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Right Selection of Equipment by Using Analytical Hierarchy Process

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Abstract: *Selection of construction equipment play's very crucial role for a successful completion ofproject. Today's construction projects are going highly mechanized day by day and equipment cost goes up to 10% to 30% of total project cost. Selectionof construction equipment is always a key factor to achieve economy & proper execution in projects. TheAHP (Analytical Hierarchy Process) considers best alternative option's among which the best decision is to be made. The AHP use makes selection process easy& informative. In this paper we are going to analyse how AHP helps to select a proper set of equipment's to overcome the time delay also to increase the profit in project. This method makes theselection process easy, flexible. Equipment cost always plays a major role in construction projects. This paper aims to use of AHP for right selection of equipment to complete project economically & successfully.*

Keywords: Construction Equipment Selection, Execution in projects, AHP in Equipment Selection, Mechanized Construction.

I. INTRODUCTION

The equipment used in construction projects (construction equipment) includes various types and models. The selection process of construction equipment is not easy, and conventional methods, such as optimization tools, expert systems or economic comparisons, frequently cannot provide the desired solution. The complexity of today's building project makes it harder to evaluate equipment alternative and make the right selection from many alternatives. With the growingawareness of the role played by mechanization and industrialization in project execution, the decreasing availability of skilled manpower, andless budget and schedule constraints in acompetitive construction condition, companies and project management teams often lack the equipment's to select the best combination of cranes, concrete pumps, forming systems, and otherequipment suitable to meet project requirements. The cost proper planning, selection, procurement, installation, operation, maintenance and equipment replacement policy plays an important role in management for the successful completion ofproject. With the growing use of machinery it'snecessary for construction engineer to get familiar with the construction equipment's and upkeep of the wide range of modern equipment.

AHP is a widely used one of the multi-criteria decision making method that was originally developed by prof. Thomas L. Satty. AHP gives pair-wise comparisons which allow in judgments and increases the precision of the results. AHP helps capture both subjective and objective evaluation measures, providing a useful mechanism for checking the consistency of the evaluations thusdecreasing bias in decision making.

II. OBJECTIVES

- Use of AHP tool in equipment selection to mitigatethe confusion.
- To increase profitability and decrease the timedelay in choice of tools and equipment
- To make construction process as per scheduledtime management.
- Equipment life and replacement alternatives.

III. LITERATURE SURVEY

1. Aviad Shapira, Marat Goldenberg - Elaborates selection of equipment for construction projects, amain factor in the successful completion of the project.
2. Natalia Horn akova, Luka s Jurık1, Henrieta Hrablik Chovanova, Dagmar Cagan ova, Dagmar Babcanova By

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applying AHP method to decision making process on appropriate handling equipment based on the determinate criteria and input condition of the enterprise.

3. Govindan Kannan Says the study of equipment economics and productivity is as old as equipment itself.
4. James M. Monnotetal Through his study say that into-days' time the construction equipment is extremely advanced and equipped with technology so need to select right equipment.
5. Kamal M. Al-Subhi, Al-Harbi Says that the analytical hierarchy process (AHP) is the best decision making method for use in project management and better equipment selection.
6. Sangwook Lee - Says the analytic hierarchyprocess (AHP) approach has been widely applied inmulti-attribute decision-making situations sincebeing introduced in 1980. It has been believed that the AHP is appropriate to assist decision-making and selection of equipments.
7. Aviad Shapire shows the quantitative measuresand risks scale of safety hazards on construction sites due to the working of tower crane
8. James M. Monnot through his study say that in to- days' time the construction equipment is extremely advanced and equipped with technology to collect volumes of data regarding every aspect of the machine's operation.
9. Sujit Kumar Goshal Shows application of Analytical Hierarchy Process (AHP) as important tool in decision making process. AHP removes the decision problem and make more more easy to select best alternatives of equipment.
10. Thomas L satty Says The Analytic Hierarchy Process (AHP) is a theory of measurement through pairwise comparisons and relies on the judgmentsof experts to derive priority scales.

IV. METHODOLOGY

Phase 1) Site selection: The best site is selectedanalysed in this paper.

