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.

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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

λmax = Σ (SUM ÷ Importance Score)/n

n – number of factors

2. Calculation of Consistency Index (CI)

CI = (λmax - 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).

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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.

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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

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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

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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.

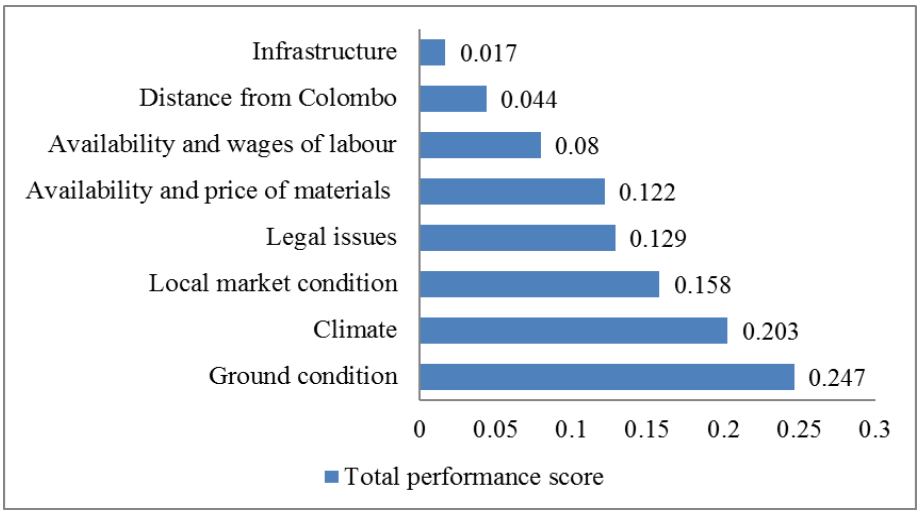

Figure 1: Overall performance scores of location factors

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

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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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