk of time and cost overruns as main benefits of RC approaches, which are achieved as a result of better time and cost control over the project. Other than that, adopting RC practices is seen to provide an opportunity for innovation, especially in the development of value engineering changes and constructability improvement [19]. Evidence from the UK construction industry indicates that practices such as partnering and value management are providing a platform to develop sustainability strategies [10]. A case study on the National Museum of Australia [20], which was the first project alliance in building construction in the world, have observed significant added value to the client and many innovations resulting from the collective work of the parties to the contract. Many government organisations in UK that have adopted partnering have documented a decrease in litigation [17] owing to the framework for conflict resolution and improved communication. Furthermore, alliances are seen by smaller contractors, as an opportunity to join forces to work on large projects and to develop on the areas of work that need improvement [21].

Other than these measurable improvements, benefits of partnering (i.e. RC) include improvements in subjective areas such as worker morale as well [17]. This is achieved through the delegation of increased levels of authority in decision-making. Such authority raises the level of accountability of individuals and leads to increased commitment. A similar view is held by Lamont [22], who states that the empowerment, which is a direct result of partnering, can encourage individuals to work together more effectively.

The case studies and surveys around the world have proven and established numerous benefits of RC practices in the construction industry. The examples of such successful partnerships/alliances have encouraged a considerable number of clients and contracting organisations around the world to adopt these strategies. Partnering and alliances, which may be considered as the most widespread adaptations of RC in construction, has been well researched

in many countries. Comprehensive case studies have been done on milestone projects, such as the National Museum of Australia [20], which has successfully adapted project alliancing to achieve significant benefits to all parties. Further studies in the area [8], have identified the factors facilitating and impeding partnering in countries such as, Singapore and Hong Kong. Sri Lankan construction industry however, is still far behind in this context. According to Rameezdeen [7], the only type of practice based on RC principles adopted in Sri Lanka is joint ventures (1-3%). This has also been attributed to the involvement of international contractors. However, in future as clients' expectations continue to rise, Sri Lanka will need to follow the initiative of countries such as, UK, Australia, Singapore etc; and shift towards project delivery processes encouraging cooperation and collaboration within project teams and supply chains, such as partnering. Therefore, it is worthwhile to investigate the factors, which are facilitating and deterring the adaptation of these practices in the present Sri Lankan context.

4. Research Method and Approach

4.1 Selection of respondents

The implementation of RC practices requires a change of attitudes and culture in the project delivery teams. This research sought to gather the perceptions of project team members, with respect to the applicability of thirty facilitators and thirty-nine impediments to RC identified through the literature survey in the Sri Lankan context. The inherent adversarial relationships present in the traditional DBB procurement culture was expected to form a barrier, in gathering data on the facilitators and impediments to RC, preventing any truly significant conclusion from being drawn up. To overcome this problem, two separate samples were selected from projects with traditional Design-Bid-Build (DBB) type procurement arrangements and projects with Design and Build (D&B) type procurement arrangements. It was decided that selection of ten construction projects with each type of procurement arrangement was a suitable and manageable sample size for this research. Selection of these two samples also enabled to explore any significant improvements in the facilitators to RC with higher degrees of integration in the project teams. The convenient sampling technique was used with the main purpose of securing a good response rate. In addition, the nature of the data collected was such that no bias could be expected by selecting the convenient sampling technique over random sampling.

RC approaches are generally advocated for large projects, which are able to gain the most benefits from implementing these approaches. This was also considered in selecting projects for this research and therefore, projects with large project values were selected. The project values of the selected projects ranged from Rupees forty-two million to Rupees ten billion. Out of the twenty projects selected, six (i.e. thirty percent) had project values greater than Rupees 1.5 billion. Only fifteen percent of the projects had project values less than Rupees 100 million.

In each DBB project, a member of the consulting team and a member of the construction team were selected and questionnaires were distributed to them. In the projects with D&B arrangements, the same team (from a single organisation) acted as the design and the

construction team. Therefore, in this instance, a single questionnaire was given to a member of the project team.

Table 1: Facilitators and Impediments to RC

	Facilitators to RC		Impediments to RC
1	Senior management "championing" of the partnering (i.e. RC) process	**1**	Prevailing attitude of cynicism
2	Empowering decision making process at the lowest possible level	**2**	Rigid / preconceived attitudes about specific sectors / partners
3	Support and enthusiasm of the client	**3**	Lack of belief in the effectiveness of partnering
4	Client's knowledge about the project processes	**4**	Too narrowly focused role / job
5	Vertical intra-organisational trust	**5**	Restricted internal / external authority
6	Mutual trust among parties	**6**	Lack of understanding of RC concepts
7	Efficient communication	**7**	Inadequate partnering skills
8	Effective coordination of parties	**8**	Lack of RC experience
9	Team working spirit of all parties	**9**	Conflicting priorities
10	Timely responsiveness	**10**	Competitiveness (within sector)
11	Alignment of project objectives of parties	**11**	Intolerance of other sectors
12	Alignment of commercial objectives of parties	**12**	Incompatible organisational cultures
13	Adhering to mutual goals	**13**	Lack of competency to perform
14	Mutually agreed performance appraisal mechanisms	**14**	Poor communication
15	Mutually agreed dispute resolution mechanisms	**15**	Lack of top management commitment
16	Combined responsibility of parties	**16**	Up front time required and cost for implementing RC
17	Continuous periodic evaluation	**17**	Bureaucratic client organisations
18	Long-term commitment	**18**	Poor project planning
19	Adequate resources of parties	**19**	Inappropriate procurement strategies
20	Experience in RC approaches	**20**	Inappropriate risk allocation/sharing
21	Learning culture within project teams	**21**	Price only selection methods
22	Capacity for innovation	**22**	Ambiguous contract clauses/documents
23	Positive attitude towards continuous improvement	**23**	Lack of scope for innovations
24	Flexible contracts to address uncertainties	**24**	Lack of client's initiatives
25	Encouraging and motivating risk-reward plans	**25**	Lack of team working attitude
26	Inclusion of all key parties in risk-reward plan	**26**	Lack of trust
27	Equitable risk allocation / sharing arrangements	**27**	Inappropriate issue resolution mechanisms
28	Clearly defined risk allocation / sharing arrangements	**28**	Separate coordination and monitoring plans
29	External facilitators	**29**	Being conditioned in win-lose environments

30	Conducting work shops for relationship building	**30**	Potential legal liabilities in resolving non-contractual issues
		31	Commercial pressures of contacting parties
		32	Absence of a risk-reward plan
		33	Exclusion of consultants from the risk-reward plan
		34	Exclusion of major subcontractors from the risk-reward plan
		35	Exclusion of major suppliers from the risk-reward plan
		36	Externally determined reward system for middle management or site staff
		37	Separate / unrelated risk-reward plans for different parties
		38	Local social / political / economic climate
		39	Incompatible public sector rules and regulations

4.2 Profile of Respondents

All the respondents fall into the category of 'professionals'. Some held senior or middle management positions within their respective organisations. Therefore, all the respondents were actively interacting and dealing with members from other organisations working in the project team. Thus, their views on the facilitators and impediments to the development of more collaborative working relationships were developed through hands-on experience of working with other project parties. Table 2 gives the years of experience of the respondents in the construction industry. On average, respondents have worked in the industry for 14 years. Seventy-seven percent of the respondents had over six years of experience in the industry.

Table 2: Years of Experience in the Construction Industry

Years of Experience	Number	Percentage (%)
1-5	7	23
6-10	6	20
11-15	5	16
16-20	5	16
21-25	4	13
Over 26	3	10
Total	30	100

4.3 Design of the Questionnaire

The questionnaire was divided into two main sections. The first section sought general information about the respondents, while the second section sought the respondents' perceptions on the factors facilitating /impeding collaborative working between project parties in that particular project. Facilitators and impediments to RC, which were found through the literature review were analysed and factors such as, mutual objectives, external facilitators, past

experience in RC practices etc; which obviously was not applicable to the Sri Lankan context, where no RC approaches are being practiced were excluded. The remaining factors were combined and thirty-seven items were obtained. The questionnaire requested the respondents indicate their degree of agreement, on a seven-point Likert scale ranging from disagree very strongly to agree very strongly, on each of the issues considering the selected projects. Therefore, care was taken to have a roughly equal number of positively and negatively worded items, to force the respondent to consider each item carefully, thereby minimizing the effect of responses automatically set towards either agreement or disagreement. A seven-point Likert scale was chosen as appropriate for the purpose of this research as it is easy to understand and interpret by respondents and discriminates well between respondents' perceptions. Furthermore, as this questionnaire dealt with factors, which may be perceived as sensitive to the respondents, it was decided to use a neutral point on the scale to avoid forcing the respondents to one side and alienating them, thus resulting in fewer completed surveys.