Phase 2) Literature review: from variousliterature it has been observed that various author has carried out their work related to equipment selection.

Phase 3) Questionnaires and Interview: by questionnaire survey and in-depth interview with regards to equipment selection has been conducted. The person involved in this survey is project manager of site, plant and machinery head, siteengineer.

Phase 4) Cost estimate of Alternatives: The feasible alternatives has been worked out and Cost estimate of the various alternatives has done

Phase 5) Develop Analytical Hierarchy Process: with the evaluation and use of AHP the alternative has been generated.

Phase 6) Total evaluation: Calculate difference in the alternatives and after that calculate the better alternative has finalized.

The data collection procedure was done by different types which are mentioned below:

1. Telephonic Questionnaire
2. Video Call Questionnaire
3. Physical Interview Questionnaire

The data collected from the above mentioned types of questionnaire was in the raw form which was assembled in an appropriate manner and then the data analysis procedure was started. Equipment combinations for the project. These are focused on construction of the high-rise tower.

IV. EQUIPMENT'S ALTERNATIVES

Equipment type	Alternative 1	Alternative 2	Alternative 3
Tower cranes(C)	C1: Full- height external crane serving mainly tower (L1=55m, H1= 276 m) C2 : Free- standing crane serving lower structure (*L*2=40	C1, C2: Two full-height external cranes, one on each side of tower (*L*1 =*L*2=40 m, *H*1=276 m, *H*2=280 m)	C1: Internal climbing crane primarily serving the tower (*L*1=40m, *H*1=36 m) C2: Free- standing crane serving the lower structure (*L*2=40 m,

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	m, *H2*=36 m)		*H2*=36 m)
Concrete pumps(P)	Stationary pump with climbing placing boom (*L*=32 m)	Truck- mountedpump	Stationary pump with climbing placing boom (*L*=40 m)
Formingsystems	Automatic climbing system for allvertical concrete elements of tower (core andexternal walls)	Crane- assisted forms for all vertical concrete elements of tower	Automatic climbing system for concrete core of tower(external precast concrete wallpanels)

V. Daily Crane Employment Requirement

Material/ Element	Unit	Qty	Life cycleduration per unit (min)	Total duration, cranes only (min)		
				Alternative 1	Alternative 2	Alternative 3
Concrete for walls and columns	m3	25	12	concrete pump	300	Concrete pump
Concrete for slabs	M3	90	12	concrete pump	1080	Concrete pump
Reinforcement steel	Ton	6	24	144	144	144
Slab forms	Complete work	1	120	120	120	120
Core forms	Complete work	1	120	Doka shuttering	120	Doka shuttering
External wall form s	Complete work	1	120	Doka shuttering	120	Doka shuttering
External precast panels	Pcs			-	-	400
Finish materials						
Total				264	1884	664
15% idling time:				40	282	100
Total time				304	2166	764
Required work shifts of cranes (for 10-h, 600-min shift)				1-day shift	3-shifs: two parallel day shift, 1 night shift	1 day shift parallel night shift

VI. Cost Evaluation

Equipment	Cost Factor	Cost Estimate (Rs.)		
Tower Crane (C1)		Alternative 1	Alternative 2	Alternative 3
	Capital cost or rental	47,00,000	45,00,000	30,00,000
	Maintenance	6,00,000	5,00,000	5,00,000
	Insurance, taxes, license	7,70,000	7,00,000	5,50,000
	Transportation, erecting, dismantling	3,90,000	3,90,000	7,00,000

