

Intelligent Consulting System for selection of Material handling equipment

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ABSTRACT: Effective movement of materials plays an important role in successful operation of any organization. Proper methods adopted for material movement are also crucial for the overall safety of the personnel involved in the manufacturing processes. Selection of the appropriate material handling equipment (MHE) is a vital task for improving productivity of an organization. In today's technological era, varieties of MHEs are available to carry out a desired task. Depending on the type of material to be moved, there are many quantitative and qualitative factors influencing the selection decision of a suitable MHE. The problem of selecting the right type of MHE for a given purpose can be solved using multi-criteria decision-making (MCDM) methods which are capable of dealing with the combination of crisp and fuzzy data. In this paper, an MCDM method employing fuzzy axiomatic design principles is applied for selecting the most appropriate MHE for the given task. As a measure of suitability, the total information content is calculated for each MHE and the MHE alternative with the least total information content is regarded as the best choice. And also find out top 10 factors that effecting selection of material handling equipment.

KEYWORDS: Material handling equipment, Multi Criteria Decision Making, Axiomatic Fuzzy Logic, Construction Management, Software development.

I. INTRODUCTION

We are in the world of advance technology. Each and every activities getting simplifying day by day but in the field of construction industries dragging slowly in the implementation of advance technology. Construction industries is the second most sector in which number of people work and it is also the main factor for economic stability. Main factor that effecting construction industries are man, money, machine and material. But there is a main pseudo factor called decision making because selection of man, money, machine and material will entire construction organisation. Eventually it may cause of collapse of the organisation. So innovation in decision making system is essential.

Intelligent consulting system for selection of material handling equipment is an advance as well as innovative form of artificial intelligent making. It is made by principle of axiomatic fuzzy logic. Axiom is the block consist certain range and fuzzy logic means the degree of trueness. It represented by a couple of numerical and arithmetical application. For taking a decision, it depends number of factors or number of requirements and for material handling equipment having its on limited expressible properties such as dimension, power, equipment capacity etc. and how much of our requirement that meet properties

ICS is a system that artificially take decision by numerical expression of how much of requirement that meet material handling equipment properties. The main relevance of use method it is pre-programmed software, algorithm that are set from experienced civil engineer. So even an inexperience project manager can take decision by the help of ICS. In this thesis show the beta version of software and that are completed according to programmer point of view. But there should needed revision according to other point of view and their requirement.

There are so many multicriteria decision making techniques such as Analytical Hierarchy process (AHP) was used by Thomas L. Sathy[1], Analytical network process that used by Mohammadreza Sadeghi et al.[2], TOPSIS that was used

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

by Amin Zadeh Sarrah et al[3], Fuzzy Axiomatic design that was used by Anant V. Khandekar et al[4] etc out of it found that Fuzzy Axiomatic design was perfect for the software and it give realistic value compare with other. The draw back of tradional methods are mention by S. Razavialavi et al[5], Application of multicriteria methods (MCM) to decision making in planning phase of construction projects (related to the problem of construction sites selection). The problem is identified as a significant one from many different aspects such as economic aspect, civil engineering aspect, etc. what indicates the necessity for evaluation of multiple sites by several different criteria is stated by Niska Jajac et al [6].

The work in this paper is divided in two stages. 1) Algorithm used for making software 2) Factors that influence for selection of material handling equipment, For first stage the software is adopted by with axiomatic fuzzy logic that are prepared by Anant V. Khandekar et al[4] .For second stage there are so many factors such operation cost, ownership cost, dimension etc. (refer table 6) And they are ranked by conducting questionnaire survey from 55 respondent Section II will explain about algorithm and with an example and Section III will explain about top factors that effecting. Finally, Section IV present conclusion

II. RELATED WORK

Algorithm that had used for making this software having numerous calculation based on computing, probability, fuzzy logic in scientific manner in which that are proposed by Anant V. Khandekar et al[4]. The main purpose of using this software is to find the best alternative or best equipment as per user's requirement which having multi criteria which may impossible to solve mentally. It is based on fuzzy logic, Fuzzy logic means "degree of trueness". It expressed in the range between 1 and 0, where 0 represent false and 1 represent true. In between value represent degree of truenes. So here every values convert into a trapezoid with height 1 and coordinates will express as mention below. So main procedure for using this software are

1. Accepting equipment property.
2. Accepting equipment requirement
3. Converting all data into trapezoidal member function
4. Evaluating
5. Obtaining result

Explanation can be easily illustrate with an example. Considered Back hoe loader (BHL) election problem consists of 10 different alternative to be evaluate for 8 criteria. The expected design values of those criteria according to the industrial requirements are given in table1.

