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Evaluation of factors affecting Bar Benders and Steel Fixers Productivity of an Infrastructure Project in India by AHP

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Abstract — **As construction industry is majorly labour oriented industry. Its major concern is how to increase the productivity of labour. Bar Benders and Steel Fixers who are responsible for bending, cutting and fitting of reinforcement bars contribute majorly in timely completion of the project. Hence their productivity is important in the estimation of time taken by the activities and in estimating numbers of bar benders and steel fixers are needed to complete the work in time. Many intrinsic and extrinsic factors are contributing towards the productivity of bar benders and steel fixers but only few can be controlled by management. This paper represents the evaluation and identification of factors affecting the productivity of bar benders and steel fixer in an infrastructure project. These factors are analysed and ranked with the help of Analytic hierarchy process. After evaluation, top five components identified are Training, Bar Bender and Steel Fixer skills, Complexity in bar bending schedule, Distance between binding place to place of cutting and bending and Workspace which are bearing upon the productivity of bar benders and steel fixers.**

Keywords— *productivity, Bar Benders, Steel Fixers, Analytic hierarchy process.*

I. INTRODUCTION

Productivity is commonly defined as a ratio between an output value and an input value used to produce the output. There is nothing as dangerous to an economy as a decrease in productivities because it generates inflationary pressure, social conflict, and mutual suspicion (Drucker, 1980). This article is useful for construction/project manager, planning engineer and all those related directly or indirectly to project planning and management. The Bar Benders and Steel Fixers productivity can significantly contribute in timely completion of project. These norms are calculated and referred from reliable sources. As the productivity of Bar Benders and Steel Fixers varies with geographical locations across the world, these norms are more suitable for Indian scenario. These factors can certainly prove handy to project planning and management (PPM) personnel as they can use it for performing Bar Benders and Steel Fixers requirement calculation (of an infrastructure projects) and for cross checking the existing daily progress report (DPR) of their site to know how well the Bar Benders and Steel fixers are performing.

II. AHP

Thomas L. Saaty. developed the analytic hierarchy process (AHP). The AHP is created to solve complex problems involving multiple criteria (multi-criteria decision making) (MCDM) process. The AHP is advantageous as it is designed to handle cases in which the subjective judgments of individuals are significant part of the decision process. Additionally, the AHP helps in reducing bias in the decision by incorporating a useful technique for checking the consistency of the decision maker's evaluations.

III. FACTORS

Diameter of bar used in structure –DB
Cutting and bending-CB
Complexity in bar bending schedule-CBB
Type of structure-TS
Technical advancement-TA
Workspace-WS
Distance between binding place to place of cutting and bending-DBC
Storage location-SL
Lighting-LI
Weather-WE
Bar Bender and Steel Fixer skills-BS
Working hours in a day-WH
Proper sanitation-PS
Lack of place for eating and resting-LP
Motivational factors-MF
Training-TR
Relation between Bar Bender and Steel Fixer with the site engineer-RB
Delay in payments-DP
Late arrival, early quit and unscheduled breaks-LA
Supervision-SP

These factors are segregated and grouped on the basis of different criteria like technical, environmental, health and management.

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TABLE-1

No.	Criteria	Sub Criteria
1.a)	1.Technical	Diameter of bar used in structure
1.b)		Cutting and Bending
1.c)		Complexity in bar bending schedule
1.d)		Type of structure
1.e)		Technical advancement
2.a)	2.Environmental	Work space
2.b)		Distance between binding place to place of cutting and bending
2.c)		Storage location
2.d)		Lighting
2.e)		Weather
3.a)	3.Health	Bar Bender and steel fitter skill
3.b)		Working hours in a day
3.c)		Proper sanitation
3.d)		Lack of place for eating and resting
3.e)		Motivational factors
4.a)	4.Management	Training
4.b)		Relation between Bar Bender and site engineer
4.c)		Delay in payments
4.d)		Late arrival, early quit and unscheduled breaks
4.e)		Supervision of work

III. METHODOLOGY

TABLE 2

AHP Scale of Importance for comparison pair (a_{ij})	Numeric Rating	Reciprocal (decimal)
Extreme Importance	9	1/9 (0.111)
Very strong to extremely	8	1/8 (0.125)
Very strong Importance	7	1/7 (0.143)
Strongly to very strong	6	1/6(0.167)
Strong Importance	5	1/5(0.200)
Moderately to Strong	4	1/4(0.250)
Moderate Importance	3	1/3(0.333)
Equally to Moderately	2	1/2(0.500)
Equal Importance	1	1 (1.000)

AHP starts by creating pairwise comparison matrix A,B,C and D by using Table-1 sub-criteria. The matrix A is a n×n real matrix, where n is the number of evaluation sub-criteria considered. Each entry a_{xy} of the matrix A,B,C and D represents the importance of the x^{th} criterion relative to the y^{th} criterion. The AHP employs an underlying scale with values from 1 to 9 to rate the relative preferences for two items. If $a_{xy} > 1$, then the x^{th} criterion is more important than the y^{th} criterion, while if $a_{xy} < 1$, then the x^{th} criterion is less important than the y^{th} criterion. If two criteria have the same importance, then the entry a_{xy} is 1. According to above rules, the number of entries actually filled in by decision makers is $(k^2 – k)/2$, where k is the number of elements to be compared.

