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ANALYZING FACTORS INFLUENCING CONSTRUCTION LABOR PRODUCTIVITY USING FUZZY ANALYTICAL HIERARCHY PROCESS (FAHP)

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Abstract- The construction sector contributes an indispensable role in the country economy. Among many other factors the significance of the construction labour production cannot be denied. The cost of labor comprises of 30-50% of the project costs. To improve the productivity of the construction labor, it needs to explore the factors that affect the productivity. This study is conducted to analyze the factors that affect the construction labor productivity in developing country like Pakistan. The factors were tabulated after studying detailed literature about the topic of discussion. The factors were then analyzed by taking the experts responses on a scale of 1-9. The fuzzy Analytical Hierarchy Process (Fuzzy AHP) is used to rank the factors considering the expert responses. The results reveal the "leadership and effectiveness" of the managing personals on site is the main factors that affect the labor productivity. The outcomes of this study will be used as an input of making polices for improving the labour productivity in construction industry.

Keywords- Labor Productivity, Factors affecting, Fuzzy AHP

1 INTRODUCTION

The growth of the construction sector is mainly related with productivity, and the productivity is mainly dependent on labor performance. Labor cost comprises of about 30 to 50% of the overall project's cost (Jarkas & Bitar, 2011). In construction industry, we can minimize the cost by working out the productivity. In evolved and underdeveloped countries productivity play an important role (Alaghbari, Al-Sakkaf, & Sultan, 2019).

Defining the success of a project, labor productivity plays a key role (Mahamid, 2014) . Though, many factors affects labour productivity. It comprise of factors related to materials, labour, tools and equipment, political, construction methods, environment and financing.

2 RESEARCH PROBLEM

One of the key reasons of failing the projects in terms of budget and schedule is because of poor labour productivity. So, to evolve this reason there is a need of management attention (Alaghbari et al., 2019). The project success within time and given budget is a very important task. It helps in minimizing the conflicts between the stakeholders. It would also

increase profits, contribute to the GDP and development of construction industry(Al-Najjar, 2008). To apprehend these benefits we need to improve the labour work profitability in development.

3 RESEARCH OBJECTIVES

- *To become explore the factors influencing labour productivity.*
- *To formulate guidelines for improving construction overall performance.*

4 LITERATURE REVIEW

Productivity is the rate of output against per unit time. Researchers have found that in construction industry, man power is highly consumed which directly effects project cost, time over run and many other factors (Hickson & Ellis, 2014). Labour productivity is a difficult parameter and is challenging to measure but here we are not discussing this issue, we will only study the reasons effecting labors productivity in Pakistan.

4.1 Pakistan construction industry

In past, Government of Pakistan did not compile the construction industry data due to which the industry failed to give better output. Now, construction industry is declared officially a separate industry by ministry of Pakistan. As there is war and terror, and the nation is going on through financial and force crises, the Planning Commission has assessed horribly that from declining performance of labours from the last two decades, the country economy is going down. The low labor productivity is the most crucial problem for the economy (Muzamil & Khurshid, 2014). According to (Shah & Ahad, 2017) construction industry accounts for six to nine percent of the GDP. While in Pakistan it adds only two and a half percent to the GDP.

4.2 Construction labour productivity in Pakistan

In Pakistan construction industry suffers from many problems which affect labor productivity. Thus, the efficiency of labour play a huge role in construction industry. Efficiency of labour is affected by several factors in projects. By reviewing the literature a lot of different factors exist in different countries. According to Pakistan our cultural practices is little bit different and experts have put efforts in identifying those factors. Experience members firstly, determined 54 labour factors that influence development work efficiency. After that, Questionnaire of 54 factors is distributed on 12 members. Client, consultant, contractor and academia participate three from each respectively. They suggest 15 factors out of those 54 factors. Hierarchy structure figure-1 summaries the important influencing labour productivity factors in construction industry which is suggested by the researchers in many countries. In the research, (Muzamil & Khurshid, 2014), mention that there is limited study was conducted in Pakistan regarding construction labour productivity. Another study shows that, in Pakistan there is no significant research conducted to find out and give solutions to factors which affect the productivity of labours in various way in construction industry of Pakistan (Shah & Ahad, 2017).
There are many factors and sub factors were established throughout the world and it may vary region to region because of the environment, culture and economy (Polat & Arditi, 2005). Along these lines their impact on cost and time of task likewise varies as for changed ecological, financial, security and different issues of a country (Muzamil & Khurshid, 2014).