Table 1
Equipment Requirement

Criteria	Values
Length	5500mm
Width	1980mm
Height	2470mm
Equipment Capacity	133kg
Traveling speed	High
Battery capacity	132min
Position accuracy	High
fuel efficiency	130l

Travelling speed and postion accuracy are linguistic variable, these requirement are according to priority, i.e. high medium and low. Trapezoidal mapping of these linguistic variable are shown in table 3

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

Travelling speed and position accuracy in property part in table 2 can convert by taking normalization. Normalization is the process of dividing numeric value with maximum value of corresponding criteria. E.g. Consider the traveling speed, the value of BHL2 is 35 and maximum value of traveling speed is 36. So normalized value of traveling speed of BHL2 is $(35/36) = 0.975$. Then this value convert into trapezoidal member function by the equation given below.

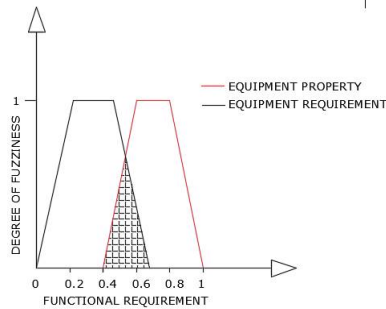


Fig 1. Graphical representation of overlapping of Equipment property trapezoid vs Equipment requirement trapezoid

Trapezoidal member $\alpha_{i,j}(A_{ij}) = 0$
 Trapezoidal member $\beta_{i,j}(B_{ij}) = 0.33 * D_{ij}$
 Trapezoidal member $\gamma_{i,j}(C_{ij}) = \min[(2 * N_{ij}), 1]$
 Trapezoidal member $\delta_{i,j}(D_{ij}) = \min[(0.62 * 2 * N_{ij}), 1]$

Table 2
Property of BHL alternative

OBJECT NAME	LENGTH	WIDTH	HEIGHT	EQUIPMENT CAPACITY	TRAVELING SPEED	BATTERY CAPACITY	POSITION ACCURACY	FUEL EFFICENCY
Units	(mm)	(mm)	(mm)	(kg)	(km/hr)	(min)	(mm)	(l)
BHL1	6270	2240	2960	180	36	135	10	135
BHL2	5500	1880	2470	261	35	130	10	130
BHL3	5550	1980	2470	275	35	130	10	130
BHL4	5750	2050	2470	300	35	130	10	130
BHL5	5210	2235	3560	193	36	130	10	136
BHL6	5000	2035	2470	225	34	135	10	133
BHL7	5275	2245	2575	245	35	133	10	134
BHL8	5450	2240	2960	180	35	132	10	130
BHL9	5650	1980	2470	245	35	130	10	130
BHL10	5440	2235	2470	193	35	135	10	130

Where N_{ij} is normalize value, i and j represent position of value in row and column.

Except travelling speed and position accuracy are numerical variable. Conversion of trapezoidal value is just multiply with 0.8, 0.9, 1.1 and 1.2 for Alpha, Beta, Gamma and Delta respectively

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

Table 3
Trapezoidal mapping of linguistic variable

Linguistic Variable	Trapezoidal member function
High	(0.4,0.6,0.8,1.0)
Medium	(0.2,0.4,0.6,0.8)
Low	(0.0,0.2,0.4,0.6)

Table 4
Trapezoidal member function of Equipment Requirement

Criteria	Values
Length	(4400,4950,6050,6600)
Width	(1584,1782,2178,2376)
Height	(1976,2223,2717,2964)
Equipment Capacity	(106.4,119.7,146.3,159.6)
Traveling speed	(0.4,0.6,0.8,1.0)
Battery capacity	(105.6,118.8,145.2,158.4)
Position accuracy	(0.4,0.6,0.8,1.0)
fuel efficiency	(104,117,143,156)

Table 5 shows the trapezoidal member function of BHL1, like that find the trapezoidal member function of each alternative. By comparing equipment requirement trapezoidal member function with equipment property trapezoidal member function of each as per fig 1, we get corresponding scores called 'Information Content (IC)' by following equation

Information content $IC = \log_2(\text{Area of Trapezoid of equipment property} / \text{common area between equipment requirement and property})$. And the sum of all the IC of each criteria and sorted in ascending order. So one which having least alternative can selected as best for our requirement.

