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ABSTRACT: Equipment selection is a key factor in modern construction industry. As it is a complex factor, current models offered by literatures fail to provide adequate solutions for major issues like systematic evaluation of soft factors and weighting of soft benefits in comparison with costs. This paper aims at making a comparative study between GA and AHP by utilising MATLAB as a tool. It is a convenient tool offering an orderly methodical thinking. It guides them in making consistent decisions and provides a facility for all necessary computation.

Keywords*: Methodical Thinking, Soft Factors, Equipment Selection.*

I. INTRODUCTION

Construction equipment planning aims in identifying the construction equipment to carry out project tasks, assessing equipment performance capability, forecasting datawise requirements of numbers and types of equipment. Finally one has to think about a particular method for selecting equipment which will be more productive and less expensive and more profitable. There are several methods pertaining to this topic are available in MATLAB tool box out of which genetic algorithm is considered in this paper.(4) ,(3).

II. ANALYTIC HIERARCHY PROCESS TOOL BOX

Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended sub-problems, each of which can be analyzed independently.

The elements of the hierarchy can be related to any aspect of the decision problem tangible or intangible, carefully measured or roughly estimated, well or poorly understood anything at all that applies to the decision at hand.(1)

Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them with one another two at a time, with respect to their impact on an element above them in the hierarchy.
In making the comparisons, the decision makers can use concrete data about the elements, but they typically use their judgements about the elements' relative meaning and importance. It is the essence of the AHP that human judgments, and not just the underlying information, can be used in performing the evaluations.(2)

III. INPUT DATA FORMAT FOR ANALYTIC HIERARCHY PROCESS

3.1 Required Information

The following data available for each of the machinery used in the project is considered.

i. 15 Month Machine data of Availability.
ii. 15 Month Machine data of Working Hours.
iii. 15 Month Machine data of Diesel Consumption.

The above data collected for the project under consideration is given in Table 1.

3.2 Format of Input

The input data has been prepared in Microsoft Excel format for ten machines, the sample of which is shown below:

<Machine _1> <Avail_ Hr s/ Month> <Working_Hrs/Month>
<Idle_Hrs/Month><Diesel_Consmp/Month>
<Machine _2> <Avail_ Hr s/ Month> <Working_Hrs/Month>
<Idle_Hrs/Month><Diesel_Consmp/Month>
<Machine _3> <Avail_ Hr s/ Month> <Working_Hrs/Month>
<Idle_Hrs/Month><Diesel_Consmp/Month>
.
<Machine _n> <Avail_ Hr s/ Month> <Working_Hrs/Month>
<Idle_Hrs/Month><Diesel_Consmp/Month>

Fifteen month data is taken for consideration. But here one month consumption is given as a random
The performance data provide information about the actual productivity of each equipment for a period of 15 months. It shows the equipment's particulars, nature of work done, with detailed information about shift hours, available hours, running hours along with availability percentage, utility percentage and diesel consumption. The equipment productivity at the end

of every month is shown in monthwise plant and equipment performance data are given in Table 1.

