Analyzing the Impact of Location Factors on Building Construction Cost in Sri Lanka

Thulasimaaran Parameswaran, T.S. Jayawickrama and D.G. Melagoda
Department of Building Economics
University of Moratuwa
Moratuwa, 10400, Sri Lanka
thulasipara@gmail.com, tsjayawickrama@yahoo.com, dgmelagoda92@gmail.com

Abstract

Impact of location factors in building construction cost is increasing over past decades in all over the world. It draws the attention towards the concept of analysing the impact of location factors to determine how to estimate the building construction cost with a high level of accuracy to prevent client's money from unexpected fluctuations and provide most suitable design within client's budget. Even though location index is considered in most countries, Sri Lanka has failed to use it and still uses single cost index considering only the time factor where location index is vital. This necessitates the development of a holistic analysis on impact of location factors approach to the construction sector in Sri Lanka. Preliminary questionnaire survey validated and modified the location factors identified in literature review. Further, it is established the most significant factors based on respondents' comments towards impact on construction cost in building construction. Moreover, percentages of major cost elements in total construction cost were recognized as material (40%), labor (24%), plant and equipment (9%), preliminaries (10%), overheads and profit (17%). Detailed survey focused on prioritization of location factors with AHP tool for major cost elements of building construction; ground condition and climate are identified as most significant impact factors.

Keywords
Building Construction Cost, Location, Sri Lanka

1. Introduction

Estimate is the net projected cost of implementing the work for a given project. It reflects all items of expenditure which are required to accomplish the work (MacBain, 2014). In construction industry, it is a forecast of the measure of a project considering accessible information at the season of expectation (Sitsabo, 2012). A main measure of success in making budget estimates is forecasting the outturn capital cost and the whole life cost precisely at project inception (Samphaongoen, 2009). Contractors want to be confident that the estimates which form the substance of their tenders are realistic and if their tender prices are unswervingly high, they will fail to attract work and on the other hand if their prices are too low, they will get work at unprofitable rates (Statewide Program Management Group, 2008).

Factors such as construction site condition, complexity of the project, market rate, project schedule, quality of plans and regulatory requirement, location, type and size of the project influence the construction cost estimate and substantially impact the project cost (Cartlidge, 2013). Hence, the cost of developing or obtaining individual project elements differs not just over time, but also across geographical areas (Abeysinghe, 2010). For example, in the UK, tender price is differed based on the region of the country where the work is performed; normally, London and the South East of England being expensive; the area variations are shown in a location index that is used to adjust prices (Samphaongoen, 2009). Therefore, variances in prices between cost analysis data and cost plan are adjusted using some indices namely, building cost indices, location indices and tender price indices. These are achieved using index numbers stating relative to a base year (Cartlidge, 2013).

Even though location indices are vital and considered in most of the countries, only the time factor is considered in published price indices in Sri Lanka. Sri Lankan construction industry uses Construction Industry Development Authority (CIDA) bulletin, which include the construction statistics that are published monthly. However, CIDA bulletin has not specified any location factors for Sri Lankan construction industry. Thus, it was found that there are regional impacts in pricing material, labor and plant in Sri Lanka, therefore, it is important to have location indices in Sri Lanka to improve the accuracy and efficiency in pricing tenders (Abeysinghe, 2010). Accordingly, this study anticipates filling the research gap by exploring the suitability of location factors in Sri Lankan construction industry. It is aimed at analysing the impact of location factors on building construction cost to be achieved through the objectives 1) To identify the major location factors which are affecting construction cost, 2) To examine the impact of location factors for building construction cost in Sri Lanka and 3) To propose a mechanism to analyse the impact of location factors on building construction cost in Sri Lanka.

2. Literature Review

Factors influencing the cost of building are nature of the project, cost of the design, total height of the building, method of procurement, legislative constraints, environmental factors, method of construction and also the location (Ashworth, 2004; Lowe, 2007; Sitsabo, 2012; Cunningham, 2013). The building construction cost may be decomposed into major elements such as labor, material, equipment, preliminaries and overheads (Chris, 2008). Variations in construction cost is typically due to differences in building design, time required for construction, as well as the current supply and demand factors. Unusual changes in supply and demand characteristics impact building cost elements (Dell'Isola, 2003). Basically, construction material purchase price is directly influenced by their accessibility to supply and the demand for them in the nearby market (John, 2013).

