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A STUDY OF FACTOR AFFECTING LABOUR PRODUCTIVITY IN CONSTRUCTION PROJECT USING FUZZY TOPSIS

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Abstract : This paper study about productivity of labour. Construction industry plays very important role in economy of country, and in construction industry labours is important factor and plays very important role in construction. The success of any construction project is depends upon the resources, material and labour productivity. Labour productivity is depend on or affected by various factors.For this study various factors affect labour productivity are identified and this factos are analyse by using the fuzzy TOPSIS method

IndexTerms **- Labour productivity, factors, fuzzy TOPSIS.**

1.INTRODUCTION

Construction industry is fast growing industry in world. Construction industry plays very important role in world economy. completion of project affects on the cost, time and quality of the work. For completion of project labours are important. There are various factors responsible for labour productivity. labour productivity is the output of labour.in construction industry labour can cover profit and give loss also to the contractor or engineer. There are different factors around the construction which affect the productivity that is output.in construction industry multiple activities are involved. all activities are depend upon resources like men, machinery, material etc. all resources use are important. For every construction project productivity cost, time, quality and safety are the main factors of concern.

This paper is to study or identify this different factors which affects the labour productivity. due to this labour productivity the time , cost, work, and safety about the construction is also give negative impact to the construction.

1.1NEED OF STUDY

Labour productivity rates are used as indicators of the construction time performance. Due to various factor labour productivity is affected and due to which time, cost, work progress are also affected.

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2RESEARCH METHODOLOGY

The general methodology of this study relies largely on the survey form the questionnaire and data that has been collected from the contractors, Engineers and builders. This study has adopted the more general definition of labor productivity and fuzzy logic is a method. Triangular fuzzy scale are used for this study. For this study various factors are study from different literature. The top 20 factors are identify and take for the study. Top 20 factors are; 1) lack of supervision, 2) delay in materials, 3) coordination among design discipline, 4) error in design drawing, 5) working overtime, 6) lack of leadership, 7) skill of labour, 8) payment delay, 9) labour availaibility, 10) material shortage, 11) equipment shortage, 12) temperature on site, 13) delay in decision making, 14) high wind, 15) rainfall, 16) site accident, 17) experience of labour, 18) labour age, 19) absence of training for labour, 20) improper planning

2.2FUZZY TOPSIS

TOPSIS (technique for order preference by similarity to ideal solution). The Fuzzy TOPSIS method is a technique that was extended from the concept of TOPSIS to tackle numerous MCDM problems in an uncertain environment. Fuzzy numbers were first applied by Chen and Hwang in 1992 to the TOPSIS method to establish the Fuzzy TOPSIS method. There are many advantages of using the Fuzzy TOPSIS method to solve MCDM problems. The fuzzy-TOPSIS method has become a very popular tool in recent times in a relatively large number of practical applications where user opinions and performance ratings are expressed in linguistic scores. Multi criteria decision maker problem have as common characteristics multiple objectives and multiple criteria which usually are in conflict with each other. The decision makers have to select, assess or rank these alternatives according to the weights of the criteria. TOPSIS method is called as ideal solution.it is also called as multiple decision making method. In fuzzy topsis positive ideal solution and negative ideal solution are determine. Triangular fuzzy scale are used for this study.