As the data collected using the Likert scale were ordinal in nature, it was not possible to carry out arithmetical calculations such as, mean or standard deviation [23]. Instead, the median and the inter quartile range were used. The median was taken to represent the average response of the respondents. The Mann-Whitney *U* test, which is the nonparametric equivalent of the independent samples t-test, was used to detect any differences in the respondents' perceptions between groups. The Mann-Whitney *U* tests were designed to distinguish between the perceptions of, (1) the project team members in Design-Bid-Build and Design and Build type projects and (2) the contractors and consultants in Design-Bid-Build projects

5. Data analysis and discussion

5.1 Factors Facilitating RC in the Sri Lankan Context

Considering the median responses given by the respondents, thirty out of the thirty-seven factors considered could be regarded as factors facilitating the development of RC in the current Sri Lankan context. Out of these, nearly seventy-five percent of the respondents 'agreed', 'agreed strongly' or 'agreed very strongly' that there is vertical intra-organisational trust and top management commitment towards developing cooperative relationships between project parties. The results also indicated that none of the respondents disagreed to the statements that their organisations possessed good competency to perform and that there was good capacity for innovation within the project team. Similarly, there was strong agreement among respondents to the statement that there was a mutually agreed dispute resolution mechanism in the projects. With respect to above three items seventy-five percent of the respondents stated that they 'agree', 'agree strongly' or 'agree very strongly' with the statements, whereas the remaining 25% of the respondents were 'undecided' on the issue.

Factors such as, open and efficient communication between parties, effective coordination between parties, team working attitude of all parties and mutual trust among parties, which are essential in building a RC culture, all had a median of 5. This meant that on average respondents 'agreed' that these factors were present in the current project environments. These factors, along

with top management support were found to be the most important facilitators of RC in the works of Cheng and Li [24] and Kumaraswamy et al [8]. Thus, the presence of these factors to this extent in the present project environment, where polarisation of parties is expected due to past experiences of adversarial relationships, disputes etc; is an important aspect.

5.2 Factors Impeding RC in the Sri Lankan Context

On average, the respondents agreed that commercial pressures on organisations prevented them from working co-operatively with other project parties. This was especially relevant to the contractors, as increased competition, as well as lowest price selections, had forced them to operate in increasingly tight margins. Thus, they are forced to compromise and choose between developing collaboration and better relationships with project parties having conflicting objectives to their own and their own objectives of profit maximisation. The result was consistent with the findings of the Construction Industry Institute of Australia (CIIA) study, where there was strong agreement among respondents that commercial pressures on organisations was a barrier to developing successful partnering relationships.

In addition to above, median responses of 'undecided' were obtained for six items, where the responses were spread in an equal manner between agreement and disagreement. For instance, the results revealed that the respondents were divided between agreement and disagreement, with respect to long-term commitment of the other project member organisations, the ability of their own organisations to work collaboratively with competitor organisations, equality between project parties, timely responsiveness to problems, joint responsibility for the project outcome and arrangements to share rewards as well as risks. Therefore, it was necessary to investigate these items further and explore if the perceptions improved with integration of teams, by comparing between DBB and D&B projects before a conclusion could be made.

5.3 Differences in Ratings by Consultants and Contractors in DBB Projects

The Mann-Whitney *U* test was carried out using SPSS (which is a computer software for statistical calculations), to assess whether there were any significant differences between the contractors and consultants of DBB projects. The results show that thirty out of the thirty-seven factors considered had a significance level greater than 0.05. Therefore, the null hypothesis, H_0 is supported for these thirty factors. The remaining seven factors had a significance level lower than 0.05. Therefore, for these factors the alternative hypothesis, H_1 is accepted. This means that with regard to these seven factors, there are different perceptions in the two groups of respondents.

There were considerable differences between the opinions of the two groups with respect to four items. Seventy-five percent of the contractors were willing to allow small losses to their own organisations in expectation of end of the project mutual gains or future projects from clients. This was indicative of the long-term commitment of the contractors, which is an important facilitator to RC. However, all of the consultants were either undecided or disagreed with the

statement. All the contractors were either ‘undecided’ or ‘disagreed’ with the statement that all project parties were held jointly responsible for the outcome of the project, while none of the consultants disagreed with the statement. The contractors’ responses were indicative of their frustration that the consultants were able to escape blame for problems in design and design communication. Altogether, the responses indicate that generally contractors have a more conducive attitude towards developing collaborative relationships within the project teams.

5.4 Differences in Ratings by Respondents in DBB and D&B projects

In addition, Mann-Whitney *U* tests were carried out to assess whether there were any significant differences between DBB and D&B project cultures. Results indicated that twenty-five out of the thirty-seven items considered have a significance level greater than 0.05. Thus, for these items the decision is to accept the null hypothesis H_0 that there are no differences in opinions between the two groups of respondents. Conversely, the remaining twelve factors had a significance level lower than 0.05, leading to acceptance of the alternative hypothesis H_1.

All the items, except one, showing significant differences between the two groups indicated better facilitators to RC in D&B project cultures. There were noteworthy differences between the two groups with regard to equality between parties within the project team and timely responsiveness to problems. In DBB, projects 50% of the respondents ‘disagreed’, ‘disagreed strongly’ or ‘disagreed very strongly’ to the statement that there was equality between project parties. Whereas, less than 25% of the respondents form D&B projects ‘disagreed’ with the statement. The consultants’ dominant position in the DBB project teams, especially in approving payments to contractors was significant in affecting the equality between parties in these projects. Furthermore, more than 50% of the respondents in DBB projects disagreed that there was timely responsiveness to problems arising in projects. This was interrelated to the fact that there was poor coordination in these projects. Over 50% of the respondents in DBB were undecided or disagreed (with 25% of the respondents stating they ‘disagree strongly’ or ‘very strongly’) to the fact that there was effective coordination within the project team. On the other hand, 75% of the respondents from the D&B projects stated varying degrees of agreement to the statement. Similarly, project team members from D&B projects were more supportive towards trying to reach win-win solutions to problems. This indicated that a change of adversarial attitudes was possible through better integration in the project process.

However, a surprising result was obtained for one item, where 100% of the respondents from D&B projects agreed that commercial pressures on their organisations were preventing them from working cooperatively with other project parties. On the contrary, the respondents from DBB projects gave a median response of ‘disagree’ to the statement, with less than 50% of the respondents stating that they agree with the statement. This may be explained by the fact that the D&B projects considered in the research had rigid lump sum contracts and the statement applied especially to the relationship between the D&B team and the client. In fact, in two of the projects considered there was expressed disagreement between the client and the D&B contractors with respect to claims for price fluctuation.

Overall, the test results revealed that the D&B projects had stronger facilitating environments to RC than DBB projects. Therefore, the hypothesis, that as relationships between project parties improve through integration of project teams, the project environment seemed more conducive to RC approaches was accepted.

6. Conclusions

In general, the results showed that there is a facilitating environment to Relational Contracting in the Sri Lankan construction industry. However, the factors facilitating better relationships between parties in the traditional Design-Bid-Build procurement environments are overridden by barriers to corporative working such as, adversarial climates, conflicting objectives, commercial pressures and other inherent pressures created by the traditional procurement environments. The dominant position held by the consultants in the traditional Design-Bid-Build project teams over the contractors had added on to these pressures. Commercial pressures on organisations were found to be the most prominent impediment to developing and maintaining cooperative relationships between parties.

Further, comparison of perceptions of contractors and consultants in Design-Bid-Build projects revealed that, contractors were more supportive towards the development of collaborative project environments than the consultants. This showed the frustration of the contractors towards the inferior position they are constantly given within project teams, as well as the unwillingness on the part of consultants to give up their dominant position. Mann-Whitney *U* tests between Design-Bid-Build and Design and Build project team members revealed that the factors facilitating RC were stronger in the Design and Build environments. Significant improvements were found in Design and Build projects with respect to equality between project parties, timely responsiveness to problems and the willingness of project parties to reach win-win solutions to disputes. However, a surprising finding was made with respect to one item. All the respondents from Design and Build projects agreed that commercial pressures on their organisations were preventing them from working cooperatively with other project parties, whereas, the respondents from Design-Bid-Build projects on average, disagreed with the statement. The discrepancy was attributed to the rigid lump sum contracts used in majority of the Design and Build projects, and their effect on the relationship between the client and the Design and Build team. Nevertheless, overall it could be seen that there were more or stronger facilitators to RC with increased integration in project teams. This complimented the findings of Kumaraswamy et al [11] and their statement that approaches to building a RC culture can be reinforced through measures to promote integrated teams could be held valid to the Sri Lankan context as well.

It was revealed that the research findings concurred with the findings of similar researches done in other countries. Therefore, it could be deduced that the results obtained have a high reliability. Further, these findings make all the relevant international literature on this area applicable to the Sri Lankan context as well. RC based approaches, such as, partnering and alliances are not practiced in the Sri Lankan construction industry. Therefore, the validity of the results could not be explored in a real RC culture.

Drawing from the results of this study, it is recommended that initiatives should be taken in shifting away from the traditional project delivery strategies towards RC. Measures should be taken to promote integrated teams in project delivery process. The government and other industry related institutions could initiate this movement by promoting integrated project teams and supply chains following the initiative of Construction Industry Review Committee (CIRC) of Hong Kong and Strategic Forum for Construction in UK. At the same time, awareness should be given to clients (especially clients of large scale or repetitive construction projects) on these RC practices and the potential benefits that could be obtained through their adaptation.