2.1 Reasons for construction cost variations in different locations

The location choice can mean economic accomplishment or failure for several types of commercial activities because they need detailed location conditions (Rymarzak nad Seiminska, 2012). Similarly, the cost of procuring or developing individual project features varies not just over time, but also by geographical regions (Grogan and Ichniowski, 2009). Therefore, the location of a project is undoubtedly vital when judging its approximate cost of construction (Akanni et al., 2015). When construction activities expand into new geographical regions a 'region cost factor' will be added which is the relative cost of construction in new region to another region (Woosley, 2012). This "region cost factor depends on

- the relative price of labor across areas;
- the relative price of material across areas;
- the quantity of construction activity across areas and
- the production technology.

The calculated factors specify that regional cost factors must not be taken as static across time but must be permitted to differ to reflect various behaviors of factor prices in various zones of the nation over time (Isherwood, 2003). Generally, urban locations are expensive than rural areas due to higher wages of labors, costs associated with access constraints, limited space for staff accommodation facilities and material storage and the additional security required (Cunningham, 2013). Alternatively, higher transportation costs associated with longer distances to ship the material to market will play a larger role as well, especially for imports (Odusami and Onukwube, 2008). Construction costs strongly depend on the area's local market conditions. Especially, strange changes in demand and supply activity attributes affect some building parts (or material) in the nearby market center, and thus the cost of certain building segments may fluctuate (Abeysinghe, 2010).

Availability of labor force, quality of labor force, unemployment rate, labor unions, attitude towards work, labor turnover, motivation of workers and work force management may change in different regions (Brook, 2016). Besides, when the construction activity is extremely high in a specific region, there might be shortages of construction material, if this was not predicted in initial cost estimate, delays may occur, and the prices of these material increase (Paul, 2005). The cost of transportation of the material to the construction site escalates as the distance increases (Odusami and Onukwube, 2008).

Furthermore, factors such as national regulations, availability of reserves, and state and local regulations play major roles in estimation of material cost. Correspondingly, slowdown in obtaining permits at reserve sites results in a shortage of sand, gravel and crushed stone which directly affects the material prices (MacCarthy and Atthirawong, 2003). Changes to industrial, safety, taxation and environmental laws are not uncommon (Martin et al., 2009), thus problems may arise when the law changes through the location and during the life of a project (Akanni et al., 2015).

The ground condition of the selected site is a factor that can generously impact building construction costs. The augmented expenses can be experienced in construction due to poor ground bearing limit combined with poor working conditions for men and machines as they got to be impeded (Ashworth, 2004).

Weather conditions can severely affect the performance of construction works. Nevertheless, this impact differs widely since it is based on the location of the project (Johannes et al., 1985; National Association of Home Builders Research Center and Columbia Enterprises, 2005) and on the specific moment in time, which the task is carried out (Oyedele, 2015).

2.2 Need for cost adjustment for location factor

The need to contemplate construction prices across capital urban areas, villages, towns and rural regions relies upon the degree to which price changes vary in each of the areas. It additionally depends on the available resources to create location indices and to gather location price data. Where location price patterns do not contrast significantly, it is adequate simply to recognize metropolitan regions, other extensive urban areas, small urban areas, towns, and rural areas. A few nations [e.g. Greece) incorporate indices only in respect of capital urban areas, on the supposition they are illustrative of the urban zones for the whole nation. Where location contrasts are critical, a good topographical dispersion is imperative (The Scottish Government, 2009).

Tender price is differed based on the region of the UK where the work is performed, normally London and the South East of England being the expensive and the area variations are shown in a location index that is used to adjust prices (Samphaongoen, 2009). The Building Cost Information System (BCIS) yearly issue a set of location indices that cover most part of the UK, and these can be used for adjustments in case where the cost-analysis data in different location is applied for a cost plan in another location.