2.3 Methodology flow chart

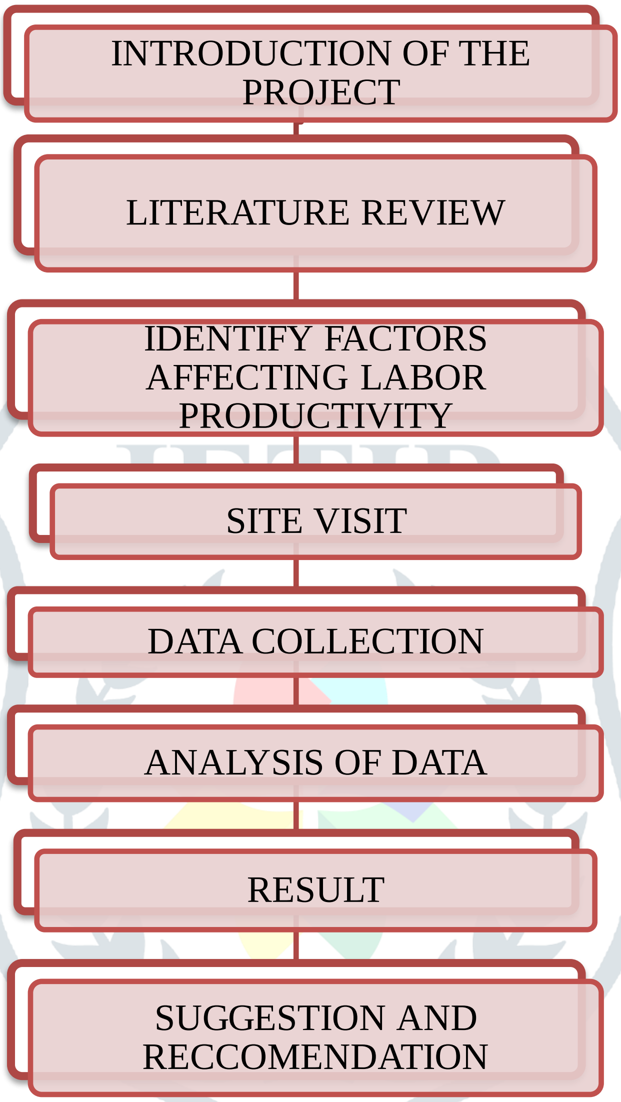

fig.2.3 methodology flow chart

3.2 Data collection

For the data collection questionnaire survey is carried out. The purpose of the questionnaire design is to determine the how much selected factors affect on the labor productivity.The following questions refer to a questionnaire hierarchical structure to determine the importance of the criteria i.e time, cost , work, safety. The questionnaire should be completed by experience person.the respondant response to the factoe (question) through number using 1- 4 scale are as follows;

Table 3.2.1 fuzzy triangular scale

scale	**Definition**	**Fuzzy Triangular Scale**
1	Weakly Affecting	(1, 2, 3)
2	Fairly Affecting	(3, 4, 5)
3	Strongly Affecting	(5, 6, 7)
4	Absolutely Affecting	(7, 8, 9)

Weightage of Criteria: Time, Cost, Work And Safety
To determine the weight of criteria we have discussions with faculty members and the following weights were decided.

Table 3.2.2 weightage of criteria

Criteria	**Weightage**	**Fuzzy Number**		
Time	high	5	6	7
Cost	Medium	3	4	5
Work	Low	1	2	3
Safety	Very high	7	8	9

4.Data Analysis

Step 1: The development of fuzzy set of MCDM problem is briefly in matrix format as [with the construction of the weight vector [w1,w2,…….,wn]

Step 2:calculate aggregated fuzzy weights for criteria.

The aggregated fuzzy rating ˜xi j = (ai j, bi j, ci j) of ith alternative w.r.t. jth criterion is obtained as follows:

Table 4.1 aggregated fuzzy weight in matrix format

		Time			**Cost**			**Work**			**Safety**		
SR.NO.	Factor												
1	Lack of supervision	5	6.68	9	1	6.653	9	3	6.72	9	1	5.882	9
2	Delay in material supply	1	6.8	9	3	5.8	9	1	6.04	9	1	2.6666667	9
3	Coordination among design disciline	1	6.12	9	1	4	9	1	5.32	9	1	2.44	9
4	Errors in design drawing	1	6	9	1	4.549	9	1	5.019607843	9	1	2.6	9
5	Working overtime	1	5.72	9	1	4.204	9	1	5.26	9	1	4.8431373	9
6	Lack of leadership	1	5.24	9	1	4.235	9	1	6.052631579	9	1	3.4	9
7	Skill of labour	1	5.373	9	1	3.922	9	1	5.568627451	9	1	4.2352941	9
8	Payment delay	1	7.24	9	1	6.32	9	1	6.31372549	9	1	2.68	9
9	Labour availability	1	6.833	9	1	5.510	9	3	6.31372549	9	1	2.4313725	9
10	Material shortage	1	6.784	9	1	5.569	9	1	6.277777778	9	1	2.7058824	9
11	Equipment shortage	1	6.471	9	1	5.176	9	3	6.12	9	1	2.8627451	9
12	Temperature on site	1	4.941	9	1	3.451	9	1	4.863	9	1	4.9803922	9