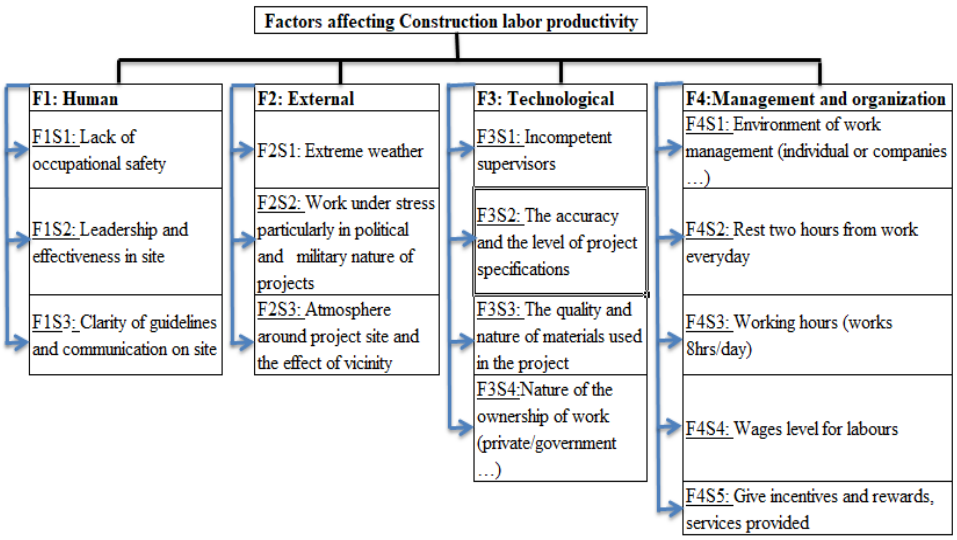

Figure 1: Hierarchy of the study

5 RESEARCH METHODOLOGY

To meet the research objectives firstly, we review the literature and identified the variables that influence work profitability. After that we design a questionnaire and determine the most reliable factors that pressurize the construction industry of Pakistan to give much attention regarding labor productivity. The client, consultant, contractor and the academia involves by fulfilling the questionnaire. In this survey total twelve (12) members fulfill the questionnaire, three from each respectively. And in the last phase we rank the variables that influence work efficiency, for this we use Fuzzy AHP technique. The figure-2 shows the research methodology flowchart.

5.1 Analytical Hierarchy process (AHP)

To make appropriate results of the criteria this survey is planned to assemble and examine decisions from participants. Analytical Hierarchy process uses a pairwise evaluation technique to make weightings (ratio scales) for criteria, instead of other simple ranking by other relative index's (Strehlow et al., 2003). Moreover, the application of AHP does not involve difficult arithmetic calculations; it can easily be understood without problems.

5.2 Fuzzy theory

The main purpose for the creation of this idea was to represent ambiguity precisely and to make available formal tools for dealing with the vagueness nature to many problems (Asad, Kermani, & Hora, 2015). Triangular or trapezoidal fuzzy numbers are popular (Guha & Chakraborty, 2011).In this work our focus is on the use triangular fuzzy number, fuzzy AHP. Following Table shows its Scale (Koulinas, Marhavilas, Demesouka, Vavatsikos, & Koulouriotis, 2019).

Table 1- Standard scale

Table of labels associated with Saaty's model (Lamata, 2004).

Definition	Saaty's Scale	Triangular number
Ai and Aj are equally important	1	[1,1,1]
Ai is moderately more important than Aj	3	[2,3,4]
Ai is strongly more important than Aj	5	[4,5,6]
Ai is very strongly more important than Aj	7	[6,7,8]
Ai is extremely more important than Aj	9	[8,9,9]
The scales 2,4,6, and 8 are also used and represent compromises among the tabulated scale	2,4,6, and 8	In the same way

5.3 Fuzzy AHP

As ambiguity and doubt are most joint conditions in lot of decision creation issues, a decent result making model wants to tolerate ambiguity (Asad et al., 2015). Linguistic values membership functions are generally categorized by Triangular Fuzzy Numbers, are suggested to estimate best evaluations as a replacement for of conventional numerical correspondence approach, due to the fact the ambiguous linguistic approach can take the reliable rating mind-set of judgment makers under consideration (Liang & Wang, 1994). via Analytical hierarchy process, the significance of numerous catogories is acquired from a procedure of paired assessment, where the significance of the elements or categories of drivers of intangible belongings are matched two-on-two in a hierarchic shape (Sun, 2010).