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A tool for strategic safety-rating of constructors

K. Imriyas
Faculty of the Built Environment, University of New South Wales, Sydney, Australia.
(imriyas@unsw.edu.au)

Abstract

The construction industry has poor safety records in globally. Improving safety has been an important goal for the WorkCover, Australia. Setting up a rating system for contractors that evaluates them on their safety records and the workplace safety programs in place would be a good strategy towards this goal. This paper proposes a model that serves this purpose. The proposed model can derive a safety index for a contractor, which may be utilised as one of the factors for tender evaluations by clients whereby better-rated contractors may be favoured. It could also be used by insurance companies so that lower insurance premiums for better-rated firms. The implementation of the model in the WorkCover can facilitate accident control in the construction industry.

Keywords: Occupational health and safety, Safety index, Tender evaluation, Insurance, WorkCover, Australia

1. Introduction

The construction industry appears to have poor safety performance records globally. It was reported that the construction industry of the Unites States accounted for only 5% of the United States' workforce but claimed a disproportionate 20% of all occupational fatalities and 9% of all disabling injuries [12]. In Great Britain, construction accounted for 31% of all work-related deaths in 2002/03 [5]. The incidence of workplace fatalities in the Australian construction industry was 9.2 fatalities per 100 000 employees in 2002–03 which was three times higher than the national average of 3.1 fatalities per 100 000 employees [4]. Raising safety standards by introducing new laws and frameworks has been a goal for safety authorities like the Health and Safety Executive (HSE) in the UK, Occupational Safety and Health Administration (OSHA) in the US and the WorkCover in Australia. It is hypothesised that setting up a new rating system for construction companies that evaluates them on their safety performances would be a good strategy towards this goal. The rating may be utilised as one of the factors for tender evaluations whereby better-rated contractors may be favoured. It could also be used by insurance companies so that lower insurance premiums for better-rated firms. A company that pays lower premium for insurance would be more competitive in bidding.

Safety rating has received broad attention in the construction literature. There are few previous efforts that introduced models for safety rating including: Experience Modification Rating (EMR), Accident Rate (AR), Incident Rate (IR), Score Card (SC), and Safety Performance

Evaluation Framework (SPE). The EMR reflects the cost a contractor has to pay for workers' compensation insurance. Workers' compensation is directly related to safety performance via claims paid due to accidents. It is calculated by taking the ratio between the dollar amount of actual workers' compensation claims filed to the dollar amount of expected claims for a particular type of construction, and is a three-year running average starting one year prior to the last full year. Thus, an EMR of 1.2 means that a contractor has to pay 20% more for workers' compensation insurance than a similar company with an EMR of 1.00 [7]. However, this method is not reflective of the present safety performance of a company since the latest EMR is based on an average of a contractor's performance four, three and two years ago [9]. The AR measures a contractor's safety performance simply by the number of reported accidents. Contractors diligently reporting and investigating accidents are disadvantaged in comparison with less scrupulous contractors who under-report accident occurrence [17]. The IR is computed based on the number of lost time cases, number of days lost for all lost time cases and number of fatalities, injuries and illness with or without lost workdays. Similar to the AR, the accuracy of the IR depends on how honest a contractor in revealing the reportable incidents [13]. In the SC system, six key aspects are rated in projects including: provision and maintenance of plant, provision and maintenance of work environment, provision of information, instruction and training, provision and implementation of safety systems of work, employment of safety officers/supervisors, and site accident records. The weighted score reflects the safety performance of the contractor. However, the key weakness of the system is that it only considers safety commitment at project level [13]. The SPE framework takes into account of safety commitment at project and organisational level. However, this model totally ignores a contractor's accident history which reflects the actual execution of implemented safety programs. Hence, the aim of this study is to develop an effective tool for safety-rating of construction companies. The specific objectives are:

- Identifying and exploring the factors that need to be assessed for safety-rating of contractors;
- Developing an effective model for safety-rating of contractors; and
- Automating the model as a fuzzy system.

However, due to word limitation this paper discusses only the proposed safety-rating model for contractors, and the subject is discussed in various sections in due order. Firstly, the hypothesis, aim and objectives of the research are outlined in the introduction. Secondly, the literature review findings on safety performance evaluation methods and variables are described. Then a new model for safety rating is proposed followed by the conclusion.

2. Evaluating contractor's safety performance

It was found in the literature that the equal assessment of three key factors is important to evaluate the safety performance of contractors.

1. Dingsdag [4] quoted that sustained improvement in safety performance on sites will not happen without an established safety culture at organisational level. Thus, evaluating the

safety culture in a contractor organisation is a key factor towards safety performance evaluation.

2. Mohamed [11] argued that the existence of safety climate on sites leads to safe work behaviours by operatives and thereby lesser accident rates. Measuring the safety temperature on site is therefore a key factor for safety performance evaluation.
3. While the previous two factors are pro-active and they are good measures of risk exposure, it is important to monitor how safe work behaviour is practised at both organisational and project levels through an obvious indicator. Every contractor is required to procure workers' compensation insurance to transfer the compensation liability for occupational injury victims as set out by Workers' compensation ACT. Thus, it is likely that contractors will report all the incidents diligently to the insurer to relieve them from financial burden of compensating. Hence, the usage of workers' compensation data to develop a passive indicator would be a reasonable step in this regard.

2.1 Measuring organisational safety culture

Organisational culture is defined as "a complex framework of national, organisational and professional attitudes and values within which groups and individuals function" [6]. Part of that culture in hazardous industries relates to safety, which is the "ability of organisations to deal with risks and hazards so as to avoid damage or losses and yet still achieve their goals" [14]. In construction, the safety culture is concerned with the ability to manage safety with a top-down organisational approach [11]. Safety climate on construction sites is a product of safety culture in the organisation. Many authors defined the components of a good safety culture as described below.

- Jaselskis [10] and Parker [14] recommended the following features to cultivate a good safety culture in a contractor organisation:
    1. The availability of a safety department of adequate size and competency with set benchmarks, aims, objectives, action plans and responsibilities.
    2. Adequate safety investments by the organisation to strengthen upper management attitude towards safety.
    3. Adequate number of safety meetings conducted between upper management and field safety representatives and between upper management and subcontractors.
    4. Adequate number of informal site inspections made by upper management. Choudhry [3] reinforced that the top management of an organisation with good safety culture would commit to conducting safety climate surveys on construction sites to ensure employees are motivated to adhere to standard work procedures.
    5. The existence of reward systems to recognise good safety performances by the upper management and the safety department members.
- Reason [15] proposed that an organisation with an effective safety culture would have a safety management information system. The desired features for a construction safety management information system were recommended by various authors as described below.
    1. Sorine & Walls [18] emphasized the need of a module to store, analyse, update and communicate necessary safety information on standard job procedures which includes: (1) sub-steps, potential hazards associated with each sub-step, and recommended

precautionary measures; (2) history of previous incidents and near misses in sub-steps with causes and effects; (3) regulatory mandates regarding a sub-step.

2. Blotzer [1] suggested having a module for accident reporting and investigation, and safety reminders.
3. Rivers [16] recommended incorporating a module to capture direct and indirect costs of accidents, analyse these data and produce various accident cost summaries for the project and for the company as a whole for disseminating to site and upper managements. This information can motivate safety professionals to set safety benchmarks and goals both at organisational and site levels. The direct costs include: workers' compensations; equipment repair and replacement costs; fines, fees and settlements; damages to works and temporary structures. The indirect cost refers to the cost of production downtime.
4. Cheung [2] quoted that the integration of such computer technologies as web, database and knowledge base is essential to produce a robust safety management information system for construction.

2.2 Measuring safety climate on site

Mohamed [11] identified ten constructs that establish a good safety climate on site, viz:

1. Commitment construct – the greater the level of management commitment towards safety, the more positive the safety climate.
2. Communications construct – the more effective the organisational communications dealing with safety issues, the more positive the safety climate.
3. Safety rules and procedures construct – the better the perception of safety rules and procedures, the more positive the safety climate.
4. Supportive environment construct – the higher the level of support given by co-workers, the more positive the safety climate.
5. Supervisory environment construct – the more safety aware and relationship oriented the supervisors, the more positive the safety climate.
6. Workers' involvement construct – the higher the level of workers' involvement in safety matters, the more positive the safety climate.
7. Personal appreciation of risk construct – the higher the level of workers' willingness to take risk, the less positive the safety climate.
8. Appraisal of physical work environment and work hazards construct – the greater safety's integration in site layout planning to identify safety hazards, the more positive the safety climate.
9. Work pressure construct – the higher the perception of valuing expediency over safety, the less positive the safety climate.
10. Competence construct – the greater one's experience and knowledge of safety issues, the more positive the safety climate.

Imriyas [8] introduced a comprehensive list of factors with their respective attributes for facilitating safety climate measurements in construction projects, and Table 1 summarises those factors. Despite the table lists most of the key elements of safety climate measurement, it could be improved by adding two more factors: (1) Incentive systems for encouraging workers' involvement in ensuring the safety of oneself and co-workers, (2) Work pressure and operational targets that conflict with safe behaviours.