13	Delay in decision making	1	6.824	9	1	5.56	9	3	6.196	9	1	2.8571429	9
14	High wind	1	5.76	9	1	4	9	1	5.373	9	1	6.6	9
15	Rainfall	1	6.235	9	1	4.824	9	1	6.157	9	1	7.2941176	9
16	Site accident	5	7	9	1	6.16	9	5	6.863	9	5	7.76	9
17	Experience of labour	1	5.412	9	1	4.039	9	1	5.216	9	1	3.745098	9
18	Labour age	1	4.137	9	1	3.176	9	1	4.157	9	1	3.92	9
19	Absence of training for labour	1	6.157	9	1	5.647	9	3	6.24	9	3	6.8	9
20	Improper planning	5	6.980	9	3	6.62	9	5	6.980	9	3	7.28	9

Step 3 :calculate the normalized fuzzy decision matrix.

$$r_{ij} = \left(\frac{aij}{cij}, \frac{bij}{cj}, \frac{cij}{cj}\right), j\epsilon B$$

$$r_{ij} = \left(\frac{aj}{cij}, \frac{aj}{cij}, \frac{aj}{cij}\right), j\epsilon c$$

$$c_{j=\max cij, if\ j\epsilon B}$$

$$a_{j=\min aij, if\ j\epsilon c}$$

Where B = set of benefit criteria and C = set of cost criteria

Table 4.2.Normalized fuzzy decision matrix

		5	**6**	**7**	**3**	**4**	**5**	**1**	**2**	**3**	**7**	**8**	**9**
SR. NO.	Factor												
1	Lack of supervision	0.111111	0.149700599	0.2	0.111111	0.150306748	1	0.3333333	0.746666667	1	0.111111111	0.6535948	1
2	Delay in material supply	0.111111	0.147058824	1	0.111111	0.172413793	0.3333333	0.1111111	0.671111111	1	0.111111111	0.2962963	1
3	Coordination among design disciline	0.111111	0.163398693	1	0.111111	0.25	1	0.1111111	0.591111111	1	0.111111111	0.2711111	1
4	Errors in design drawing	0.111111	0.166666667	1	0.111111	0.219827586	1	0.1111111	0.557734205	1	0.111111111	0.2888889	1
5	Working	0.111111	0.174825175	1	0.111111	0.237864078	1	0.1111111	0.584444444	1	0.111111111	0.5381264	1

	overtime												
6	Lack of leadership	0.111111	0.190839695	1	0.111111	0.236111111	1	0.1111111	0.67251462	1	0.111111111	0.3777778	1
7	Skill of labour	0.111111	0.186131387	1	0.111111	0.255	1	0.1111111	0.618736383	1	0.111111111	0.4705882	1
8	Payment delay	0.111111	0.138121547	1	0.111111	0.158227848	1	0.1111111	0.701525054	1	0.111111111	0.2977778	1
9	Labour availability	0.111111	0.146341463	1	0.111111	0.181494662	1	0.3333333	0.701525054	1	0.111111111	0.2701525	1
10	Material shortage	0.111111	0.147398844	1	0.111111	0.179577465	1	0.1111111	0.697530864	1	0.111111111	0.3006536	1
11	Equipment shortage	0.111111	0.154545455	1	0.111111	0.193181818	1	0.3333333	0.68	1	0.111111111	0.3180828	1
12	Temperature on site	0.111111	0.202380952	1	0.111111	0.289772727	1	0.1111111	0.540305011	1	0.111111111	0.5533769	1
13	Delay in decision making	0.111111	0.146551724	1	0.111111	0.179856115	1	0.3333333	0.688453159	1	0.111111111	0.3174603	1
14	High wind	0.111111	0.173611111	1	0.111111	0.25	1	0.1111111	0.596949891	1	0.111111111	0.7333333	1
15	Rainfall	0.111111	0.160377358	1	0.111111	0.207317073	1	0.1111111	0.684095861	1	0.111111111	0.8104575	1
16	Site accident	0.111111	0.142857143	0.2	0.111111	0.162337662	1	0.5555556	0.762527233	1	0.555555556	0.8622222	1
17	Experience of labour	0.111111	0.184782609	1	0.111111	0.247572816	1	0.1111111	0.579520697	1	0.111111111	0.416122	1
18	Labour age	0.111111	0.241706161	1	0.111111	0.314814815	1	0.1111111	0.461873638	1	0.111111111	0.4355556	1
19	Absence of training for labour	0.111111	0.162420382	1	0.111111	0.177083333	1	0.3333333	0.693333333	1	0.333333333	0.7555556	1
20	Improper planning	0.111111	0.143258427	0.2	0.111111	0.151057402	0.3333333	0.5555556	0.775599129	1	0.333333333	0.8088889	1