Table 5
Trapezoidal member function of Equipment property of BHL1

Criteria	Values
Length	(5016,5643,6897,7524)
Width	(1792,2016,3464,2688)
Height	(2368,2664,3256,3552)
Equipment Capacity	(144,162,198,216)
Traveling speed	(0.4,0.6,0.8,1.0)
Battery capacity	(108,121.5,148.5,162)
Position accuracy	(0.4,0.6,0.8,1.0)
fuel efficiency	(108,121.5,148.5,162)

Similar with above calculation can construct a software. The main advantage of constructing software can save time and got instant result. The screen shot image of software are listed below.

By inputting data in this software that based on above calculation we got BHL3 is best alternative with IC value of 5.82. Based on IC value decision can be measurable, So it can compare easily.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

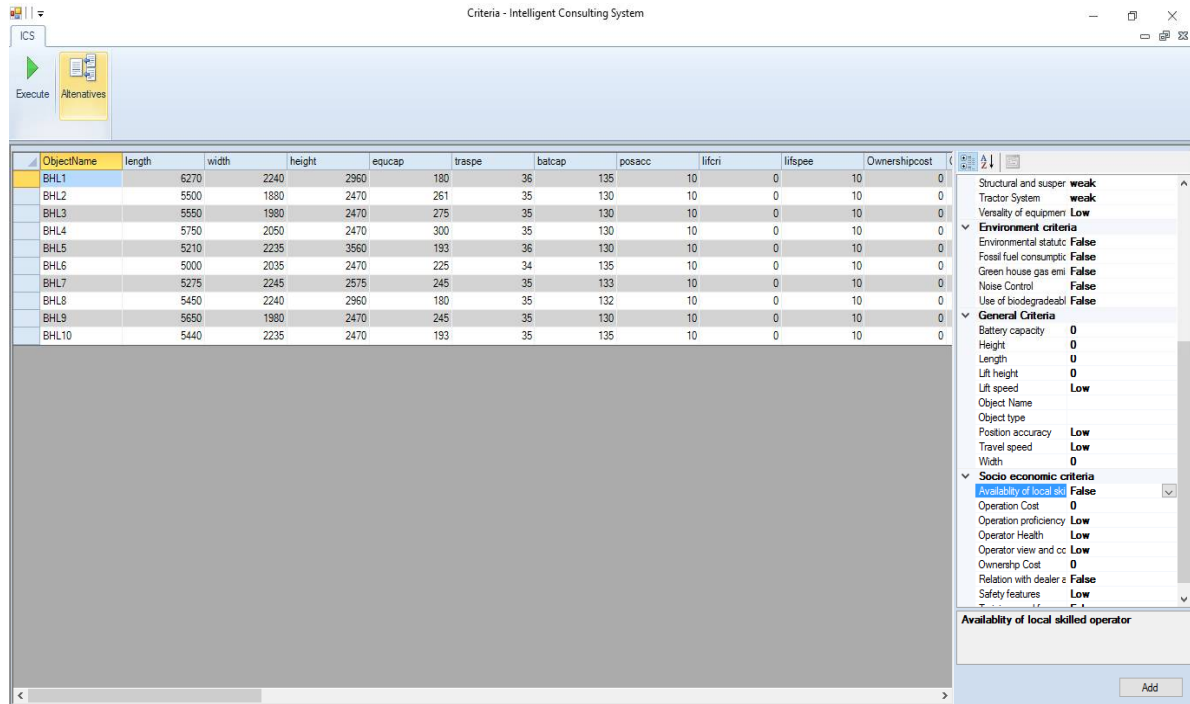


Fig 2. Inputting data

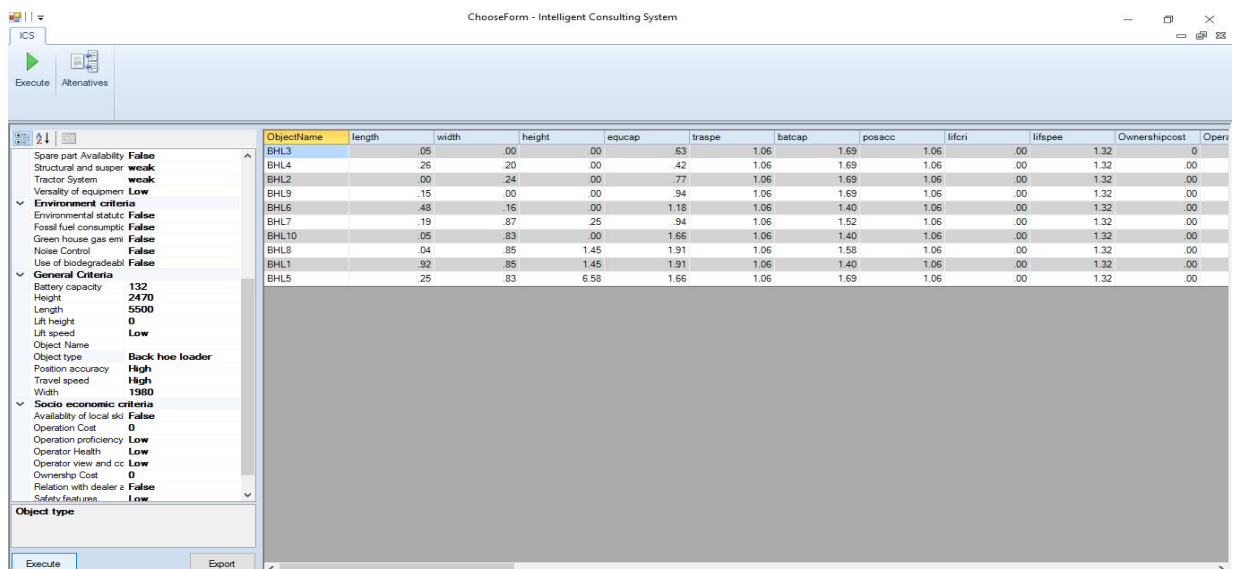
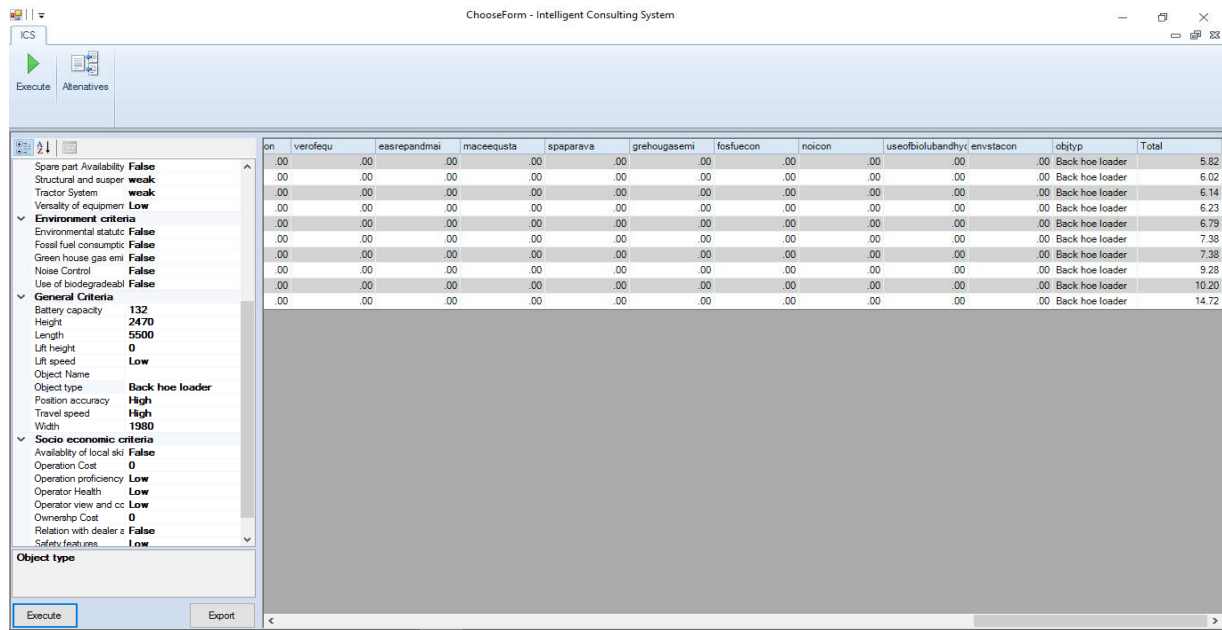


