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Soft factor consideration in equipment selection and to develop an analytical hirearchy process for the same.

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ABSTRACT

The present work raises the issue of soft factors in the selection of construction equipment for the high rise residential towers. The soft factors mean those factors which are uncertain, informal, intangible and qualitative in nature. Some of the example like working on night shift, transportation problem, fluctuation in markets, safety consideration, whether conditions etc.

In this study evaluation of soft factors for the equipment selection process is done and simultaneously analytical hierarchy process (AHP) is applied for the same to suggest the best alternative for soft factors. For study purpose two different sites namely Panvel city and Thane city is selected. Based on the importance of the project a questioner survey and in-depth interview has been conducted and soft factor is evaluated and simultaneously a structure integration of AHP is develop and also a analysis has been done.

This analysis listed variety of soft factors in the present day construction work which is usually ignored by the construction industry and it's also highlighted the proposed selection model for construction equipment. The study exposed the dominance factor of one over another which has further helped in deciding the rank of the soft factors for the construction equipment in the construction field. The result of consistency ratio is also less than or equal to 0.1 therefore the judgment is also acceptable and the said work is going on a right path.

Keywords- soft factors, analytical hierarchy process, selection of equipment, high rise residential tower, cranes.

I. INTRODUCTION

"The cost of the project varies from 10 to 30 % of the total cost of the project, depending upon the extent of mechanization. In modern fully mechanized project the cost of the equipment goes up to 30 % proper planning, selection, procurement, installation, operation, maintenance and equipment replacement policy plays an important role in management for the successful completion of project. With the growing use of machinery it has become necessary for construction engineer to be thoroughly familiar with the construction application and upkeep of the wide range of modern equipment"[9-10]

"Selection of equipment for construction projects generally involves two classes of factors or considerations. The first class comprises tangible, quantitative, formal considerations. Typical factors of this class include technical specifications of the equipment, physical dimensions of the site and constructed facility, and cost calculations; they are hereby termed "hard" factors/ considerations. The second class covers a large array of "other" factors, which are mostly intangible, qualitative, and informal in nature"[1].These soft factors are difficult to analyze as they are highly depend on climatic conditions, condition of site, location of site, construction company, workmanship etc. As this is a high rise residential tower major focus was given on tower crane as construction equipment. This study explores the role of soft factors consideration in the selection of construction equipment with a focus on high rise residential tower project. Most importantly this study explores the answer of following question.1) what soft

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factors are considered in the current project and how they are analyzed 2) The dominance factors of one over another and the importance of soft factors with the help of AHP.

The analytical hierarchy process (AHP) is the theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scale. It is these scales that measures intangibles in relative terms. The comparisons are made using a scale of absolute judgements that represent, how much more; one element dominates another with respect to a given attribute. The judgements may be inconsistence, and how to measure inconsistency is the concern of the AHP [3]

The objective behind the present study is to evaluate the soft factors which are uncertain and intangible in nature and to implies a better selection process using AHP.

II. METHOD

Thomas L. Saaty (1980) developed the following steps for applying the AHP [7]:

1) Define the problem and determine its goal.

2) Structure the hierarchy from the top (the objectives from a decision-maker's viewpoint) through the intermediate levels (criteria on which sub- sequent levels depend) to the lowest level which usually contains the list of alternatives.

3) Construct a set of pair-wise comparison matrices (size n * n) for each of the lower levels with one matrix for each element in the level immediately above by using the relative scale measurement shown in Table 1. The pair-wise comparisons are done in terms of which element dominates the other.

4) There are n(n-1)/ judgments required to develop the set of matrices in step 3. Reciprocals are automatically assigned in each pair-wise comparison.

5) Hierarchical synthesis is now used to weight the eigenvectors by the weights of the criteria and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.

6) Having made all the pair-wise comparisons, the consistency is determined by using the eigenvalue, λmax, to calculate the consistency index, CI as follows: CI=(λmax-n)/(n-1), where n is the matrix size. Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate value in Table 2. The CR is acceptable, if it does not exceed 0.10. If it is more, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.

7) Steps 3-6 are performed for all levels in the hierarchy.

Table no 1: Pair-wise comparison scale for AHP preferences [7]

Numerical rating	Verbal judgments of preferences
9	Extremely preferred
8	Very strongly to extremely
7	Very strongly preferred
6	Strongly to very strongly
5	Strongly preferred
4	Moderately to strongly
3	Moderately preferred
2	Equally to moderately
1	Equally preferred

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***Table no 2: Average random consistency (RI)** [7]*

size of matrix	1	2	3	4	5	6	7	8	9	10
Random consistency	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The study was conducted in Mumbai. One construction site is in the outskirt area of Panvel approximately 10km away from Panvel railway station and second site is in congested area of Thane city. The two projects were constructed by two different companies. The details of construction project are given in Table no 3.

Table no 3 : Profile of projects

Number	Name & location	Contractor	Main structure	Major equipment
1	Indiabulls green Panvel, Maharashtra, INDIA	ARCON	Four towers (G+3+37 storied)	• Full height five external tower cranes. • Stationary concrete pump with climbing boom.
2	KSL infrastructure Thane , Maharashtra, INDIA	SHREE	Two tower (32 floor tower)	• Three tower cranes. • Stationary concrete pump with climbing placing boom.

III. ANALYSIS AND RESULT

Table 4 presents 16 soft equipment selection factors identified by the interviews and observations. By close and numerous site visit the soft factor were worked out and formulation of AHP has been done.