Table 1: Project safety auditing roster

Safety element	Audit aspect
1. Project safety organisation	• Adequacy of the team & duties & responsibilities
2. Hazards assessment & management	• Adequacy of the in-house hazard assessment system for the project
3. Safe work practices	• Application of safe work procedures & codes of practice • Permit-to-work systems • Personal protective equipment usage
4. Safety training and competency of people	• Safety training to management team • Certification & safety training of operators • In-house safety training to workers
5. Safety inspection	• Regular inspection of hazardous activities & the work site • Housekeeping
6. Machinery & tools use & maintenance regime	• Testing & certification of machinery • Inspection systems for machinery & tools • Maintenance systems for machinery
7. Sub-contractors' safety systems	• Sub-contractors' safety management systems • Sub-contractor monitoring
8. Emergency management system	• Emergency response plan • Emergency response team • Emergency response equipment and facilities

(Source: Imriyas [8])

2.3 Measuring safety implementation through workers' compensation

Workers' compensation provides valuable protection to workers and their employers in the event of a workplace injury or disease. All Australian employers must have a workers' compensation insurance policy to insure themselves against compensation claims for workplace accidents. Depending on the nature and severity of the injury, an injured worker may be eligible for the following benefits:

- Fees for medical and related treatments - include payments made to medical specialists, hospitals and other health service providers in respect of injured workers.
- Weekly benefits – if a worker becomes unfit for work for a short period due to a workplace injury (known as partial incapacity), the worker is entitled to receive weekly benefits until he/she becomes normal or up to a maximum of 52 weeks, whichever is lesser.
- Permanent impairment benefits - if a worker has a permanent impairment as a result of a workplace injury or illness, he/she may be entitled to receive a permanent impairment benefit.
- Death benefits and funeral expenses - the benefits payable when a worker dies as a result of a workplace accident include a lump sum and weekly payments, together with payment for reasonable funeral expenses.

The total amount of workers' compensation claims that a contractor has filed in a construction projects is a passive indicator of the frequency and severity of accidents in that project, which in

turn is the result of the effectiveness of safety management. The EMR, as used in the US, represents the claims history of a contractor, but it does not take into account of the recent claims until after two years from the accident outbreak. However, a modified method would be a reasonable indicator of the previous and recent safety performances on site.

3. Proposed model for safety rating of contractors

Based on the finding of the literature reviews above, a new model for safety rating of contractors was developed as depicted in Figure 1. As per the proposed model, the Contractor Safety Performance Index (CSPI) is computed by assessing three intermediate indices using a fuzzy algorithm, as shown in Eq.1, and $0 \leq CSPI \leq 1.00$. If a contractor's safety performance is excellent, the CSPI will yield a score of 1.00. Otherwise, it would yield a score between 0 and 1.00.

$$CSPI = f\left(PSCI, OSCI, ICLR\right) \quad \text{Eq. 1}$$

Where:

1. *PSCI* is the project safety climate index, which is computed by analysing 10 project safety elements as per the framework shown in Table 2. The computation of the *PSCI* adopts a fuzzy algorithm as shown in Eq.2 below.

$$PSCI = f\left(\begin{matrix} PSO_{score}, HAS_{score}, SWP_{score}, STC_{score}, SIS_{score}, \\ MTS_{score}, SSS_{score}, EMS_{score}, WIS_{score,} WP_{score} \end{matrix}\right) \quad \text{Eq.2}$$

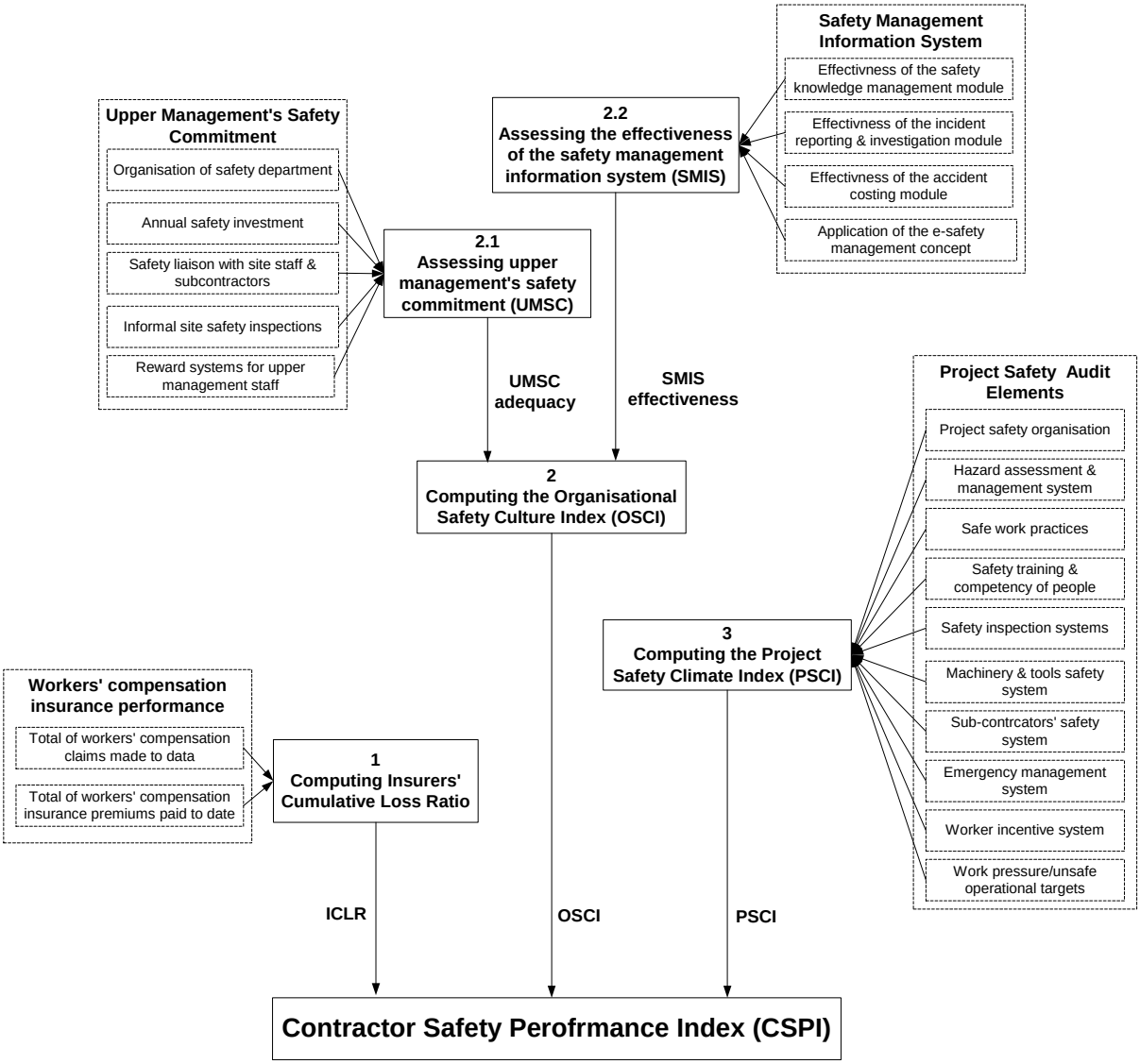

Figure 1. Proposed model for contractor safety rating

2. *OSCI* is the organisational safety culture index, which is computed by equally analysing the adequacy of upper management commitment to safety ($UMSC_{adequacy}$) and the effectiveness of the safety management information system in the organisation ($SMIS_{effectiveness}$), as shown in Eq.3.

$$OSCI = \frac{1}{2} x \left(UMSC_{adequacy} + SMIS_{effectiveness} \right)$$

Eq.3

- The $UMSC_{adequacy}$ is computed by a fuzzy algorithm as in Eq.4, analysing five variables: organisation of safety department (SD_{score}), annual safety investment (ASI_{score}), safety liaison with site staff and sub contractors (SL_{score}), informal site safety inspection (SI_{score}) and reward system for upper management staff (RS_{score}).

$$UMSC_{adequacy} = f(SD_{score}, ASI_{score}, SL_{score}, SI_{score} RS_{score})$$

Eq.4

- The $SMIS_{effectiveness}$ is computed by another fuzzy algorithm in Eq.5, analysing four variables: the safety knowledge management module (SKM_{score}), the incident reporting and investigation module (IRI_{score}), the accident costing module (AC_{score}), and the application of e-safety management concept ($e\text{-}safety_{score}$).

$$SMIS_{effectiveness} = f(SKM_{score}, IRI_{score}, AC_{score}, e-Safety_{score})$$

Eq.5

3. The *ICLR* is insurers' cumulative loss ratio, which is computed by analysing the total amount of workers' compensation claims filed by the contractor from the last 3 projects and the amount of workers' compensation insurance premiums paid for those projects. Eq.6 is utilised to compute the *ICLR* value.

$$ICLR = \frac{Total\ claims\ filed\ to\ date}{Total\ premiums\ paid\ to\ date}$$

Eq.6

The model was translated into a fuzzy expert system in which equations 1, 2, 3, 4, 5 and 6 were incorporated for computations. However, the development and the validation of the fuzzy system are not described here due to word limitations, and they are described in another paper by the author.