Table 1. Monthly Plant & Equipment Performance Data

SLN o.	Description	Shift Hrs*	Break Down Hrs	Available Hrs	HMR Reading		Hrs Run for the month	Cum. Hrs Run **	Idle Hrs	Production Qty #	Availability Percentage	Utilization Percentage	Consumables (ltrs)				
					Opening	Closing							Diesel	E. Oil	H. Oil	G. Oil	T. Oil	C. Oil
(A)	(B)	(C)	(D)	(E) = (C) - (D)	(F)	(G)	(H) = (G) - (F)		(I) = (E) - (H)	(J)	(K) = (E) / (C) *100	(L) = (H) / (E) *100	(M)	(N)	(O)	(P)	(Q)	(R)
1	Compressor 325 cfm(A)	520		520	1454	1567	113	1567	467		100%	22%	960					
2	Compressor 325 cfm(B)	300		300	423	660	137	660	163		100%	46%	900	15				
3	Concrete Pump, BP 1500(A)	450		450	1503	1723	220	1723	230		100%	49%	900	10	15			
4	Concrete Pump, BP 1500(B)	400		400	2956	3156	200	3156	200		100%	50%	360		20			
5	Concrete Pump, BP 1800(C)	480		480	4040	4290	250	4290	250		100%	52%	800					
6	Concrete Pump, BP 1800(D)	500		500	3328	3578	250	3578	250		100%	50%	850	20	40			
7	Concrete Pump, BP 1500(E)	500		500	1585	1785	200	1785	300		100%	40%	500	15	200			
8	Concrete Pump, BP 1500(F)	520		520	1661	1661	200	1661	520		100%	38%	850	12	30			
9	Concrete Pump, BP 2500(G)	500		500	5941	6121	180	6121	320		100%	36%	1600	20				
10	Concrete Pump, BP 1600(H)	500		500	6476	6666	190	6666	310		100%	38%	3500	45				
11	Concrete Pump, BP 1600(I)	600		600	4594	4774	180	4774	220		100%	43%	4500	20				
12	Concrete Pump, BP 160 K(J)	420		420	6700	6890	190	6890	250		100%	45%	4000	20				
13	Concrete Pump, BP 160K(I)(K)	480		480	4346	4466	220	4466	260		100%	45%	3000	40				
14	Concrete Pump, BP 125K(M)	400		400	5560	5720	160	5720	240		100%	60%	3500	35				
15	Concrete Pump, BP 62.5K(N)(O)	400		400	3657	3857	200	3857	200		100%	50%	600	20				
16	Concrete Pump, BP 250K(M)(N)	400		400	332	532	180	532	220		100%	45%	500					
17	Concrete Pump, BP 160K(A)(O)	400		400	2439	2639	200	2639	200		100%	50%	3000	20				
18	Escort Hydra Crane 12Ton	520		520	1723	1870	247	1870	273		100%	48%	200					
19	JCB Boche / Loader 3DX	300		300	1475	1571	198	1571	182		100%	60%	630		3			
20	JCB skidsteer loader	300		300	1197	1306	109	1306	191		100%	36%	600	1				
21	Material Hoist(A)	525		525	2289	2542	203	2542	242		100%	53%						
22	Material Hoist(B)	520		520	1804	2045	241	2045	279		100%	46%						
23	Material Hoist(C)	521		521	1660	1458	389	1458	132		100%	74%						
24	Material Hoist(D)	600		600	1470	2035	565	2035	35		100%	94%						
25	Material Hoist(F)	600		600	685	885	200	885	200		100%	50%						
26	Stetter Plant, CP 30	520		520	3644	3844	310	3844	210	3840	100%	60%		1				
27	Stetter Plant, M 1	520		520	631	810	279	810	241	5711	100%	54%						
28	Tower Crane MC-115B(A)	520		520	6542	6842	281	6842	239		100%	54%						
29	Tower Crane MC-115B(B)	520		520	3819	4061	242	4061	278		100%	47%						
30	Tower Crane MC-285B(C)	520		520	2635	3024	389	3024	131		100%	75%						
31	Tower Crane MC-115B(D)	600		600	543	1114	571	1114	29		100%	95%						
32	Tractor Escort Farmtrac 70	300		300	364	593	229	593	71		100%	76%	120					
33	Transit Mixer(A)	520	158	362	8654	8977	323	8977	39	888	70%	89%	720	2				
34	Transit Mixer(B)	520		520	4035	4197	162	4197	358	395	100%	31%	500	3				
35	Transit Mixer(C)	520		520	1231	1552	301	1552	219	784	100%	58%	660	30				
36	Transit Mixer(D)	520		520	6315	6571	256	6571	264	659	100%	49%	505	15				
37	Transit Mixer(E)	520		520	6908	7180	192	7180	328	411	100%	37%	480					
38	Transit Mixer(F)	520		520	4579	4866	287	4866	233	474	100%	55%	520					
39	Transit Mixer(G)	520		520	104	353	249	353	271	686	100%	48%	500					
40	Transit Mixer(H)	520		520	5474	5690	216	5690	304	504	100%	42%	420					
41	Transit Mixer(I)	520		520	1114	5483	371	5483	149	944	100%	71%	760	1				