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	Ties, climbing device	13,00,000	10,00,000	9,00,000
	Operator wages	5,28,000	15,84,000	10,56,000
	Operating (energy)	3,50,000	3,50,000	4,50,000
	Climbing	50,000	50,000	5,00,000
Tower Crane (C2)	Capital cost or rental		45,00,000	
	Maintenance	1,70,000	5,00,000	1,70,000
	Insurance, taxes, license	1,00,000	7,00,000	1,00,000
	Transportation, erecting, dismantling	3,90,000	3,90,000	3,90,000
	Ties, climbing device		10,00,000	
	Operator wages	5,28,000	15,84,000	10,56,000
	Operating (energy)	50,000	4,50,000	50,000
	Climbing	Marginal	50,000	Marginal
Concrete Pump	Capital cost or rental	45,00,000	20,00,00	48,00,000
	Maintenance	12,00,000	-	12,50,000
	Insurance, taxes, license	4,00,000	-	4,50,000
	Transportation, erecting, dismantling	--	--	--
	Ties, climbing device	4,50,000	-	4,50,000
	Operator wages	1,00,000	-	1,00,000
	Operating (energy)	4,15,000	-	4,60,000
	Climbing	-	3,50,000	-
Forming System (F)	Capital cost or rental	74,00,000	-	15,00,000
	Maintenance	5,00,000	1,00,000	1,50,000
	Insurance, taxes, license	5.60,000	-	1,25,000
	Transportation, erecting, dismantling	Marginal	Marginal	Marginal
	Operating (energy)	Marginal	--	Marginal
	Strengthening of concrete core (due to external precast walls)	--	--	75,00,000
	Labour wages for vertical elements	40,00,000	1,20,00,000	20,00,000
Total cost for alternative		**2,88,91,000**	**3,26,98,000**	**282,07,000**

VII. SERVICE DURATION OF EQUIPMENT(MONTHS)

Equipment	Alternative 1	Alternative 2	Alternative 3
Tower crane (C1)	24	24	24
Tower crane (C2)	6	16	6
Concretepump	10	6	10
Formingsystem	14	14	14

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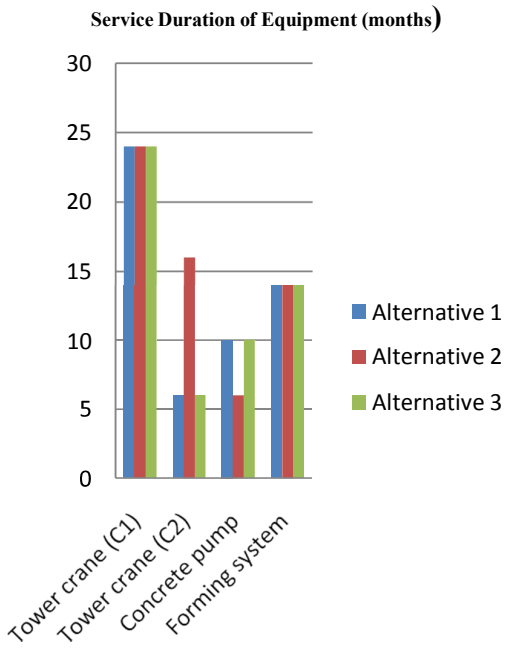

Service Duration of Equipment (months)

7.1 Analysis of Collected Data

- Pair wise comparison
- Pair-wise comparison matrix for selection ofequipment

Pair-wise comparison matrix for selection of equipment				
SSE	**F1**	**F2**	**F3**	**F4**
F1	1			
F2		1		
F3			1	
F4				1

Code	Description
F1	Management convenience
F2	Operational efficiency
F3	Progress delay
F4	Work safety

SSE	F1	F2	F3	F4
F1	1	1/5	1/5	1/3
F2	5	1	1	5
F3	5	1	1	5
F4	3	1/5	1/5	1
ColumnTotals	**14.000**	**2.4000**	**2.4000**	**11.333**

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AHP		Consistency check
0.067	6.7%	5.99%
0.408	40.8%	
0.408	40.8%	
0.117	11.7%	

CA	λmax	CI	CI/RI
1.082	4.160	0.053	0.059
0.994			
0.994			
1.064			

VIII. Results & Discussion

- Pivot (lowest cost alternative): Alternative 3
- Alternative 3 Cost (Rs): 2, 82, 07,000
- Alternative 1 Cost (Rs): 2, 88, 91,000 Cost Difference (Rs): 6,84,000.

Alternative	Total Score	Total Normalized scores
1	1.2110	0.410
3	1	0.323

IX. Conclusion

From the above analysis it is however clear that selection of equipment for any construction project or infrastructural project should not be done based on only cost analysis we must have to use various analytical tools like AHP the priority should also be given to the unforeseen factors which indirectly affects the cost of the project.

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