Fig 3. Result (scrolled left side)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016



	on	verofegu	easrepandmai	maceequsta	spapareva	grehougasemi	fosfuecon	noicon	useofbiolubandhy	envstacon	objtyp	Total	
Spare part Availability	False	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	5.82
Structural and susper	weak	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	6.02
Tractor System	weak	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	6.14
Versality of equipment	Low	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	6.23
Environment criteria		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	6.79
Environmental status	False	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	7.38
Fossil fuel consume	False	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	7.38
Green house gas emi	False	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	9.28
Noise Control	False	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	10.20
Use of biodegradeabl	False	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	10.20
General Criteria		.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	Back hoe loader	14.72
Battery capacity	132												
Height	2470												
Length	5500												
Lift height	0												
Lift speed	Low												
Object Name	Back hoe loader												
Object type	Back hoe loader												
Position accuracy	High												
Travel speed	High												
Width	1980												
Socio economic criteria													
Availability of local sit	False												
Operation Cost	0												
Operation proficiency	Low												
Operator Health	Low												
Operator view and co	Low												
Ownership Cost	0												
Relation with dealer s	False												
Safety features	Low												

Fig 4 Result (scrolled right side)

III. FACTORS THAT INFLUENCE FOR THE SELECTION OF MATERIAL HANDLING EQUIPMENT

Surveys are normally used for statistical purposes by gathering information. Most surveys use questionnaires for a base of their research. Surveys can help decide what needs changing, where money should be spent, what products to purchase, what problems there might be, or lots of other questions you may have at any time.

Surveys can be useful in some cases when the questions asked are specific and if the questions asked affect them. Sometimes surveys and questionnaires are not taken seriously leading the participant to write anything to make it less time consuming. If the survey/questionnaire is very long most people decide to ignore it which would make it useless.

The main advantages of doing survey are it is well practical. Large amounts of information can be collected from a large number of people in a short period of time and in a relatively cost effective way. Another advantage is, it can be carried out by the researcher or by any number of people with limited affect to its validity and reliability. The results of the questionnaires can usually be quickly and easily quantified by either a researcher or through the use of a software package .Can be analysed more 'scientifically' and objectively than other forms of research. When data has been quantified, it can be used to compare and contrast other research and may be used to measure change .Positivists believe that quantitative data can be used to create new theories and / or test existing hypotheses

The questionnaires were sent to clients, consultants, contractors, engineers, cement company executives, goods dealer etc. working in the construction industry in India. About 75 responses have been received. Among them 20 responses were rejected. Then to increase the accuracy of data experienced professionals responses were selected and finally considered 55 valid responses. The questionnaire sought to establish indices for the casual factors identified. Format of questionnaire survey like listed a 34 criteria in likert scale of value 1 to 5 .where '1' for Not at all important '2' for Slightly important '3' for Moderately Important '4' for Very important and '5' for extremely important. Data that obtain from questionnaire survey are listed in table 6.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