Table 2: Framework for evaluating safety climate on construction sites

Estimating the Project Safety Climate Index						
A) Project safety organisation						
Please rate the adequacy of the duties and responsibilities of the following personnel/team in the project safety organisation.	Low……..High					
1. Workplace safety and health coordinator	1	2	3	4	5	
2. Workplace safety and health auditor	1	2	3	4	5	
3. Workplace safety and health committee	1	2	3	4	5	
PSO $_{score}$						
B) Hazards assessment and management system						
Please rate the adequacy of the following aspects of the risk assessment and management system in the project.	Low……..High					
1. Risk assessment team and responsibilities	1	2	3	4	5	
2. Risk assessment procedures	1	2	3	4	5	
3. Reporting procedures to workers of identified risks	1	2	3	4	5	
4. Control measures for risks identified	1	2	3	4	5	
HAS $_{score}$						
C) Safe work practices						
C.1) Work procedures: Please rate the effectiveness of the work methods and procedures for the following trades.	Low…….High					
1. Concrete works	1	2	3	4	5	NA
2. Structural steel and pre-cast assembly	1	2	3	4	5	NA
3. Erection and dismantling of scaffolds and false works	1	2	3	4	5	NA
4. Works at heights	1	2	3	4	5	NA
5. Demolition works	1	2	3	4	5	NA
6. Excavation works	1	2	3	4	5	NA
7. Piling operations	1	2	3	4	5	NA
8. Welding and cutting works	1	2	3	4	5	NA
9. Works in confined spaces	1	2	3	4	5	NA
10. Works in toxic/contaminated environments	1	2	3	4	5	NA
11. Use of construction plant such as excavators, trucks, etc.	1	2	3	4	5	NA

Estimating the Project Safety Climate Index						
12. Use of cranes	1	2	3	4	5	NA
13. Electrical installation and use	1	2	3	4	5	NA
Sub-section score						
C.2) Permit-to-work (PTW) systems:						
Please rate the effectiveness of the PTW systems for the following trades.	Low…….High					
1. Working at heights	1	2	3	4	5	NA
2. Excavation works	1	2	3	4	5	NA
3. Working in confined spaces	1	2	3	4	5	NA
4. Welding and cutting works	1	2	3	4	5	NA
5. Demolition works	1	2	3	4	5	NA
6. Working in toxic/contaminated environments	1	2	3	4	5	NA
Sub-section score						
C.3) Personal protective equipment(PPE) use:						
Please rate the adequacy of the PPE use for the following trades.	Low……..…High					
1. Concrete works	1	2	3	4	5	NA
2. Structural steel and pre-cast assembly	1	2	3	4	5	NA
3. Erection & dismantling of scaffolds & false works	1	2	3	4	5	NA
4. Works at heights	1	2	3	4	5	NA
5. Demolition works	1	2	3	4	5	NA
6. Excavation works	1	2	3	4	5	NA
7. Piling operations	1	2	3	4	5	NA
8. Welding and cutting works	1	2	3	4	5	NA
9. Works in confined spaces	1	2	3	4	5	NA
10. Works in toxic/contaminated environments	1	2	3	4	5	NA
11. Use of machinery such as excavators, trucks, etc.	1	2	3	4	5	NA
12. Use of cranes	1	2	3	4	5	NA
13. Electrical installation and use	1	2	3	4	5	NA
Sub-section score						

Estimating the Project Safety Climate Index							
SWP *score*							
D) Safety training and competency of people involved							
D.1) Safety training to management team: Please rate the adequacy of the safety training to the following personnel in the project.	Low……..……High						
1. Demolition supervisor(s)	1	2	3	4	5	NA	
2. Excavation supervisor(s)	1	2	3	4	5	NA	
3. Piling supervisor(s)	1	2	3	4	5	NA	
4. Lifting supervisor(s)	1	2	3	4	5	NA	
5. Scaffold and/or suspended scaffold supervisor(s)	1	2	3	4	5	NA	
6. False work supervisor(s)	1	2	3	4	5	NA	
7. Welding & cutting supervisor(s)	1	2	3	4	5	NA	
8. Confined space work supervisor(s)	1	2	3	4	5	NA	
9. Toxic/contaminated environment work supervisor(s)	1	2	3	4	5	NA	
10. Project management team members	1	2	3	4	5	NA	
Sub-section score							
D.2) Certification & safety training of operators: Please rate the adequacy of the certification & safety training of the following operators in the project.	Low……..…High						
1. Crane erector(s)	1	2	3	4	5	NA	
2. Crane operator(s)	1	2	3	4	5	NA	
3. Riggers(s)	1	2	3	4	5	NA	
4. Signal men	1	2	3	4	5	NA	
5. Scaffold erector(s) and/or suspended scaffold rigger(s)	1	2	3	4	5	NA	
6. Erectors of hoists and lifts	1	2	3	4	5	NA	
7. Operators of hoists and lifts	1	2	3	4	5	NA	
8. Operators of plant like excavators, bull dozer, etc.	1	2	3	4	5	NA	
9. Construction vehicle drivers	1	2	3	4	5	NA	
Sub-section score							
D.3) In-house safety training to workers:	Low……..……..…High						

Estimating the Project Safety Climate Index						
Please rate the adequacy of the following modules of the in-house safety training to workers in the project.						
1. Site rules & regulations, and proper use of PPE	1	2	3	4	5	
2. Emergency response for various possible incidents	1	2	3	4	5	
3. First aid procedures	1	2	3	4	5	
4. Safe handling of tools and equipment	1	2	3	4	5	
Sub-section score						
STC_{score}						
E) Safety inspection system						
E.1) Inspection of worksite: Please rate the adequacy of the inspection system for the following items in the project.	Low……..……...High					
1. Excavations by a competent person on a daily basis and after hazardous events (e.g. inclement weather)	1	2	3	4	5	NA
2. Scaffolding by a scaffold supervisor on a weekly basis and after inclement weather	1	2	3	4	5	NA
3. False works by a PE or other competent person before, during and after casting and after inclement weather	1	2	3	4	5	NA
4. Demolition by a competent person on a daily basis and after inclement weather	1	2	3	4	5	NA
5. Material loading platform by a competent person on a regular basis and after inclement weather	1	2	3	4	5	NA
6. Temporary structures such as site office, canteen, site hoardings & concrete batching plant on a regular basis	1	2	3	4	5	NA
7. Specialised structures or operations like use of customised shoring systems by a competent person	1	2	3	4	5	NA
8. General site by a safety personnel or the site manager	1	2	3	4	5	NA
Sub-section score						
E.2) Housekeeping: Please rate the adequacy of the housekeeping for the following locations/items in the project.	Low…...……High					
1. Construction worksite	1	2	3	4	5	NA
2. Workers' quarters	1	2	3	4	5	NA
3. Toilets and washing facilities	1	2	3	4	5	NA
4. Canteen or eating places	1	2	3	4	5	NA
5. Site offices	1	2	3	4	5	NA
6. Storages for materials, tools & wastes	1	2	3	4	5	NA

Estimating the Project Safety Climate Index						
Sub-section score						
SIS_{score}						
F) Machinery and tools use and maintenance regime						
F.1) Testing & certification of machinery: Please rate the adequacy of the testing & certification of the following machinery in the project.	Low…….High					
1. Lifting gears (12 monthly)	1	2	3	4	5	NA
2. Lifting appliances (12 monthly)	1	2	3	4	5	NA
3. Lifting machines (12 monthly)	1	2	3	4	5	NA
4. Hoists and lifts (6 monthly)	1	2	3	4	5	NA
5. Air receivers (24 monthly)	1	2	3	4	5	NA
6. Explosive power tools (36 monthly)	1	2	3	4	5	NA
Sub-section score						
F.2) Inspection of machinery & tools: Please rate the adequacy of the inspection system for the following machinery in the project.	Low…….High					
1. Cranes by crane operators on a daily basis	1	2	3	4	5	NA
2. Electrical distribution board by a competent person on a daily basis	1	2	3	4	5	NA
3. Electrical equipment and tools by a competent person on a regular basis (weekly/more frequent)	1	2	3	4	5	NA
4. Construction vehicles like trucks, forklift, bull dozer, etc. by drivers or a designated person on a daily basis	1	2	3	4	5	NA
5. Temporary electrical installation by a licensed electrical worker	1	2	3	4	5	NA
6. Specialised equipment by a competent person	1	2	3	4	5	NA
Sub-section score						
F.3) Maintenance of machinery: Please rate the adequacy of the maintenance regime for the following machinery in the project.	Low……...……..High					
1. Tower crane(s)	1	2	3	4	5	NA
2. Mobile crane(s)	1	2	3	4	5	NA
3. Gondola(s)	1	2	3	4	5	NA
4. Piling machine(s)	1	2	3	4	5	NA
5. Passenger hoist(s)	1	2	3	4	5	NA

6. Mobile working platform(s)	1	2	3	4	5	NA
7. Construction vehicles like truck, forklift, bulldozer, etc.	1	2	3	4	5	NA
Sub-section score						
MTS_{score}						