Step 4 : calculate wighted normalized fuzzy decision matrix.

$$v_{ij=}r_{ij\times w_{ij}}\ i = 1,2,\ldots.m\ and\ j = 1,2,\ldots n$$

Table 4.3 weighted normalized fuzzy decision matrix

SR. NO.	Factor	Time			cost			work			safety		
1	Lack of supervision	0.555556	0.898203593	1.4	0.333333	0.601226994	5	0.3333333	1.493333333	3	0.777777778	5.2287582	9
2	Delay in material supply	0.555556	0.882352941	7	0.333333	0.689655172	1.6666667	0.1111111	1.342222222	3	0.777777778	2.3703704	9
3	Coordination among design disciline	0.555556	0.980392157	7	0.333333	1	5	0.1111111	1.182222222	3	0.777777778	2.1688889	9
4	Errors in design drawing	0.555556	1	7	0.333333	0.879310345	5	0.1111111	1.11546841	3	0.777777778	2.3111111	9
5	Working overtime	0.555556	1.048951049	7	0.333333	0.951456311	5	0.1111111	1.168888889	3	0.777777778	4.3050109	9
6	Lack of leadership	0.555556	1.145038168	7	0.333333	0.944444444	5	0.1111111	1.34502924	3	0.777777778	3.0222222	9
7	Skill of labour	0.555556	1.116788321	7	0.333333	1.02	5	0.1111111	1.237472767	3	0.777777778	3.7647059	9
8	Payment delay	0.555556	0.828729282	7	0.333333	0.632911392	5	0.1111111	1.403050109	3	0.777777778	2.3822222	9
9	Labour availability	0.555556	0.87804878	7	0.333333	0.725978648	5	0.3333333	1.403050109	3	0.777777778	2.16122	9
10	Material shortage	0.555556	0.884393064	7	0.333333	0.718309859	5	0.1111111	1.395061728	3	0.777777778	2.4052288	9
11	Equipment shortage	0.555556	0.927272727	7	0.333333	0.772727273	5	0.3333333	1.36	3	0.777777778	2.5446623	9
12	Temperature on site	0.555556	1.214285714	7	0.333333	1.159090909	5	0.1111111	1.080610022	3	0.777777778	4.4270153	9
13	Delay in decision making	0.555556	0.879310345	7	0.333333	0.71942446	5	0.3333333	1.376906318	3	0.777777778	2.5396825	9
14	High wind	0.555556	1.041666667	7	0.333333	1	5	0.1111111	1.193899782	3	0.777777778	5.8666667	9
15	Rainfall	0.555556	0.962264151	7	0.333333	0.829268293	5	0.1111111	1.368191721	3	0.777777778	6.4836601	9
16	Site accident	0.555556	0.857142857	1.4	0.333333	0.649350649	5	0.5555556	1.525054466	3	3.888888889	6.8977778	9