IV. RESULTS FOR ANALYTIC HIERARCHY PROCESS

The input data like availability, working hours, diesel consumption available in the excel files are accessed and processed by the analytic hierarchy process tool box and the result are presented. The equipment taken into consideration are compressor, concrete pump, escort hydra crane, JCB bachoe loader, JCB skidsteer loader, material hoist, stetter plant, towe crane, tractor escort farmtrack, transit mixer. The sample output is shown in Fig. 1.

Fig.2 Matlab Equipment Selection Result for AHP in Command Window

V. GRAPHICAL RESULTS OBTAINED FROM MATLAB

For test case, 10 different kinds of machines with different category, (hoist, crane, tractor escort, hydra crane, compressor, concrete pump, etc.) are considered. Various brands of machines and their performance is taken into account for every catagory. The sample is taken as the best machine from the availability of the machines, Woking hour, Idle Hour, Percentage of the availability and Diesel consumption of the machine.

In the graph, ***continuous line*** indicates the selected machine among various other brands based on their performance and ***dotted line*** indicates the other machines which are unselected and their performance index in percentage.

The result obtained from different brands of **COMPRESSOR**, "*Compressor cfm 325(B)"* is selected based on availability of equipment, utilization percentage, diesel consumption etc. (Fig.2 [a])

The result obtained from different brands of **CONCRETE PUMP**, *"Concrete pump BP 1800 (D)"* is selected based on availability of equipment, utilization percentage, diesel consumption etc. (Fig.2 [b])

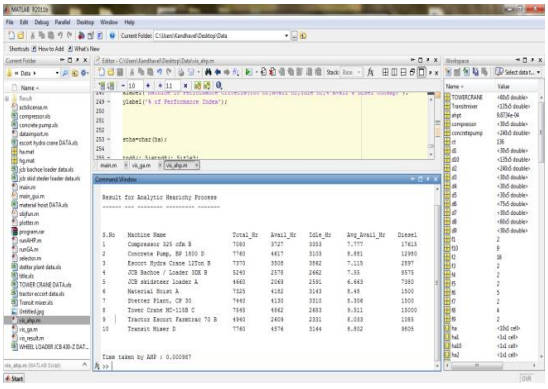
The result obtained from different brands of **HYDRA CRANE**, *"Escort Hydra Crane 12Ton (B)"* is selected based on availability of equipment, utilization percentage, diesel consumption etc. (Fig.2 [c])