G) Sub-contractors' safety systems

Please rate the adequacy of the following items of sub-contractors in the project.	Low……..……...High				
1. Safe work procedures	1	2	3	4	5
2. Safe use of plant, machinery and tools	1	2	3	4	5
3. Safety inspection systems	1	2	3	4	5
4. Trained operatives and supervisors	1	2	3	4	5
5. Adherence to safety requirements during construction	1	2	3	4	5
SSS_{score}					

H) Emergency management system

H.1) Emergency response plan: Please rate the adequacy of the emergency response plan for the following emergency scenarios in the project.	Low……..……...High				
1. Fire & explosion	1	2	3	4	5
2. Failure & collapse of structures/temporary supports	1	2	3	4	5
3. Failure & collapse of heavy machinery & equipment	1	2	3	4	5
4. Leakage of hazardous substances	1	2	3	4	5
5. Adverse weather & flooding	1	2	3	4	5
Sub-section score					

H.2) Emergency response team: Please rate the adequacy, competency and set-responsibilities of the following emergency response team members for various emergency scenarios in the project.	Low……....……High				
1. Emergency coordinator(s)	1	2	3	4	5
2. Site safety personnel	1	2	3	4	5
3. Designated rescuer(s)	1	2	3	4	5
4. First-aider(s)	1	2	3	4	5
5. Specialist operators(s)	1	2	3	4	5

Estimating the Project Safety Climate Index						
Sub-section score						
H.3) Emergency equipment: Please rate the adequacy of the emergency response equipment and facilities for the following emergency scenarios in the project.	Low……..…….High					
1. Fire & explosion	1	2	3	4	5	
2. Failure & collapse of structures/temporary supports	1	2	3	4	5	
3. Failure & collapse of heavy machinery & equipment	1	2	3	4	5	
4. Leakage of hazardous substances	1	2	3	4	5	
5. Adverse weather & flooding	1	2	3	4	5	
Sub-section score						
EMS_{score}						
I) Worker incentive system: Please rate the adequacy of the following incentives in the project towards motivating safe behaviours of workers and supervisors.	Low…….High					
1. Worker safe behaviour incentive	1	2	3	4	5	
2. Co-worker safe behaviour incentive	1	2	3	4	5	
3. Supervisor safety incentive	1	2	3	4	5	
WIS_{score}						
J) Work pressure: Please rate the following items in the project that contribute to work pressure in the project.	Low…….High					
1. Reasonableness of operational targets	1	2	3	4	5	
2. Workers' perception about work pressure on site	1	2	3	4	5	
3. Supervisors' perception about work pressure on site	1	2	3	4	5	
WP_{score}						

4. Conclusion

Improving safety in the construction industry has been a long felt need of the WorkCover in Australia. One of the strategies towards this goal is to set up a rating system that evaluates contractors on their safety performances. This study developed a model that evaluates

contractors' safety performances analysing three such factors as organisational safety culture, safety climate on site and actual implementation of documented safety management system. The model can be used by the WorkCover, Australia for deriving safety indices for contractors. These indices can give manifest pictures of contractors' safety consciousness which can be a key factor for clients in tender evaluations, and for insurance companies in premium-rating of workers' compensation insurance. Contractors with lower indices would have competitive advantages in the industry, which will motivate other contractors to improve safety. Eventually, this would pave the way to an accident-proof construction industry.

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The Effect of Winner's Curse on Post-Contract Management

Himal Suranga Jayasena,
Faculty of Architecture, University of Moratuwa, Sri Lanka
(email: suranga@becon.mrt.ac.lk)
Ruwandika Uhanowitage,
State Engineering Corporation, Sri Lanka
(email: ruwandink@yahoo.com)

Abstract

This study aims to identify whether there is an adverse effect to the client when a project is awarded to a bidder with a large winner's curse. The contractor is likely to run in to cash flow problems when he suffers from a large winner's curse. Therefore it is suspected that this would also have adverse effect to the client.

The study is interesting because large winner's curses are found to exist in Sri Lankan construction industry. Hence, some winning contracts may carry numerous problems due to very low or negative profits. The contractor may try to compensate his poor cash flow by submitting numerous claims and he may try to make profit by reducing the quality and time performance. Thus, this research intends to establish the relationship between the winner's curse and post contract management difficulties.

The research was designed as a correlation research with a survey based on 20 building projects. The winning bid range and winning margin are used to measure the winner's curse. Post contract management difficulties are measured using the contractor's claim attitude index.

The research finds that winning margin showed better correlation to claim attitude than the winning bid range. This indicates that the perceived winner's curse has higher impact than the real winner's curse on post contract management difficulties. Therefore the findings suggest that a client should be cautious when awarding the contract to a bidder with a large winning margin.

Keywords: Disaster Claim attitude index, Post contract management, Winner's curse, Winning bid range, Winning margin

1. Introduction

This paper presents a study conducted in Sri Lanka to identify whether there is an adverse effect to the client when a project is awarded to a bidder with a large winner's curse. The study is interesting because large winner's curses are found to exist in Sri Lankan construction industry [8] and the knowledge about their effect is limited.

1.1 Background

Awarding the contracts to the most appropriate contractor is one of the critical decisions to be taken by a construction client. This is very important to achieve successful project outcomes [11, 14, 15]. Awarding the contract to the lowest bidder is usually practiced in the public sector particularly because of its greater accountability. Many private clients also award contracts to the lowest bidder for cost reasons [4, 5, 6]. Therefore, the lowest bidder is typically the winner.

Successful bidders (that is, those who won the competition) tend to obtain returns that (on average) lie below initial projections. This discrepancy between realized and anticipated returns, and the possibility that winning bidders end up making losses, is called the winner's curse [1].

There is evidence that high probability for large winner's curse to exist in the Sri Lankan construction industry [7]. This means that the winning contracts shall either carry losses with below average profits or even negative profits. The contractor is likely to run in to cash flow problems when he suffers from a large winner's curse. Under the circumstance the contractor may try to compensate his poor cash flow by submitting numerous claims. He may also try to make profit by reducing time and quality performance [3]. Either context would lead to post contract management difficulties as the client and consultants would be required to take extra effort for corrective measures.

2. Winner's Curse

The Winner's Curse is a term originally apprehended in the oil industry and it described a phenomenon that occurred in common value auctions with incomplete information [2]. In common-value auctions, the value of the item is the same to everyone but different bidders have different estimates about the underlying value [9].

For example, an oil field had an actual intrinsic value of $10 million, oil companies might estimate its value to be anywhere from $5 million to $20 million. The bidder who erroneously estimated at $20 million would win in the auction, but will later find that it was not worth the amount he paid. Accordingly, even when a bidder's evaluations are correct on average, a bidder's evaluations on the tract he wins are not correct on average: they are biased upward [1]. If he wins, he loses money and thus he is cursed.

2.1 Winner's curse in the construction industry

Recall that the winner in the construction industry in competitive bidding is typically, the bidder who submits the lowest bid. When each bidder estimates the project cost and bids accordingly, the winner would probably be the bidder who has most underestimated project value. Thus he wins the contract and agrees to complete the project for a price which is less than the "right price" or the "true value" of the project. The winner therefore may become disappointed in the first instance of having largely underestimated; and later will look for means of rectifying it.

2.2 Detection of the winner's curse

The difference between the lowest and second lowest bids is often referred as "winner's curse." However, the correct quantitative measure of the winner's curse should be the difference between the "right price" of the project and the winning bid [13]. However, the "right price" is literally unknown and thus the measure is not practical.

To represent the winner's curse, winning margin is a useful measure. The term "winning margin" (*W*) is the difference between the second lowest bid and lowest bid. The "percentage-winning margin" (*PW*) is the ratio of the winning margin to the lowest bid and can be used to compare across projects of differing sizes [8]. These can be mathematically represented as:

$$W = (P_1 - P_0) \quad \text{, and}$$

$$PW = \frac{(P_1 - P_0)}{P_0} \times 100$$

where, P0 is the lowest bid and P1 is the second lowest bid. Since the winning margin is the obvious foregone profit to the winner, it represents the perceived winner's curse.

A recent study has shown that the winner's curse in the Sri Lankan industry is a serious issue. The average percentage-winning margin was equal to 9.323 [7]. This means that a second lowest bid is 9% larger than the lowest in general and this is significantly a high figure. The study further found that the distribution of bid prices was symmetrical and close to the normal distribution. Most of the bids were scattered closely around the average bid. With the conjecture that the majority is correct, the right price lies in the centre. When the lowest bid that lies in tail of the distribution, is the winning bid; there is a high probability for large winner's curse to exist.

With the presumption that the majority is correct, the winner's curse measured based on the average bid price would be a better representation of real winner's curse. Therefore to measure the winner's curse "winning bid range" (*B*) can be used and it is the difference between the average bid and the winning bid. The percentage- winning bid range (*PB*) is the ratio of the winning bid range to the winning bid. These are mathematically represented as

$$B = (P_a - P_w)$$

$$PB = \frac{(P_a - P_w)}{P_w} \times 100$$

Where, P_a is the average bid and P_w is the winning bid; and P_w is equal to P_0 when the lowest is the winning bid.