17	Experience of labour	0.555556	1.108695652	7	0.333333	0.990291262	5	0.1111111	1.159041394	3	0.777777778	3.328976	9
18	Labour age	0.555556	1.450236967	7	0.333333	1.259259259	5	0.1111111	0.923747277	3	0.777777778	3.4844444	9
19	Absence of training for labour	0.555556	0.974522293	7	0.333333	0.708333333	5	0.3333333	1.386666667	3	2.333333333	6.0444444	9
20	Improper planning	0.555556	0.859550562	1.4	0.333333	0.604229607	1.6666667	0.5555556	1.551198257	3	2.333333333	6.4711111	9

Step 5: compute the (FPIS) FUZZY POSITIVE IDEAL SOLUTION And (FNIS) FUZZY negative ideal solution

$A^{+}=(v_1^{+}, v_2^{+}, \ldots \ldots \ldots v_n^{+})$ *an ideal solution*
$v_j^{+} = \{maxi, vij\ min, vij\}$ $BA = Benefit\ attribute$
J∈ $B.A\ .J \in C.A.$
$A^{-} = (v_1^{-}, v_2^{-}, \ldots \ldots .\ v_n^{-})Negative\ or\ ideal\ solution$
$v_j^{-} = \{man_i. v_{ij}, max_{i.} v_{ij}\}$ $BA = Benefit\ attribte$
J∈ $B.A.J \in C.A.$

Table 4.4 Ideal solution and negative ideal solution

A+		**0.555556**	**1.450236967**	**7**	**0.333333**	**1.259259259**	**5**	**0.5555556**	**1.551198257**	**3**	**3.888888889**	**6.8977778**	**9**
A-		0.555556	0.828729282	1.4	0.333333	0.601226994	1.6666667	0.1111111	0.923747277	3	0.777777778	2.16122	9

Step 6: calculate distance from each allternatine to the FPIS And to the FNIS.

$d(A_1, A_2) = \sqrt{1/3}[(a_1 - a_2) + (b_1 - b_2) + (c_1 - c_2)]$
$d_i^{+} = \sum_{j=1}^{k} d\left(v_{ij}, v_j^{+}\right), i = 1,2, \ldots \ldots \ldots ., m$
$d_i^{-} = \sum_{j=1}^{k} d\left(v_{ij}, v_j^{-}\right), i = 1,2, \ldots \ldots \ldots ., m$

Table 4.5 alternative to positive solution

Sr.no.	Factor	Time	cost	work	safety		Si+
1	Lack of supervision	3.248833	0.379915106	0.132578	2.038352		5.7996783
2	Delay in material supply	0.327868	1.952396811	0.28355	3.171563		5.7353775
3	Coordination among design disciline	0.271265	0.149683403	0.333504	3.268098		4.0225506
4	Errors in design drawing	0.259944	0.219363608	0.359347	3.199819		4.0384742
5	Working overtime	0.231683	0.177710115	0.338473	2.338194		3.0860593
6	Lack of leadership	0.176207	0.181758418	0.282864	2.869317		3.5101464
7	Skill of labour	0.192517	0.138136398	0.314088	2.549193		3.1939343

8	Payment delay	0.358828	0.36162211	0.27048	3.165926		4.1568556
9	Labour availability	0.330353	0.307889705	0.154197	3.271798		4.0642384
10	Material shortage	0.32669	0.312317282	0.271974	3.154997		4.0659779
11	Equipment shortage	0.301934	0.280899373	0.169253	3.089155		3.8412402
12	Temperature on site	0.136227	0.057832224	0.373713	2.293736		2.8615081
13	Delay in decision making	0.329625	0.311673766	0.163055	3.091494		3.895847
14	High wind	0.235888	0.149683403	0.329238	1.892283		2.6070924
15	Rainfall	0.281731	0.2482554	0.277502	1.812044		2.6195323
16	Site accident	3.251244	0.3521309	0.015094	0		3.6184689
17	Experience of labour	0.197189	0.155288746	0.342207	2.733457		3.428142
18	Labour age	0	0	0.443932	2.666449		3.1103809
19	Absence of training for labour	0.274654	0.318077232	0.159639	1.024358		1.7767282
20	Improper planning	3.251098	1.961306958	0	0.931271	FPIS	6.1436758