TABLE-3 COMPARISION MATRIX OF TECHNICAL

FACTORS	DB	CB	CBB	TS	TA
DB	1.000	4.000	2.000	0.250	0.200
CB	0.250	1.000	0.250	3.000	0.200
CBB	0.500	4.000	1.000	9.000	3.000
TS	4.000	0.333	0.111	1.000	0.250
TA	5.000	5.000	0.333	4.000	1.000
Total	10.750	14.333	3.694	17.250	4.650

TABLE-4 COMPARISION MATRIX OF ENVIRONMENT

FACTORS	WS	DBC	SL	LI	WE
WS	1.000	2.000	4.000	1.000	2.000
DBC	0.500	1.000	6.000	3.000	5.000
SL	0.250	0.167	1.000	5.000	8.000
LI	1.000	0.333	0.200	1.000	7.000
WE	0.500	0.200	0.125	0.143	1.000
Total	3.250	3.700	11.325	10.143	23.000

TABLE-5 COMPARISION MATRIX OF HEALTH

FACTORS	BS	WH	PS	LP	MF
BS	1.000	7.000	4.000	5.000	6.000
WH	0.143	1.000	3.000	3.000	5.000
PS	0.250	0.333	1.000	7.000	6.000
LP	0.200	0.333	0.143	1.000	5.000
MF	0.167	0.200	0.167	0.200	1.000
Total	1.760	8.867	8.310	16.200	23.000

TABLE-6 COMPARISION MATRIX OF MANAGEMENT

FACTORS	TR	RB	DP	LA	SP
TR	1.000	4.000	4.000	6.000	4.000
RB	0.250	1.000	1.000	4.000	5.000
DP	0.250	1.000	1.000	1.000	3.000
LA	0.167	0.250	1.000	1.000	2.000
SP	0.250	0.200	0.333	0.500	1.000
Total	1.917	6.450	7.333	12.500	15.000

Once the matrix A,B,C and D is formed, it is possible to derive from A the normalised pairwise comparison matrix (A norm)

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by making equal to 1 the sum of the entries in each column,i.e. each entry a_{XY} of the matrix (A norm) is computed as.

$$\text{Normalise } a_{xy} = \frac{axy}{\sum \text{all elements in the y column}}$$

Similarly all other normalise matrixes B,C and D are derived. All columns in the normalised pairwise comparison matrix now have a sum of 1.Average of each row is computed. An essential consideration to check the quality of the final decision relates to the consistency of judgments that the decision maker established during the series of pairwise comparisons.
For the check of consistency of the data, the AHP offers a method to measure the degree of consistency among the pairwise judgments provided by the decision maker.

1) The decision process can carry on if the degree of consistency is tolerable.
2) If the degree of consistency is unacceptable the decision maker should reexamine and possibly revise the pairwise comparison judgments before proceeding with the analysis.

The AHP provides a measure of the consistency of pairwise comparison judgments by calculating a consistency ratio. The ratio is designed in such a way that if values of the ratios are more than 0.10 then it is indicative of inconsistent judgments.

Compute the Consistency Index (CI):

$$CI = \frac{\lambda_{avg} - m}{m - 1}$$

Where λ = average consistency measure for all alternatives
m = number of alternatives

Compute the Consistency Ratio (CR):

$$CR = \frac{CI}{RI}$$

Where RI = the random index, which is the consistency index of a randomly generated pair-wise comparison matrix.