Thus, the fuzzy- Analytical hierarchy process method had better and more appropriate than conventional Analytical hierarchy process in practical, where an ambiguous pairwise assessment environment exists (Lee, Chen, & Chang, 2008).
Step 1: In the first step, pairwise comparison matrices of factors/criteria of the hierarchy structure within the dimensions is develop. Allocate linguistic variables to the pairwise assessments by means of asking that which one is more important of each 2 dimensions, as following matrix A

$$A' = \begin{bmatrix} 1 & a'_{12} & \cdots & a'_{1n} \\ a'_{21} & 1 & \cdots & a'_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a'_{n1} & a'_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & a'_{12} & \cdots & a'_{1n} \\ 1/a'_{12} & 1 & \cdots & a'_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a'_{1n} & 1/a'_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

Where $\tilde{a}_{ij} = \begin{cases} \tilde{9}^{-1}, \tilde{8}^{-1}, \tilde{7}^{-1}, \tilde{6}^{-1}, \tilde{5}^{-1}, \tilde{4}^{-1}, \tilde{3}^{-1}, \tilde{2}^{-1}, \tilde{1}^{-1}, \tilde{1}, \tilde{2}, \tilde{3}, \tilde{4}, \tilde{5}, \tilde{6}, \tilde{7}, \tilde{8}, \tilde{9}, & 1, i \neq j \\ 1 & i = j \end{cases}$

Step 2: For finding Fuzzy Geometric mean and Fuzzy weights of every factor we use Geometric Mean Technique (Srdjevic et al., 2013).

$$r'_i = \left(a'_{i1} * \cdots * a'_{ij} * \cdots * a'\right)^{1/n} \quad (2)$$

$$\widetilde{W}_1 = \tilde{r}_1 * (\tilde{r}_1 + \tilde{r}_2 + \tilde{r}_3 + \tilde{r}_4 + \tilde{r}_5 + \tilde{r}_6)^{-1} \quad (3)$$

Step 3: For finding the overall weight we use the formula (Sun, 2010).

$$BNP_{w_1} = \left[\left(U_{w_1} - L_{w_1}\right) + \left(M_{w_1} - L_{w_1}\right)\right]/3 + L_{w_1} \quad (4)$$

Adding fuzzy numbers (+):

$$A' + B' = (l_1, m_1, u_1) + (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (5)$$

Multiplying TFNs (*)

$$A' * B' = (l_1, m_1, u_1) * (l_2, m_2, u_2) = (l_1 l_2, m_1 m_2, u_1 u_2) \quad (6)$$

Triangular Fuzzy number subtraction (-)

$$A' - B' = (l_1, m_1, u_1) - (l_2, m_2, u_2) = (l_1 - l_2, m_1 - m_2, u_1 - u_2) \quad (7)$$

Division of triangular FNs (/): $A'/B' = (l_1, m_1, u_1)/(l_2, m_2, u_2) = \left(\frac{l_1}{u_2}, \frac{m_1}{m_2}, \frac{u_1}{l_2}\right)$ (8)

Inverse of the munbers $(A')^{-1} = (l_1, m_1, u_1)^{-1} = \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right)$ (9)