Table no 4 : Equipment selection soft factor

Number	Selection factor	Management convenience	Work safety	Operational Efficiency	Progress delay
1	Site accessibility				+
2	Labour availability				+
3	Transportation problem				+
4	Equipment age and maintenance			+	
5	Contractor replacement				+
6	Obstacles on site		+	+	
7	Strong winds (safety)		+		+
8	Overlapping of cranes.		+		

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9	Working on night shifts (safety)	+	+		+
10	Obstruction during winter season		+		+
11	Interaction with other equipment		+		+
12	Previous experience with equipment	+		+	
13	By tradition of equipment	+		+	
14	Progress plan and time table	+			+
15	Working on night shift (management)	+			+
16	Specialization of work			+	

From table no 4 the dominance factor has been analyzed for project delays, work safety, operational efficiency and management convenience and a structure hierarchy is develop for the soft factors as shown in fig no 1.

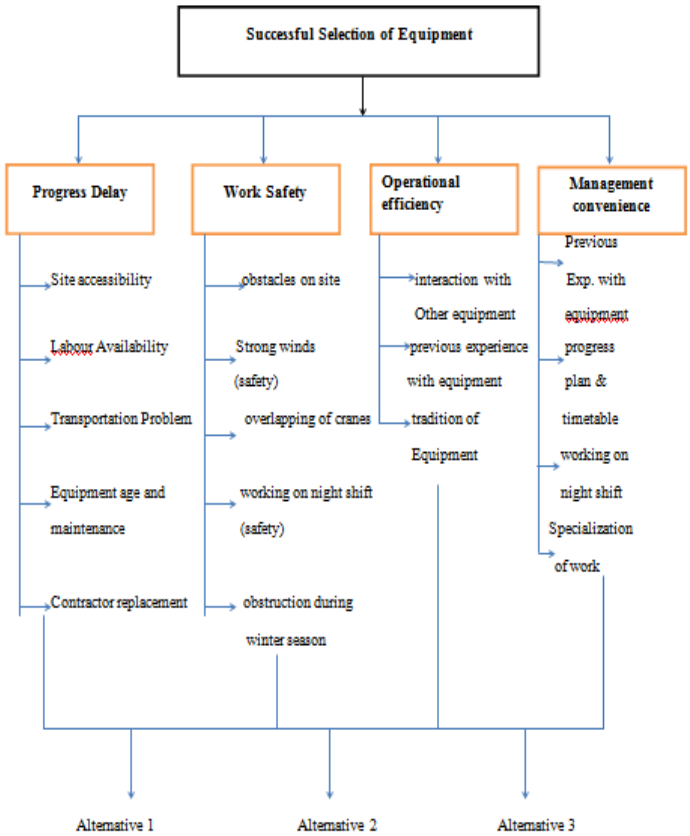

Figure no (1): analytical hierarchy for soft factor

Leading question: which factor has a greater impact on the management convenience and up to what extend?
A1: previous experience with equipment
A2: progress plan and time table
A3: working on night shift

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A4: specialization of work

Step no 1

	A1	A2	A3	A4
A1	1	1/4	4	1/6
A2	4	1	4	1/4
A3	1/4	1/4	1	1/5
A4	6	4	5	1
Sum	11.25	5.50	14.0	1.62

Step no 2

	A1	A2	A3	A4
A1	0.089	0.045	0.286	0.103
A2	0.356	0.182	0.286	0.154
A3	0.022	0.045	0.07	0.123
A4	0.533	0.727	0.357	0.617
	1	1	1	1

Step no 3

priority vector
0.130
0.24
0.06
0.55
0.99 ≈1<ok>

Step no: 4

$$0.130\begin{pmatrix}1\\4\\1/4\\6\end{pmatrix} + 0.24\begin{pmatrix}0.25\\1\\1/4\\4\end{pmatrix} + 0.06\begin{pmatrix}4.0\\4.0\\1\\5\end{pmatrix} + 0.55\begin{pmatrix}1/6\\1/4\\1/5\\1\end{pmatrix} = \begin{pmatrix}0.521\\1.168\\0.2706\\2.63\end{pmatrix}$$

Weighted sum matrix

Step no 5: 0.521/0.130=4.01; 1.168/0.245=4.76; 0.2706/0.065=4.16; 2.63/0.55=4.74

$$\lambda max = \frac{4.01+4.76+4.16+4.74}{4} = 4.41$$

Step no 6:

$$C.I = \frac{\lambda max - n}{n-1} = 0.13$$

Step no 7: Consistency ratio = consistency index/ random consistency=C.I/R.I =0.13/0.9= 0.1 ≤ 0.1 therefore ok.

IV. CONCLUSION

- For any equipment user proper weightage must be given to the soft factors like working on night shift, whether condition, safety consideration, transportation problem before using the equipment to the construction site which is usually ignored in current scenario.
- From the above analysis it is clear that progress plan and time table i.e. (A2) is more dominant than previous experience with equipment i.e. (A1) as far as management convenience factor is concern.
- Previous experience with equipment (A1) is more dominant than working on night shift (A3).
- Similarly specialization of work is more dominant than previous experience with equipment.
- And likewise from the whole analysis it is clear that the specialization of work is more dominant than other three factor i.e. A4>A2>A1>A3.
- Consistency ratio is less than 0.1 i.e. CR≤0.1 which means that judgement for the given matrix is acceptable.

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