In Sri Lankan construction industry, since there is no parallelism in price fluctuation patterns between the regions; a standard location adjustment for estimates is not robust. Therefore, reasoned professional judgment is required for the location adjustment in estimates (Abeysinghe, 2010). Further to author, reasonably different pattern could be found between Colombo and other regions, and other regions had relatively better correlation among them. Therefore, two indices (i.e; for Colombo and Outer-Colombo regions) would be the first step of developing regional indices.

3. Research Methodology

To achieve the aim of this study survey method was selected. A preliminary questionnaire survey was conducted among four (04) construction industry experts. It was developed based on literature findings to accomplish three purposes. First is to validate and identify more location factors affecting building construction cost, second is to measure the percentage of major cost elements that contribute to building construction cost and third is to identify the impact of location factors to those cost elements. Results were used to develop the hierarchical structure to identify the link between location factors and major cost elements.

Subsequently, Analytic Hierarchy Process (AHP) was adopted. One of the AHP tool's unique features is its ability to compute a measure of the inconsistencies made by the decision makers. This enables the decision makers to identify "errors," revise their judgments, and improve the quality of their decision. The location factors identified for each cost element in the preliminary survey were entered into the pair wise comparison matrix to formulate human judgment with the relative weight of each pair. The preferences are quantified by using the one-to-nine scale (1-Equally important, 3-Moderately more important, 5-Strongly more important, 7-Very strongly more important, 9-Etremely more important). Table 1 shows the square matrix of pairwise comparison. Geometric means of pair-wise comparison responses given for each criterion is indicated as P1 to P6 in the table. Reciprocal values of those criterions are denoted by 1/P1 to 1/P6 while sum of each column is represented by S1 to S4.

Table 1: Square matrix for pairwise comparison

Location Factor (LF)	**Factor 1 (f1)**	**Factor 2 (f2)**	**Factor 3 (f3)**	**Factor 4 (f4)**
Factor 1	1.00	P1	P2	P3
Factor 2	1/P1	1.00	P4	P5
Factor 3	1/P2	1/P4	1.00	P6
Factor 4	1/P3	1/P5	1/P6	1.00
Sum	S1	S2	S3	S4

Then, by dividing each entry of the matrix with the sum of entries in the respective column, it was normalized by the relative weight. Tale 2 illustrates method of calculating normalized square matrix.

Table 2: Normalized square matrix calculation

LF	**f 1**	**f 2**	**f 3**	**f 4**	**Sum**	**Relative weight (RW)**
f 1	1 /S1	P1/S2	P2/S3	P3/S4	x1	x1/X = W1
f 2	1/S1P1	1/ S2	P4/S3	P5/S4	x2	x2/X = W2
f 3	1/S1P2	1/S2P4	1/ S3	P6/S4	x3	x3/X = W3
f 4	1/S1P3	1/S2P5	1/S3P6	1/ S4	x4	x4/X = W4
					X	

Judgment of the respondents may not be consistent. Therefore, the results were validated by consistency ratio (CR) values. Method of consistency calculation is showed in Tale 3.

Table 3: Consistency calculation

LF	f 1	f 2	f 3	f 4	Sum	Σ / RW
f 1	1 xW1	P1xW2	P2 xW3	P3xW4	Z1	Z1/ W1
f 2	W1/P1	1 xW2	P4 xW3	P5xW4	Z2	Z2/ W2
f 3	W1/P2	W2/P4	1 xW3	P6xW4	Z3	Z3/ W3
f 4	W1/P3	W2/P5	W3/P6	1 xW4	Z4	Z4/ W4

The maximum Eigen value was calculated as the next step and it was denoted by "λmax". In the AHP process, it is an important validating parameter to calculate Consistency Ratio as follows.

1. Calculation of λmax

$$\lambda max = \Sigma\ (SUM \div Importance\ Score)/n$$

n – number of factors

2. Calculation of Consistency Index (CI)

$$CI = (\lambda max - n) / (n - 1)$$

3. Calculation of Consistency Ratio (CR)

$$CR = CI / RI$$

Where, RI is Random Index for matrices which order 1 to 10 and RI value depends on the number of factors applied for the evaluation (Saaty, 1994). Table 4 illustrates the RI values for number of 1 to 10 factors.