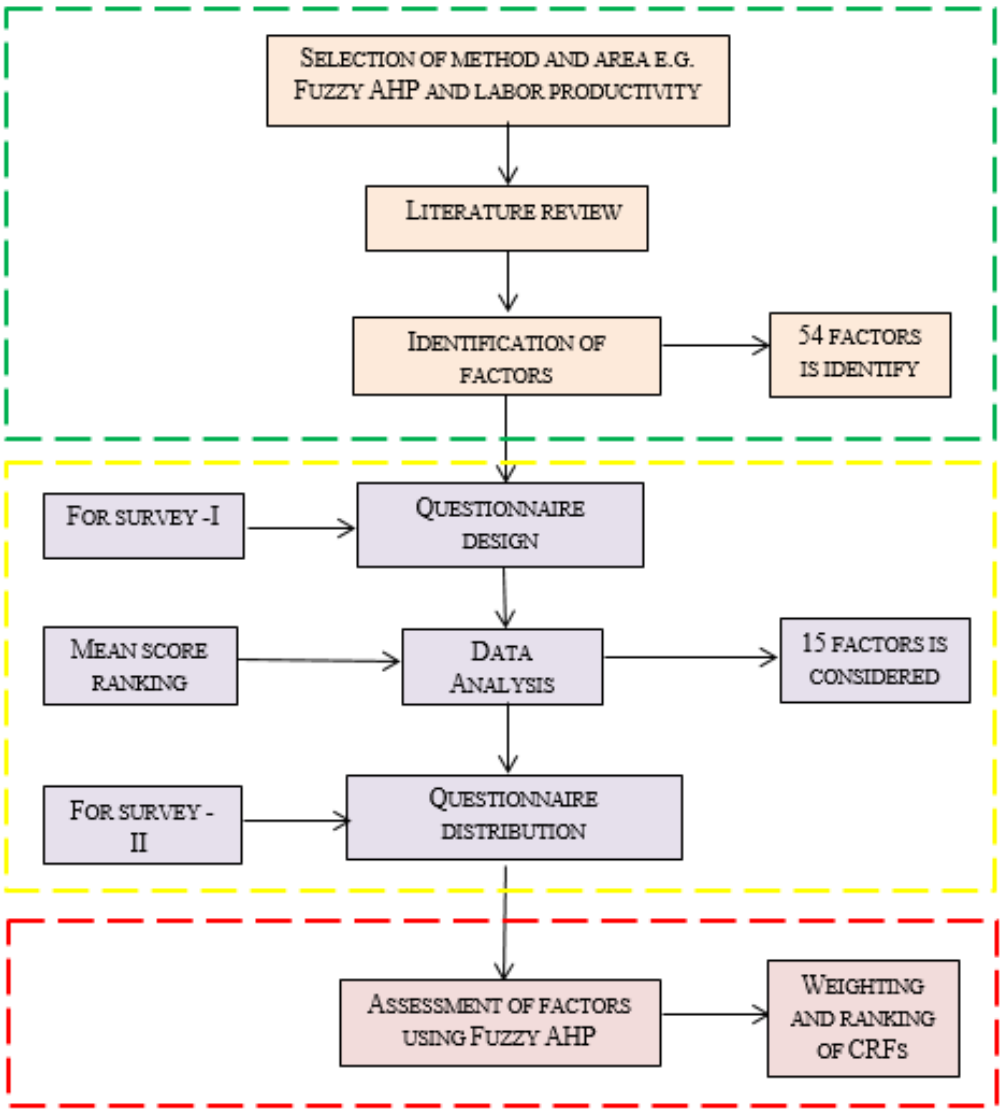

Figure 2: Hierarchy of the study

6 RESULTS

To improve the construction labor productivity of Pakistan we have to focus on the determined factors as shown in table 2. Out of fifteen factors, the top factors that affect construction labor productivity are 1) leadership and effectiveness in site 2) work under stress particularly in political and military nature of projects 3) atmosphere around project site 4) incentive and rewards also affect and 5) Extreme weather condition.

Table 2- Final results of the fuzzy AHP computations

Main Factors	Overall weight	Percentage (%)	sub-factors	overall weight	Percentage (%)	Ranking
FI	0.15	14.34	F1S1	0.23	22	10
			F1S2	0.494	48	1
			F1S3	0.301	29.4	6
F2	0.17	15.83	F2S1	0.31	30.1	5
			F2S2	0.356	34.8	2

			F2S3	0.354	34.6	3
F3	0.43	40.04	F3S1	0.25	24.4	9
			F3S2	0.218	21	13
			F3S3	0.3	29	7
			F3S4	0.26	25.4	8
F4	0.32	29.79	F4S1	0.224	22	11
			F4S2	0.09	9	15
			F4S3	0.17	17	14
			F4S4	0.219	21	12
			F4S5	0.32	31	4

7 CONCLUSION

By reviewing the literature it is determine that no study is conducted in Pakistan that consider factors affecting construction labour productivity. With the help of linguistic variables Fuzzy AHP can overcome such incompetence. This technique is a more organized and effective method than the other MCDM methods. Hence, fuzzy AHP is an efficient method for coping with the fuzziness of the facts involved in identifying the preferences or results of different decision variables (Sezhian, Muralidharan, Nambirajan, & Deshmukh, 2011). The authors assess different factors; the top most factor that affect construction labour productivity is 'leadership and effectiveness in site 'while in other countries it is different. By improving or mitigating such factors Pakistan construction industry improves labour productivity. By considering these factors farther research may conducted to mitigate the issues in the context of industry 4.0. The author (Poirier, E. A., Staub-French, S., & Forgues, D. 2015) determined in a study that labor productivity is improved in a prefabricated sector ranging from 75% to 240% by using Building information modeling..

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