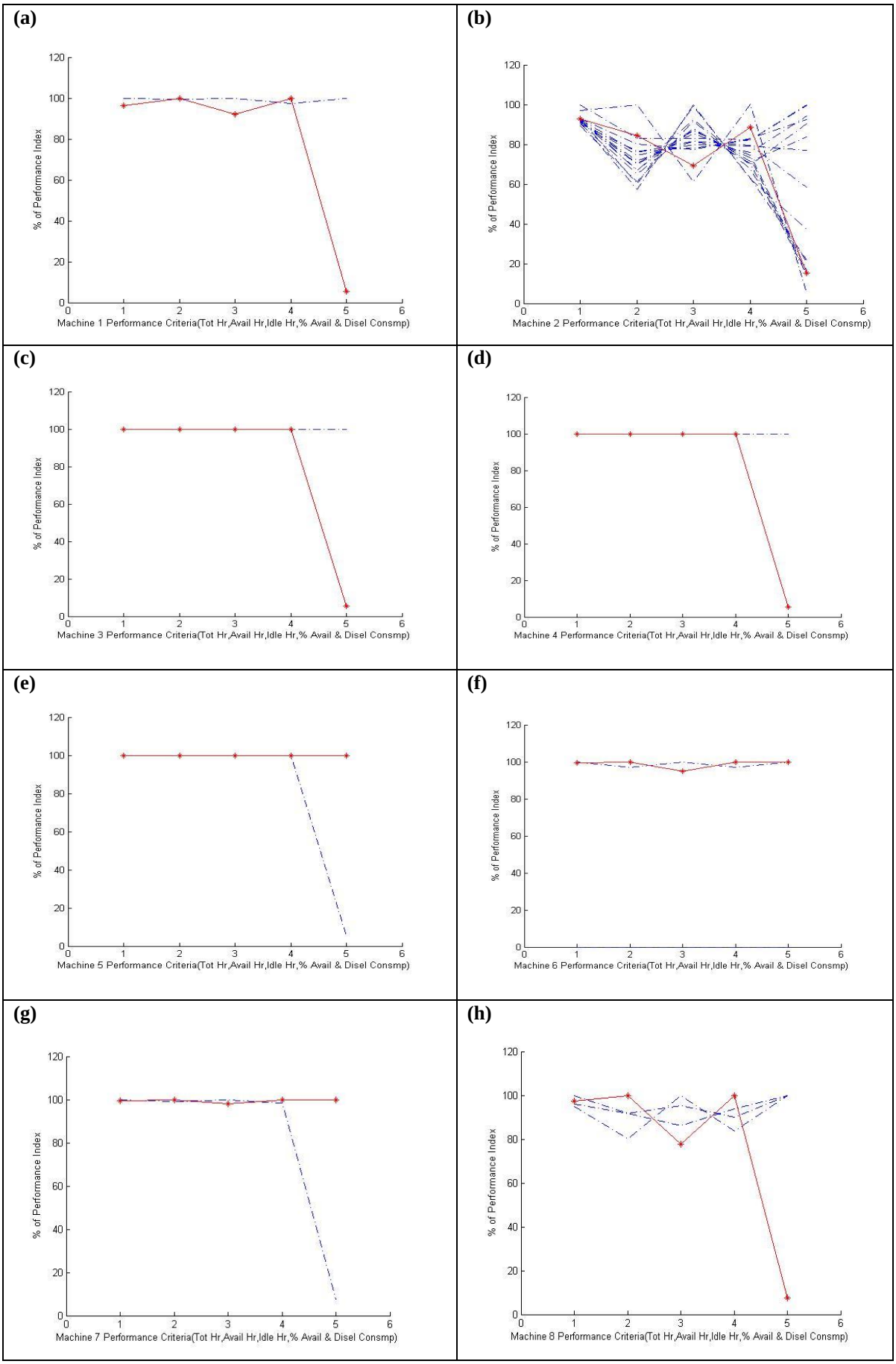
The result obtained from different brands of **JCB BOCHE LOADER**, *"JCB Boche / Loader 3DX (B)*" is selected based on availability of equipment, utilization percentage, diesel consumption etc. (Fig.2 [d])

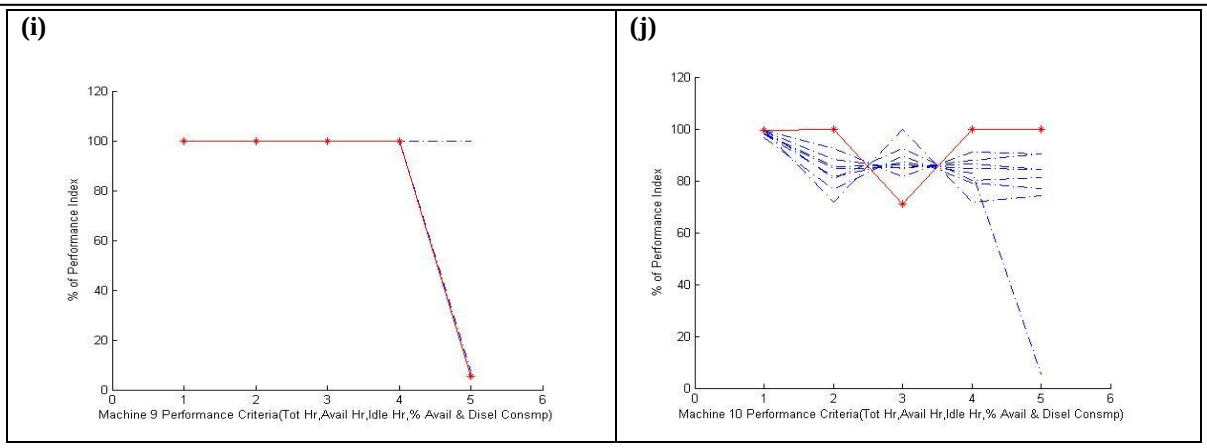
The result obtained from different brands of **JCB SKID LOADER**, *"JCB skidsteer loader (A)"* is selected based on availability of equipment, utilization percentage, diesel consumption etc. (Fig .2 [e])