Table 4: Average RI based on matrix size

Size of matrix (n)	Random consistency index (RI)
1	0.00
2	0.00
3	0.52
4	0.89
5	1.11
6	1.25
7	1.35
8	1.4
9	1.45
10	1.49

If the consistency ratio is 0.10 or less, it is a positive evidence for the informed judgment. It can be concluded as the data set was considered as to be consistent and validated (Saaty, 1994).

4. Research Findings

Summarizing the literature and preliminary survey findings, factors affecting building construction cost due to the location (location factors) can be delineated as distance from Colombo, availability and price of material, availability and wage of labors, legal issues, ground condition, local market condition, infrastructure and climate specific to Sri Lankan construction industry. Further, experts were requested to identify the location factors affecting each cost element fromr3 and above eight (08) factors. Results are illustrated in Table 5 below. Respondents are indicated as R1, R2, R3 and R4 in the table. 'x' denotes respondents agreement on the effect of location factor on the cost element while '-' denotes disagreement.

Table 5: Location factors affecting each cost element

Cost elements / Location Factors	Material				Labor				Plant and Equipment				Preliminaries				Overhead and Profits			
	R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4
Distance from Colombo	x	x	x	-	-	-	-	-	x	-	x	x	x	x	-	x	-	-	-	-
Local market condition	x	x	x	x	x	x	x	x	x	x	x	-	-	x	-	x	-	x	-	x
Availability and wages of labor	-	-	-	-	x	x	x	x	-	x	-	-	-	x	-	x	-	-	-	x
Availability and price of material	x	x	x	x	-	-	-	-	-	-	-	-	-	x	-	x	-	-	-	x
Legal issues	x	x	-	x	x	-	-	x	x	-	-	-	x	x	x	x	-	x	x	x
Ground condition	x	x	-	-	x	x	-	-	x	x	-	x	-	x	x	x	-	x	x	x
Infrastructure	-	-	-	-	-	-	-	-	x	x	-	x	-	x	x	x	-	-	-	-
Climate	x	-	x	x	x	x	x	x	x	x	x	-	-	x	x	x	-	-	x	x

Based on the responses, there is no impact by "distance from Colombo" on material and overhead and profits; "availability and wages of labor" on material; "availability and price of material" on labor and plant and equipment; 'infrastructure' on material, labor and plant and equipment. Thus, the perception of the impact on different cost elements varies as per the respondent. Even solitary respondent's agreement on the impact of a location factor on cost elements was considered positive.

Another objective of the preliminary questionnaire survey was to divide the building construction cost into five major elements and identify the percentage of those cost elements to the building construction cost in Sri Lankan context. The major cost elements distinguished are material, labor, plant and equipment, preliminaries, overhead and profit. The respondents were asked to comment on the percentage of each major cost elements to total construction cost of a building. Results with average are given in Table 6 below.

Average of this result was considered as final percentage of the major cost elements for a building. Therefore, percentage of 'Material' cost is 40% of building construction cost. Labor, plant and equipment, preliminaries and overhead and profit components received 24%, 9%, 10% and 17% of building construction cost respectively.

Table 6: Elemental cost percentage from total building cost

Respondents	Material (%)	Labor (%)	Plant and equipment (%)	Preliminaries (%)	Overhead and profits (%)
R1	43	22	8	12	15
R2	42	29	4	10	15
R3	40	23	7	5	25
R4	35	23	15	12	15
Average	**40**	**24**	**9**	**10**	**17**

The questionnaire survey was conducted among experienced Quantity Surveyors to prioritize and assign relative weight to location factors under each major cost element. Relative weight of each factor on each cost element, which is later considered as the 'performance score' and consistency ratio are showed in the Table 7.