Random index (RI) is the consistency index of a randomly generated pairwise comparison matrix. RI varies with the number of elements being compared (i.e., the size of pairwise comparison matrix) and takes on the following values:

TABLE-7

m	RI
1	0
2	0
3	0.58
4	0.9
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.51

TABLE-8

Factors	DB	CB	CBB	TS	TA	Total	Weight	Consistency measure
DB	0.093	0.279	0.541	0.014	0.043	0.971	0.194	6.604
CB	0.023	0.070	0.068	0.174	0.043	0.378	0.076	7.793
CBB	0.047	0.279	0.271	0.522	0.645	1.763	0.353	7.173
TS	0.372	0.023	0.030	0.058	0.054	0.537	0.107	9.458
TA	0.465	0.349	0.090	0.232	0.215	1.351	0.270	8.016
Total	1.000	1.000	1.000	1.000	1.000		CI	0.702
							RI	1.120
							CR	0.627

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TABLE-9

Factors	WS	DBC	SL	LI	WE	Total	Weight	Consistency measure
WS	0.308	0.541	0.353	0.099	0.087	1.387	0.277	7.135
DBC	0.154	0.270	0.530	0.296	0.217	1.467	0.293	8.387
SL	0.077	0.045	0.088	0.493	0.348	1.051	0.210	7.560
LI	0.308	0.090	0.018	0.099	0.304	0.818	0.164	5.914
WE	0.154	0.054	0.011	0.014	0.043	0.277	0.055	5.467
Total	1.000	1.000	1.000	1.000	1.000		CI	0.473
							RI	1.12
							CR	0.422

TABLE-10

Factors	BS	WH	PS	LP	MF	Total	Weight	Consistency measure
BS	0.568	0.789	0.481	0.309	0.261	2.409	0.482	6.842
WH	0.081	0.113	0.361	0.185	0.217	0.958	0.192	6.881
PS	0.142	0.038	0.120	0.432	0.261	0.993	0.199	6.250
LP	0.114	0.038	0.017	0.062	0.217	0.448	0.090	5.264
MF	0.095	0.023	0.020	0.012	0.043	0.193	0.039	5.390
Total	1.000	1.000	1.000	1.000	1.000	CI		0.281
						RI		1.120
						CR		0.251

TABLE-11

Factors	TR	RB	DP	LA	SP	Total	Weight	Consistency measure
TR	0.522	0.620	0.545	0.480	0.267	2.434	0.487	5.608
RB	0.130	0.155	0.136	0.320	0.333	1.075	0.215	5.446
DP	0.130	0.155	0.136	0.080	0.200	0.702	0.140	5.417
LA	0.087	0.039	0.136	0.080	0.133	0.475	0.095	5.214
SP	0.130	0.031	0.045	0.040	0.067	0.314	0.063	5.131
Total	1.000	1.000	1.000	1.000	1.000		CI	0.091
							RI	1.12
							CR	0.081

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IV. RESULT

TABLE-12

Top five factors affecting productivity of Bar Benders and Steel Fixers
1.Training
2.Bar Bender and Steel Fixer skills
3.Complexity in bar bending schedule
4.Distance between binding place to place of cutting and bending
5.Workspace

V. CONCLUSION

On the basis of present study in this research paper, 20 factors are identified and questionnaire is generated to study the factors affecting Bar Benders and Steel Fixers productivity in an infrastructure project and circulated to all the stakeholders to conduct the survey. With the results acquired from this survey, a pairwise comparison matrix is created using AHP model. From this matrix, the consistency measure is calculated for each factor which gives Training, Bar Bender and Steel Fixer skills, Complexity in bar bending schedule, Distance between binding place to place of cutting and bending and Workspace as the top five factors affecting the productivity of Bar Benders and Steel Fixers.

REFERENCES

[1] Adnan Enshassi, Peter Eduard Mayer, Sherif Mohamed, Ziad Abu Mustafa (2007) " Factors affecting labour productivity in building projects in the gaza strip. "Journal of Civil Engineering and Management. 2007, 13(4); 245-254

[2] Ibrahim Mahamid, A.Al-Ghonamy, M. Aichouni "Major Factors Influencing Employee Productivity in the KSAPublic Construction Projects" IJCEE-IJENS Vol: 14 No: 01

[3] Agapiou, A., Flanagan, R., Norman, G., and Notman, D. "The Change Role of Builders'Merchants in the Construction Supply Chain" Construction Management and Economics, Vol.16, 1998, pp351-361.

[4] Park, H; Thomas, S. R and Tucker, R. L. (2005). Benchmarking of construction productivity. Journal of Construction Engineering and Management, 137(7), 772-778

[5] Saaty, T.L. The Analytical Hierarchy Process, McGraw-Hill, New York, 1980.

[6] Saaty, T. L., Decision-making with the AHP: Why is the Principal Eigenvector necessary? In: Klaus Dellmann (Ed.), Proceedings of the Sixth International Symposium on the Analytic Hierarchy Process, ISAHP 2001, 383-396, Bern, 2001.

[7] Ibrahim Mahamid, A.Al-Ghonamy, M. Aichouni "Major Factors Influencing Employee Productivity in the KSAPublic Construction Projects" IJCEE-IJENS Vol: 14 No: 01.