Table 4.6 alternative to negative ideal solution

Sr.no.	**Factor**	**Time**	**cost**	**work**	**safety**		**Si+**
1	Lack of supervision	3.248833	0.379915106	0.132578	2.038352		5.7996783
2	Delay in material supply	0.327868	1.952396811	0.28355	3.171563		5.7353775
3	Coordination among design disciline	0.271265	0.149683403	0.333504	3.268098		4.0225506
4	Errors in design drawing	0.259944	0.219363608	0.359347	3.199819		4.0384742
5	Working overtime	0.231683	0.177710115	0.338473	2.338194		3.0860593
6	Lack of leadership	0.176207	0.181758418	0.282864	2.869317		3.5101464
7	Skill of labour	0.192517	0.138136398	0.314088	2.549193		3.1939343
8	Payment delay	0.358828	0.36162211	0.27048	3.165926		4.1568556
9	Labour availability	0.330353	0.307889705	0.154197	3.271798		4.0642384

10	Material shortage	0.32669	0.312317282	0.271974	3.154997		4.0659779
11	Equipment shortage	0.301934	0.280899373	0.169253	3.089155		3.8412402
12	Temperature on site	0.136227	0.057832224	0.373713	2.293736		2.8615081
13	Delay in decision making	0.329625	0.311673766	0.163055	3.091494		3.895847
14	High wind	0.235888	0.149683403	0.329238	1.892283		2.6070924
15	Rainfall	0.281731	0.2482554	0.277502	1.812044		2.6195323
16	Site accident	3.251244	0.3521309	0.015094	0		3.6184689
17	Experience of labour	0.197189	0.155288746	0.342207	2.733457		3.428142
18	Labour age	0	0	0.443932	2.666449		3.1103809
19	Absence of training for labour	0.274654	0.318077232	0.159639	1.024358		1.7767282
20	Improper planning	3.251098	1.961306958	0	0.931271	FPIS	6.1436758

Step 7: calculate the closeness coefficient CCi for each factors.

$$cc_i = \frac{d_i^-}{d_i^- + d_i^+}, i=1,2,\ldots\ldots m$$

Table 4.7 closeness coefficient

Sr.no	**factors to be consider**	**Cci**
1	Lack of supervision	0.413482329
2	Delay in material supply	0.388689422
3	Coordination among design disciline	0.569724509
4	Errors in design drawing	0.570446538
5	Working overtime	0.679738643
6	Lack of leadership	0.627509969
7	Skill of labour	0.663012521
8	Payment delay	0.57229271
9	Labour availability	0.573460324
10	Material shortage	0.578129612
11	Equipment shortage	0.595913907

12	Temperature on site	0.697268984
13	Delay in decision making	0.592687117
14	High wind	0.74126047
15	Rainfall	0.751344236
16	Site accident	0.609366368
17	Experience of labour	0.635806107
18	Labour age	0.657786212
19	Absence of training for labour	0.815847192
20	Improper planning	0.336003061

Step 8: give rank to the factors.

5.RESULTS AND DISCUSSION
According to the closeness coefficient the rank is given to the factors.

Table 5 rank

Sr.no	factors to be consider	Cci
1	Absence of training for labour	0.815847192
2	Rainfall	0.751344236
3	High wind	0.74126047
4	Temperature on site	0.697268984
5	Working overtime	0.679738643
6	Skill of labour	0.663012521
7	Labour age	0.657786212
8	Experience of labour	0.635806107
9	Lack of leadership	0.627509969
10	Site accident	0.609366368
11	Equipment shortage	0.595913907
12	Delay in decision making	0.592687117

13	Material shortage	0.578129612
14	Labour availability	0.573460324
15	Payment delay	0.57229271
16	Errors in design drawing	0.570446538
17	Coordination among design disciline	0.569724509
18	Lack of supervision	0.413482329
19	Delay in material supply	0.388689422
20	Improper planning	0.336003061

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