3. Research Methodology

The research was design as a correlation research based on an industry survey. The sampling population was Sri Lankan building projects, which were awarded to Grade M4 or above contractors and completed during last five years. A random sample of 20 projects was used for collection of data. All data was abstracted from the project documents. Both winning margin and winning bid range were used to measure the winners curse.

The challenge was to measure the project management difficulties. Current literature did not produce an appropriate quantitative measure. Thus, it became necessary to unfold a new measure.

Claim management is one of the main issues of the post contract management activities. And also cost performance is one of the main concerns when considering the contractor's performance [12]. If the contractor runs into the cursed context and tries to rectify it at the expense of client's time and money; the key strategy he would use, is to make numerous claims [10]. This would yield additional paperwork and negotiations for client and his consultants; and also cause adversarial relationships. Therefore the contractor's Claims Attitude Index (Y) was identified to measure the level of post contract management difficulties. It was the ratio between the amount claimed for the contractual claims such as variations, fluctuations and cost headings under time extensions by the contractor, and the actual amount approved for payment:

$$\text{Claim attitude index } (Y) = \frac{\text{Quoted amount by contractor}}{\text{Approved amount}}$$

4. Data Analysis

The correlation between variables was tested using the Pearson Correlation Coefficient. Two independent variables: Percentage Winning Margin (PW) and Percentage Winning Bid Range (PB), were analysed for correlation with dependant variable: Claims Attitude Index (Y). The analysis results are presented in Table 1 below.

Table 1: Pearson correlation analysis

Independent variables \ Dependent variable		Claim Attitude Index (Y)
Percentage Winning Bid Range (PB)	Pearson correlation coefficient	0.051
	Confidence level (1- tailed)	0.584
Percentage Winning Margin (PW)	Pearson correlation coefficient	**0.274**
	Confidence level (1- tailed)	**0.856**

Both independent variables (*PB* and *PW*) showed a positive correlation with the dependent variable (*Y*). However, PB showed poor level of correlation and confidence. Percentage Winning Margin (*PW*) showed a better level of correlation at 85.6% confidence level. Even though confidence level is little below the general statistical norms to conclude the correlation is significant; for a research of this nature, it is a significant figure.

5. Conclusions

The evidence of high probability for existence of large winner's curse in the Sri Lankan construction industry, urged the need to identify if a contractor with a large winner's curse is an adverse selection. The winners curse was quantitatively measured by two variables: Winning Margin and Winning Bid Range. Claims Attitude Index measured the post contract management difficulties to test whether the contractor is an adverse selection.

The Pearson Correlation Analysis results showed both the winning bid range and the winning margin are correlated positively with the claim attitude. Thus, the relationship between Winner's curse and post contract management difficulties found to be positive. Therefore, awarding a contract to a bidder with a larger winner's curse could be an adverse selection. However, the correlations are not significant enough to statistically theorise this as a fact. But, the results provide clear indication about the relationship.

The Pearson correlation coefficient was 0.051 between winning bid range and claim attitude with poor confidence level; but it was 0.274 between winning margin and claim attitude with confidence level of 85.6%.

Since the winning margin is a measure of perceived winner's curse; it can be now concluded that the perceived winner's curse has larger adverse impact to the post contract management

activities than that from the real winner's curse. This is because winning bid range, which is the selected measure for the real winner's curse shows a very weak relationship to the claim attitude. This is pragmatic because, the large perceived winner's curse gives the feeling to the contractor that he losses a significant amount from the contract. He would have bid 1$ less than the second lowest and still could win the contract. Thus, the Winning Margin is obviously a foregone profit.

With the conclusions of the research it is advised that a client should not award a contract to a bidder with a large winner's curse, especially when there is a large perceived curse.

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Impediments to the Development of Design and Build Procurement System in Sri Lanka

Anne Loretta Joseph,
Department of Building Economics, University of Moratuwa
(email: nnloretta@yahoo.com)
Himal Suranga Jayasena,
Department of Building Economics, University of Moratuwa
(email: suranga@becon.mrt.ac.lk)

Abstract

Design and build has become a popular mode of procuring construction work. It is now, regarded by majority of clients because is offer greater confidence to clients. Even most of the researchers had found that the design and build procurement method is better than the traditional method in most of the areas, in general it does not developing as dominant or highly practicing procurement method in most of the countries except France, Greece and also Norway and Mexico in private sector. In Sri Lanka, design and build has not extended as it is expected. Therefore, it is worthwhile to find out the reasons behind the drawbacks of design and build procurement system development. Thus this research is intended to identify the most significant impediments to the development of design and build procurement method in Sri Lanka.

A two round questionnaire survey facilitated to identify the significant impediments to the development of design and build procurement system in Sri Lanka and few unstructured interviews with most experienced professionals in the area were carried out in order to study and understand the context. Twenty significant impediments were identified and ranked according to the negative impact they create on the development of design and build procurement system. It is found that very less contribution given by the government to promote design and build is the first most significant impediment. Lack of clients' knowledge related to alternative procurement systems, less contribution to the development given by research and development institutes, unfamiliar of contractors' professionals with the design and build procurement process, clients' lack of experience with design and build procurement method, less contribution to the development given by professional institutes, and reflection of consultants' own interest in procurement selection are found as other six uppermost significant impediments.

Keywords: Design and build, Procurement method, Impediments, Sri Lanka

1. Introduction

Design and build (D&B) is becoming popular due to its advantages providing over the traditional procurement system. The D&B procurement route has witnessed significant growth in many countries over the world and considered as dominant procurement system too.

However, some researches shown than in Sri Lanka the traditional procurement system is dominating the procurement market over the years and D&B procurement system use as next alternative option among alternative procurement systems but, less in practice. There this paper presents a study undertaken to identify the impediments to the development of D&B procurement system in Sri Lankan based. The significant impediments found out through the surveys and unstructured interviews are discussed and explained in the appropriate sections.

2. Background

2.1 D&B procurement system

Design and Build procurement system is defined as, 'A construction procurement method where the contractor offers to undertake the entire design and construction of a project' by Cox and Townsend 1998 (cited in [1]). According to Moore and Dainty [2], D&B emerged as a procurement system to overcome the drawbacks of the separated system by offering greater confidence to clients seeking to avoid delays, exposure to costly claims, possible litigations and to improving project performance. D&B is now regarded by majority of clients than the for the traditional system, which providing the optimum route to obtain value for money and it is easy for the clients to enter in to a single contract rather than many where, the conflicts among parties are less. Its popularity arises from its perceived ability to bring design and construction processes closer together culturally, and associated improvements in cost and time certainty. Further, the system has also been advocated as facilitating a seamless procurement process, improving team relationships and producing a more efficiently delivered product. It offers a potential route for the implementation of new concepts such as: fair and equitable relationships, continuous performance improvement and changes in management and culture. The system reduces time to a minimum by eliminating traditional tendering procedure and produces more advantages to the clients and contractors when comparing to the traditional procurement system.

2.2 Trends in procurement systems

There was a time, when traditional system was the only option on the table to clients. An architect designs a building from beginning to its end and then contractors looked over the drawings and bid on the project. But the states now have changed and there are different project delivering methods to fulfil the client's need according to project requirements.

According to the research conducted by the Royal Institute of Charted Surveyors (RICS) Construction Faculty [3] over the years for United Kingdom (UK) construction industry, D&B is a single most prevalent alternative procurement method since year 1995. Until such time the Bills of Quantities dominated the industry. This was the time of major shifts in procurement strategies come up. This survey reinforces the dominance of D&B as a procurement strategy. D&B has remained steady at just over 40% of total workload value. Not only in UK construction industry but also in many other countries such as China, Denmark, Great Britain, Japan and United States of America (USA) D&B procurement method shows an increasing trend. In Private sector countries like France, Thailand, Norway and Mexico uses D&B system

more than 50%. Public sector too in countries like Greece and France uses the D&B as the procurement system [4].

According to the research conducted by Rameezdeen and Ratnasabapathy [5], the Measure and Pay method dominates the Sri Lankan construction industry, but decrease in certain periods paving way for other systems. Majority of public works in Sri Lanka found to be procured using these methods by considering accountability and transparency. D&B has recorded a usage rate of 20-35% during the year 1977 to 2003. The management contracts, lump sum, prime cost contracts procured only few projects during the study period. Table 2 indicates the survey result of trend procurement systems in Sri Lanka [5].

Table 2: Trend in methods of procurement in Sri Lanka (by value of contract)

% of Use (average) / Procurement System	1977 -81	1982 -86	1987 -91	1992 -96	1997 -00	2001 -03
Measure and Pay	55	50	58	50	64	72
Lump Sum	12	10	8	7	10	5
Prime Cost	10	8	5	4	3	1
Design and Build	22	31	28	35	21	22
Management Contracting	1	1	1	1	1	0
Joint Venture	0	0	0	3	1	0
Total	100	100	100	100	100	100

In Sri Lankan context the growth pattern of D&B was positive up to year 1996 and then it began to decline up to year 2000, but there after no significant changes shown in its growth. The growth of D&B is not up to the expected level in Sri Lanka when comparing with the countries mentioned earlier. The traditional procurement system remains widely procuring method and it's seems to be strong. Therefore, it is essential to explore why the D&B procurement is not popular in the Sri Lankan context and identify the barriers preventing the popularity, in order to develop the innovative procurement system in Sri Lanka.