The result obtained from different brands of **MATERIAL HOIST**, *"Material Hoist (A)"* is selected based on availability of equipment, utilization percentage, diesel consumption etc. (Fig.2 [f])

The result obtained from different brands of **STETTER PLANT**, *"Stetter plant CP 30"* is selected based on availability of equipment, utilization percentage, diesel consumption etc. (Fig.2 [j])




(a)
% of Performance Index
Machine 1 Performance Criteria(Tot Hr,Avail Hr,Idle Hr,% Avail & Disel Consmp)
(b)
% of Performance Index
Machine 2 Performance Criteria(Tot Hr,Avail Hr,Idle Hr,% Avail & Disel Consmp)
(c)
% of Performance Index
Machine 3 Performance Criteria(Tot Hr,Avail Hr,Idle Hr,% Avail & Disel Consmp)
(d)
% of Performance Index
Machine 4 Performance Criteria(Tot Hr,Avail Hr,Idle Hr,% Avail & Disel Consmp)
(e)
% of Performance Index
Machine 5 Performance Criteria(Tot Hr,Avail Hr,Idle Hr,% Avail & Disel Consmp)
(f)
% of Performance Index
Machine 6 Performance Criteria(Tot Hr,Avail Hr,Idle Hr,% Avail & Disel Consmp)
(g)
% of Performance Index
Machine 7 Performance Criteria(Tot Hr,Avail Hr,Idle Hr,% Avail & Disel Consmp)
(h)
% of Performance Index
Machine 8 Performance Criteria(Tot Hr,Avail Hr,Idle Hr,% Avail & Disel Consmp)



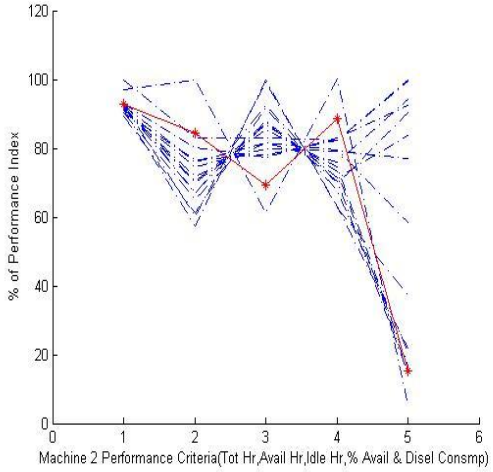


Fig.2 Graphical Results Obtained from Matlab

The result obtained from different brands of **TOWER CRANE**, *"Tower crane MC-115B C"* is selected based on availability of equipment, utilization percentage, diesel consumption etc. (Fig.2 [h])

The result obtained from different brands of **TRACTOR**, *"Tractor Escort Farmtrack 70 (B)"* is selected based on availability of equipment, utilization percentage, diesel consumption etc. (Fig.2 [i])

The result obtained from different brands of **TRANSIT MIXER**, *"Transit Mixer (D)"* is selected based on availability of equipment, utilization percentage, diesel consumption etc. (Fig.2 [j])

VI. COMPARATIVE STUDY FOR AHP AND GA

Proper method for selecting equipment which will be more productive, less expensive and profitable. There are several methods pertaining to the topic out of which genetic algorithm and analytical hierarchy process are considered in this work. Major equipment data are given in the study. The output data for the two methods are compared. From the comparison of output result for both genetic algorithm and analytical hierarchy process, the equipment's performance in total hours, available hours, idle hours and average available hours along with diesel consumption is discussed.