Table 7: Performance score and consistency ration

Cost element / Location Factor	Material	Labour	Plant and Equipment	Preliminaries	Overhead and Profits
Distance from Colombo	0.071		0.077	0.085	
Local market condition	0.140	0.130	0.204	0.057	0.276
Availability and wages of labor		0.255	0.032	0.035	0.075
Availability and price of material	0.277			0.030	0.051
Legal issues	0.120	0.109	0.196	0.162	0.124
Ground condition	0.288	0.123	0.357	0.301	0.23
Infrastructure			0.075	0.102	
Climate	0.105	0.383	0.059	0.229	0.239
Consistency Ratio	**0.073**	**0.074**	**0.099**	**0.099**	**0.099**

As stated by Saaty (1994), consistency ratio of 0.10 or less is the positive and acceptable evidence for informed judgment; the data set is considered as consistent in significant level. In all above cost elements CR value is less than 0.10, therefore, the consistency and validity of data is verified. Then, overall performance scores were obtained by multiplying the performance score for relevant location factor of each cost element by the percentage of each cost element to total construction cost of a building. 'Overall Rank' was prioritized by referring overall performance scores as illustrated in Table 8.

Table 8: Prioritized location factors

Rank	Location factors	Overall Performance Score	Overall Rank
Material - 40%			
1	Ground condition	0.115	1
2	Availability and price of material	0.111	2
3	Local market condition	0.056	5
4	Legal issues	0.048	6

Rank	Location factors	Overall Performance Score	Overall Rank
5	Climate	0.042	8
6	Distance from Colombo	0.028	15
Labour - 24%			
1	Climate	0.092	3
2	Availability and wages of labour	0.061	4
3	Local market condition	0.031	12
4	Ground condition	0.030	13
5	Legal issues	0.026	16
P & E - 9%			
1	Ground condition	0.032	11
2	Local market condition	0.018	19
3	Legal issues	0.018	20
4	Distance from Colombo	0.007	26
5	Infrastructure	0.007	27
6	Climate	0.005	29
7	Availability and wages of labour	0.003	31
Preliminaries - 10%			
1	Ground condition	0.030	14
2	Climate	0.023	17
3	Legal issues	0.016	21
4	Infrastructure	0.010	23
5	Distance from Colombo	0.009	24
6	Local market condition	0.006	28
7	Availability and wages of labour	0.004	30
8	Availability and price of material	0.003	32
OH & Profit - 17%			
1	Local market condition	0.047	7
2	Climate	0.041	9
3	Ground condition	0.040	10
4	Legal issues	0.021	18
5	Availability and wages of labour	0.013	22
6	Availability and price of material	0.009	25

In Table 8, first column named 'Rank' indicates the ranks of location factors under relevant major cost elements according to their performance scores. Overall performance scores were obtained by multiplying the performance score for relevant location factor by the performance score which is allocated for the

major cost element of relevant location factor. 'Overall Rank' was prioritized by referring overall performance scores. The overall performance score of each location factor integrated to cost elements were added together and total performance score for each location factor is obtained which is depicted in Figure 1.

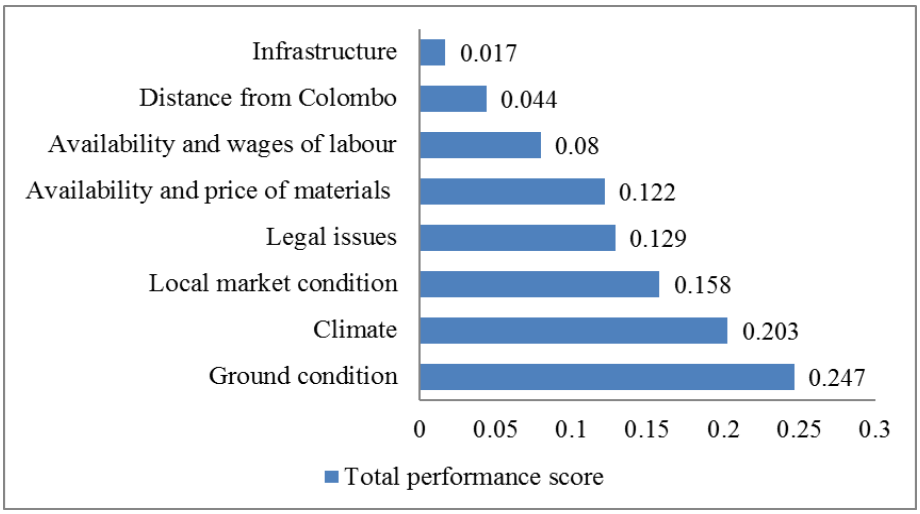

Figure 1: Overall performance scores of location factors

According to the total performance score, "ground condition" has the highest impact on the building cost when the location changes, while the "infrastructure" in the vicinity got the lowest impact.