3. Methodology

This research is designed as a survey study to identify the most significant impediments to the development of D&B procurement system in Sri Lanka. Therefore, the data collection is done based on two round structured questionnaire survey. The first round of the survey was used to identify the presence of the impediments in the local context by using a sample of ninety professionals. The next round used to rank the impediments according to their negative impact to the development of D&B. Screening process, considering the respondent who are mostly complying with the first round results reduces the second round sample size up to thirty in number. The sample for both survey rounds consisted similar number of clients, consultants and

contractors' professionals with different professional disciplines such as: Architects, Engineers and Quantity Surveyors. Some unstructured personal interviews were setup for the purpose of study the local context parallel to the first round questionnaire survey. Based on the literature survey, questionnaires were prepared and distributed to identify the current impediments that are emerged in the local context. In the basis of first round results the second round aimed to identify the significant impediments and Relative Important Index (RII) was used to analyse the data in the second round.

4. Impediments to the development of D&B procurement system in Sri Lanka

The impediments can be created externally or internally to the development of design and build procurement system. The factors that beyond the control of the stakeholders of the construction industry were identified as external factors and factors, which can be controlled by the stakeholders, were taken as internal factor. According to Rolwinson [6], the external environment factors that affect the construction industry as well as the development and use of procurement systems, which comprise political, economical, technological, financial and social aspects. The internal factors contain: issue imposed to the development of D&B procurement by client, consultant, contractor, government, statutory and regulatory bodies, research and development instituted (R&D) and professional institutes.

Twenty most significant impediments were identified both internally and externally, that effecting the development of D&B procurement system in Sri Lanka. The factors were discussed under appropriately categorized sections and explained. Table 3 shows the identified significant impediments in the rank order.

Table 3: Twenty significant impediments identified through the survey

Rank	Impediments
1	Government contribution in promoting D&B in Sri Lanka is very less
2	Clients' lack of knowledge regarding alternative procurement systems
3	Less contribution to the development of D&B procurement system by Research and development institutes in Sri Lanka
4	Contractors' professionals are unfamiliarity with D&B procurement system
5	Clients' lack of experience with D&B projects
6	Less contribution to the development of D&B procurement system by Professional institutes in Sri Lanka
7	Reflection of consultants' own interest in procurement selection
8	Government preferences for D&B only by only considering time factor
9	Poor relationships create by client with the consultants

Rank	Impediments
10	Barriers to enter in to D&B market by the construction contractors in terms of: not familiar with D&B projects earlier and incapability of contractors
11	Negative attitudes among consultants' professionals toward D&B procurement system
12	Inadequate in-house design team in contractors' organizations to compete in the market
13	Poor project management practices by the D&B contractors
14	Contractors' professionals inflexible to accept the changes when involving in D&B process
15	Effect of political environment in procurement selection
16	Barriers to enter in to D&B market by the construction contractors in term of political environment
17a	Inadequate cover by the 'Standard Conditions of Contract'
17b	Very less contribution is given by the Ministry of Finance to the development of D&B procurement system as a regulatory body of Sri Lanka
19	D&B contractors' profit making interest rather than thinking of client's requirements
20	Less market strategies used by D&B contractors in order to promote their services

4.1 Clients related factors

The study point out that the lack of clients' knowledge related to alternative procurement systems (ranked-2) act as a major barrier to the development of D&B in Sri Lanka. It is difficult for the clients to gain knowledge regarding new procurement system, since most of the construction clients are laymen and any institutes or contractors do not conduct awareness programmes for clients in order to educate them regarding the innovative procurement systems. Therefore, the clients do not intend to use alternative procurement systems other than the traditional system.

Clients' lack of experience with D&B projects (ranked-5) widely effects the selection of D&B system in their projects. On the other hand it consequently reduces the probability of using D&B for most of the projects and this factor give a negative impact to the growth of D&B procurement method. Most of the clients fear to take an additional risk by selecting a procurement system, which is not familiar to them. Also there are lack of examples in the industry to show the success of such system due to only few projects are carried out using D&B procurement system in the industry.

Other than the clients' lack of knowledge regarding alternative procurement systems and lack of experience with D&B projects; maintain poor relationships with consultants by clients (ranked-9) act as impediment to the development of D&B. Clients are overemphasis on fee rather than services, ultimately they get poor consultants services for their projects by consider low cost. Ultimately, they provide insufficient project brief, provide inadequate time to prepare proposals to contractor, often change their scope of work, create lot of difficulties in the construction stage especially in quality control and creates conflict with contractors. Therefore, this gives a negative effect to the development of D&B.

4.2 Contractors related factors

The unfamiliarity of contractors' professionals with D&B process is the forth major significant impediment in ranked order, which effect the development of D&B in Sri Lanka. The reason could be Sri Lankan professionals are generally practice the traditional procurement system due to the domination of the systems in the market. It is found that the public contracting organizations are widely use the Measure and Pay rewarding method for D&B system even though Lump Sum method is conventionally used for D&B system. In some instances they bid for Lump Sum method and later change to Measure and Pay method due to the difficulties faced after the commencement of the project. This evidences the unfamiliarity of Sri Lankan public contracting organizations with the system. In addition, most of the private contracting organizations have lack of experience with D&B projects due to the ascendancy of the traditional procurement system in the market. Therefore, most of the contractors' professionals are not willing to work for D&B projects and this act as a barrier to the development of D&B in Sri Lanka.

Also, there are barriers to the construction contractors to enter in to the D&B service market due to their incapability and unfamiliar with D&B projects earlier. Inadequate in-house design team in contractors' organizations act as a barrier to D&B contractors to, compete in the market. However, the responses from contractors for this factor are little varied from consultants and clients. Most of the contractors in Sri Lanka go for joint venture with design teams for D&B projects and the contractors feel that it is easy and better to outsource the design team. In addition, unstable demand for D&B type projects discourages the contractors to establish in-house design teams. This might be the reason for absents of pure D&B organizations which only undertake projects under D&B system in Sri Lanka. But, the consultants and clients experienced that joint ventures bring additional cost factor to the project, more difficulties and conflicts after the project completion. The improper project management practice by the D&B contractors in Sri Lanka ranked 13th in order. It is obvious that this factor prevent the consultants and clients to select D&B as project procurement. Also, the contractors' professionals are reluctant to accept the changes when involving in D&B process due to strong uncertainty avoidance and rigid culture of the Sri Lankan construction professionals also found as another impediment to the development of D&B in Sri Lanka.

Other than the above mentioned factors, contractors' profit making interest rather than thinking of clients' requirements (ranked-19) and less market strategy used by the contractors (ranked-

19) identified as a significant impediments. The profit making interest leads to reduction in quality of the project and the clients are not in a possession to derive the benefits of this procurement method without sacrificing quality. Marketing or sales development long ignored by many contractors who depend on word-of-mouth in a defined geographical marketing arena, also the market strategy used by D&B contractors are very less compare to countries which use D&B widely and this factor act as a barrier to increase the D&B projects in the context.

4.3 Consultants related factors

Reflection of consultants' own interest in procurement selection (ranked-7) has given a considerable effect to the development of D&B. The reason for this could be that the consultants do not use systematic procurement selection criteria for project procurement selection. Therefore, the selection could always be bias rather than a logical approach. Thus, consultants select the traditional procurement system as project procurement, which they are well familiar in most of the cases. The selections are made without taking additional risk by selecting an unfamiliar procurement system. Ultimately, this leads to reduction in probability of use D&B system for appropriate project scenarios.

It is revealed through the study that, there are negative attitudes among consultants' professionals toward D&B procurement system in Sri Lanka. This is due to the image among consultants' professionals regarding D&B such as loss of their traditional leading role, authority and job satisfaction. Further the consultants' professionals are reluctant to change from the tradition and experience new challenging role in the innovative procurement system due to their rigid culture. Ultimately this factor effects the D&B procurement selection in project procurement and reduces the usage of D&B.

4.4 Government and political environment

It is found that the very less government contribution in developing D&B is the first most significant impediment to the development of D&B procurement system in Sri Lanka. The government started to procure more projects using D&B system from year 2001, after publishing 'Standard Bidding Document' for D&B contracts. But bidding for most of those D&B public projects are not open to the private sector contractors. Generally government goes for negotiated based D&B contracts with public contracting organizations. This discourages the use of D&B in private sector. If the government open the tenders to the private sector, the contractors may be encouraged to develop further their D&B knowledge in order to stay competitive to bid for future projects. Once they are familiarized with D&B, the level of adoption will be increased. As a consequence, the use of D&B is significantly promoted across a broad spectrum of the construction industry, which the government fails to do so. Therefore, initiation of the D&B procurement system in private sector by the government as a major client in the construction industry is the lagging contribution within the context in order to develop D&B procurement system.