From Table.2, it is concluded that AHP method is best suited for equipment selection as it is less time consuming, best performance, with less cost as compared with the GA method.

Same variables are taken for consideration in both genetic algorithm and analytical hierarchy process method of selection. The data derived from the study shown in Table.2 indicates that the best selection method is analytical hierarchy process, as it is less time consuming, profit oriented, solves all complex problems, guides them making logical and consistent decisions and provide all facilities for necessary computations. It offers an effective means for the formalization of knowledge by competent and experienced persons.

Table.2 Result for Analytic Hierarchy Process

S. No	Machine Name	Total_ Hr	Avail_ Hr	Idle_ Hr	Avg_Avail_ Hr	Diesel
1	Compressor 325 cfm B	7080 *(-1820)*	3727(+168)	3353(-1988)	7.777(+1.52)	17615*(-10856)*
2	Concrete Pump, BP 1800 D	7760	4617	3103	8.881	12980
3	Escort Hydra Crane 12Ton B	7370	3508	3862	7.115	2897

4	JCB Bachoe / Loader 3DX B	5240	2578	2662	7.55	8575
5	JCB skidsteer loader A	4660	2069	2591	6.663	7380
6	Material Hoist A	7325(-400)	4182(+850)	3143(-1204)	8.48 (+1.69)	1500
7	Stetter Plant, CP 30	7440(-210)	4130(+217)	3310(-427)	8.306(+0.9)	1500 (-4500)
8	Tower Crane MC-115BC	7545(-1365)	4862(+2828)	2683(-4193)	9.511(+6.53)	15000
9	Tractor Escort Farmtrac 70 B	4940	2609	2331	8.033	1085
10	Transit Mixer D	7760(+770)	4576(+4844)	3144(-4354)	8.802(+8.34)	9805 (+10788)

Note: In table –ve sign indicates how much value lower that the Equipment selected by another technique via +ve sign indicates how much value higher than that the Equipment selected by another technique. Red colour identification indicates un desired and green indicates desired.

VII. CONCLUSIONS

i) This selection model offers a comprehensive solution for a systematic evaluation of qualitative decision factors. It will guide the construction industries to handle different complex criteria without losing its practicality. It also incorporates the context and unique conditions of the project, allowing manifestation of user experience and subjective perception. It gives a framework for a structural process and assuring solution consistency.

ii) This study will be very helpful for the construction industry as it gives better guidelines for the method of equipment selection. Unlike the genetic algorithm, the analytic hierarchy process method is found to be the best as it gives a wide spectrum of planning and personal judgement to take apt decision.

iii) As it gives guideline about the entire site plant and thereby allows the engineer's to make the evaluation of any equipment option.

iv) The systematic consideration of soft and hard factors of this project will make the project engineer's to accommodate owned and rented equipment duly considering cost evaluation. It gives the users in making sound and logical decisions and will guide them to train novice engineers. It gives guideline to solve complex and challenging problem that the modern construction industry spaces.

v) Above all this study will be of great importance for the future construction industry as it aims at advance decision making in equipment organisation and equipment location covering all phases of equipment use on the project.

vi) This study offers an efficient and convenient tool that makes the users into methodical thinking, guides them in making logical, consistent decisions and provides a facility for all necessary computation.

vii) As this selected tool gives a detailed account about availability hours, working hours, idle hours allowing construction industry to decide about the wastage hours. It enables them to decide the apt equipment and gives ideas about reducing the idle equipment and thereby minimizing cost and maximising profit.

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