5. Discussion

Generally, location factors impacting on the building construction cost in Sri Lanka are distance from Colombo, availability and price of material, availability and wage of labors, legal issues, ground condition, local market condition, infrastructure and climate. The process of demarcating the impact of each factor on each cost element is complex and specific factors contribute to the other categories. To overcome these issues a hierarchical structure was developed. Accordingly, highest percentage of the building cost will be obtained by material which is 40%. Others, labor, plant and equipment, preliminaries and overheads and profit cover 24%, 9%, 10% and 17% of building construction cost respectively. Therefore, ultimate success in construction cost can be achieved by more concern on the 'material' category.

According to Figure 1 'Ground condition', 'Climate', 'Local market condition', 'Availability and price of material', 'Legal issues' and 'Availability and wages of labor' have respectively obtained the highest total performance scores exceeding 0.05 and Distance from Colombo (0.044) obtained the performance score very closer to the 0.05. Therefore, the aforesaid location factors can be identified as the most significant factors to impact on building construction cost. 'Ground condition' is approximately sixteen times greater than the least significant factor which is 'Infrastructure'. It shows the criticality of the highest significant factor when comparing with the least significant factor.

In conclusion, a mechanism to quantify the critical factors that effect on construction cost has been developed in this study. The process is directed through three core steps,

1. Identification of major cost elements of a building and location factors affecting construction cost of a building

2. Structuring the location factors hierarchically (Allocation of each location factor to each cost element based on their impact)
3. Defining percentage impact of cost elements to building construction cost based on the region
4. Quantify the effect of the factors on construction cost using AHP tool
    a. Develop the weights for each cost element
    b. Develop the ratings for each location factor for each cost element
    c. Calculate the weighted average rating for each location factor and derive the indices

Accordingly, indices can be developed to adjust the cost estimates of buildings or changes in the location. This can endow with benefits to cost estimators by providing accurate and reasonable construction cost for the achievement of a fair value to the client's money. It is expected that the key location factors identified in this study improve the understandings of industry practitioners in impact of location factors on building construction cost. Analysis are conducted in own customized ways. Therefore, it cannot be expected a consistency among the location factor analysis in various buildings. In that case, implementation of developed scores in each location will allow making comparisons among locations and further find out the impact of the eight location factors on cost.

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Biographies

Thulasimaaran Parameswaran is a Quantity Surveying graduate from Department of Building Economics, University of Moratuwa, Sri Lanka. Currently, he is working as a Quantity Surveyor at Dara Engineering Consultants, Qatar. He is a member of Australian Institute of Quantity Surveyors.

T.S. Jayawickrama is a Senior Lecturer of Department of Building Economics, University of Moratuwa, Sri Lanka. She earned B.Sc (Hons) in Quantity Surveying from University of Moratuwa, Sri Lanka. She was awarded the research scholarship from the University of Singapore and earned her PhD from University of Singapore in sustainable construction. Her research interests are environmental sustainability in construction, environmental rating systems for construction, economic aspects of applying eco-friendly strategies to buildings and infrastructure and application of project management strategies to construction sites.

D.G. Melagoda is a former lecturer of Department of Building Economics, University of Moratuwa, Sri Lanka. She earned B.Sc (Hons) in Quantity Surveying from University of Moratuwa, Sri Lanka in 2017. Further, she has completed Advanced Diploma in Management Accounting, Chartered Institute of Management of Accountants (CIMA), United Kingdom in 2015. She is a Graduate member of Institute of Quantity Surveyors Sri Lanka (IQSSL). Her research interests are sustainability in construction, disaster management, project appraisal for construction, Building Information Modelling (BIM) and construction law and dispute resolution.