Table 6

Data obtained from questionnaire survey

Sl. No	Criteria	1	2	3	4	5	AVERAGE	RELATIVE IMPORTANT INDEX
1	Ownership Cost	0	1	6	26	22	4.254	0.8509
2	Operation Cost	0	1	1	21	32	4.527	0.9054
3	Availability of local skilled operator	1	5	21	24	4	3.454	0.6909
4	Operator Health	2	4	12	28	9	3.690	0.7381
5	Operator view and comfort	1	2	7	19	26	4.218	0.8436
6	Safety features	0	0	3	21	31	4.509	0.9018
7	Operator proficiency	2	4	5	35	9	3.818	0.7636
8	Training need for operator	1	0	13	15	26	4.181	0.8363
9	Relation with dealer/ supplier	2	5	6	31	11	3.800	0.7600
10	Equipment age	0	2	14	20	19	4.018	0.8036
11	Equipment capacity	0	0	7	19	29	4.400	0.8800
12	Equipment reliability	0	0	14	30	11	3.945	0.7830
13	Equipment efficiency	0	0	12	21	22	4.181	0.8363
14	Equipment operational life	0	7	14	10	24	3.927	0.7854
15	Equipment productivity	0	1	13	17	24	4.163	0.8327
16	Fuel efficiency	0	1	12	21	21	4.127	0.8254
17	Implement system	0	7	28	8	12	3.454	0.6909
18	Tractor system	0	10	29	13	3	3.163	0.6327
19	Structural and suspension system	0	7	28	10	10	3.418	0.6836
20	Power train system	0	5	29	11	10	3.472	0.6945
21	Control and information system	0	1	14	23	17	4.018	0.8036
22	Compliance with site operation condition	0	1	18	19	17	3.945	0.7890
23	Meet job	0	1	13	25	16	4.018	0.8036
24	Operation requirement	0	7	12	21	15	3.800	0.7600
25	Meet haul road condition	1	6	18	16	14	3.654	0.7309
26	Versality of equipment	1	6	17	17	14	3.672	0.7345
27	Easy repair and maintenance	0	6	15	21	13	3.745	0.7490
28	Machine / Equipment standardization	1	7	16	17	14	3.645	0.7309
29	Spare part Availability	1	1	3	20	30	4.400	0.8800
30	Greenhouse gas emission	0	7	16	19	13	3.6909	0.7381
31	Fossil fuel consumption	0	6	21	17	11	3.600	0.7200
32	Energy Saving	0	11	21	13	10	3.400	0.6800
32	Noise control	2	14	29	4	6	2.963	0.5927
33	Use of biodegradable lubricant and hydraulic oil	0	8	21	18	8	3.472	0.694
34	Environmental statutory compliance	0	5	15	14	21	3.927	0.7854

Based on questionnaire survey conducted it is conclude that The top ten factors for purchasing material handling equipment are listed above, they are Operation Cost, Safety features, Equipment capacity, Spare parts availability, Ownership cost, Training need for operator, Equipment productivity, Fuel efficiency etc and identified

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

these factors as the critical factors of material handling equipment. While considering the questionnaire survey results, the critical factors identified and should be added in software.

IV. CONCLUSION

A suite of fast analysis tools that allow the designer to obtain performance and cost information for technology selection. An optimization routine is then used to select among the combinations. So constructing an algorithm for making effective decision making for material handling equipment by multi criteria decision making. And it can be applicable in all the aspect of artificial intelligent decision making. Software was made with axiomatic fuzzy logic, validate the logic and verified by industrial requirement. This software run successfully and capable to take multi criteria decision.

By evaluating the alternative and content we will get a result as numeric value. So result in which least value is taken as most suitable result. So it is easily comparable and there will also happening for rejection result. This is because of having rejection in any criteria or more than one.

By conducting questionnaire survey in 55 well reputed firms in India that which give positive reliability test in SPSS software, It is conclude that top ten factors that effecting for selection of material handling equipment are Operation cost, Safety features, Equipment capacity, Spare parts availability, Ownership cost, Operator view and comfort, Training need for operator, Equipment efficiency, Equipment productivity and fuel efficiency.

Thinking of intelligent software will be a revolution if it replaced by tradition method will save lot of money and effort. Every human obviously having difficult to made best and effective decision. So that by using this kind of software can eliminate such problems. There are lot of innovative software such as Intelligent ERPs which can able to control flow of construction projects, Automatically Estimation software which will give accurate decision than any human, Building Information Management, RFID tagging etc. but none of local companies didn't go for innovation . They still continue with tradition method.

Effective decision is always made by several years' experience and experienced project engineer required more salary than inexperience one. So that by implementing such Intelligent software can omit the help of experienced one. So it is a helpful aid for inexperience project manager to take right decision.

Taking decisions or selecting material handling equipment in building construction projects are always potential obstacles to project success. The study reported in this project established that there are a number of causal factors which need to be selection of material handling equipment. Despite being a subject of discussion for over years, these overruns still persist as a challenge on construction projects.

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