ANALYSIS OF FACTORS AFFECTING CONSTRUCTION LABOUR PRODUCTIVITY FOR PUNE CITY

Rahul S. Chaudhari[1], [2]Ghanasham C. Sarode, [3]Pankaj P. Bhangale , [4]Sandip T. Mali

[1]Assistant Professor, Pimpri Chinchwad college of Engineering, Nigdi, Pune.

rahul.chaudhari@pccoepune.org

[2]Associate Professor, D.Y.Patil Institute of Engineering & Technology,Pimpri, Pune, India

[3]Professor, Shri Sant Gadge Baba College of Engineering & Technology, Bhusawal, India

pankajpbhangale@gmail.com

[4]Professor, Pimpri Chinchwad college of Engineering, Nigdi, Pune.

sandip.mali@pccoepune.org

_____

Abstract

Construction sector is an unorganized industry and the output mainly depends on the productivity of the construction workers. Pune is one of the fastest-growing cities and mainly growing vertically upward. Two projects of high-rise buildings were identified. After a pilot survey, data were collected from 45 construction workers. Four groups of topmost 13 factors considering interlinking of factors were formed. A strong correlation was observed between security and the PPE provided by the employer in group no I. Musculoskeletal problem with the worker is also one of the major problem and workers having an inadequate facility like medical, canteen and wash places also play a significant role. In this study, same the factors were considered for men and women but for more specific results, a separate study shall be carried out.

Keywords: Construction Labour Productivity; High Rise Building, Pearson Correlation, Regression Model.

_____

1.Introduction

In the Construction sector, productivity is mainly addressed by the output of labours and equipment. But the contribution of labour productivity is at a higher level as compared with the other. At present nearly 52 million labours are working in the construction sector in India. The skill level of those workers is not up to the mark as no formal training/education is provided to them by the employer. Due to this, they will get the required skills only through their work experience. In India, Maharashtra and Gujrat is having maximum labour productivity and the lowest is for the states like Odisha & West Bengal. Data were collected from two sites of High rise building construction projects. Due to COVID-19, limited participants from two were considered. Fifty-five factors were identified and data were collected from 45 construction workers partially by questionnaire and interviews. Through this study, a strong and weak correlation was identified by making four groups of interlinking factors. Regression analysis was carried out for the same groups. By referring to the correlation obtained through this study, improvement in the respective area can lead to improving labour productivity.

2. Literature survey

Construction Labour Productivity (CLP) is one of the most significant factors which plays a vital role in the profitability of any organization. Due to this most of the researchers focus on the same area. But the labour productivity is influenced by a multitude of factors and found that excessive overtime and delay in the material cause a major impact on CLP Anu V. Thomas and J. Sudhakumar,(2014). According to Surabhi Sengar,(2020), The productivity and reliability of any

system or process depend on the satisfactory functioning and performance of the components involved in that process. This is reflected in the reliability analysis of various complex engineering systems during the research work done. Work management which includes managers abilities and continuity in work plays important role in labours productivity than the component like the capability of workers and difficulty in the execution of the work Homyun Jang,(2009). According to the results obtained in Canada, temperature and height play a significant role in labour productivity. Those two parameters are followed by the type of work. Osama Moselhi and Zafar Khan,(2009). In Malaysia, the study shows that factors like 1. labours work experience,2. Job Category 3.Skills 4. Marital status & age,5. Nationality & training & education plays a vital role in influencing Construction Labour Productivity. Mohammed Hamza Momade,(2020).

In Saudi Arabia, the study is carried out by using AI techniques like 1.Multilayer perceptron neural network (MLPNN),2. Support vector machine (SVM), 3.General regression neural network (GRNN), 4.Multiple additive regression trees (MART) shows that the MART method is more superior to the others. MART & GRNN methods can be adopted for calculating CLP for 1.Steel fixing 2.Concrete pouring & 3.Finishing and formwork assembly work respectively Ehab A. Mlybari,(2020).CLP with high accuracy can be simulated by SVM & RF. For both, the model's probability distribution is more than 90%. The result obtained shows that advanced machine learning methods can be useful for predicting Construction Labour Productivity. Mohammed Hamza Momade,(2020).

In Canada, for predicting formwork labour productivity for High Rise Buildings, various ANN techniques were used. These include including 1.General Regression Neural Network (GRNN), 2.Backpropagation Neural Network (BNN), 3.Radial Base Function Neural Network (RBFNN), 4. Adaptive Neuro-Fuzzy Inference System (ANFIS). The analysis shows that BNN provides better results as compared to others. Sasan Golnaraghi,(2019). Decision Making Trial and Evaluation Laboratory (DEMATEL) method for data analysis and found that 1.level of skill,2. Project size,3. experience 4.communication problems with foreign workers are the most important factors which affect labour productivity in building construction projects in Australia. Farnad Nasirzadeh, (2020). According to the literature survey, it is concluded that adequate welfare facilities are not provided by the employer to the labours. Rahul S.Chaudhari (2020).

Following figure no 1 shows several factors considered for the respective study by the researchers. It is observed that for most of the studies the factors considered are less than 50 as the filtration of the questions was carried out in the pilot survey.
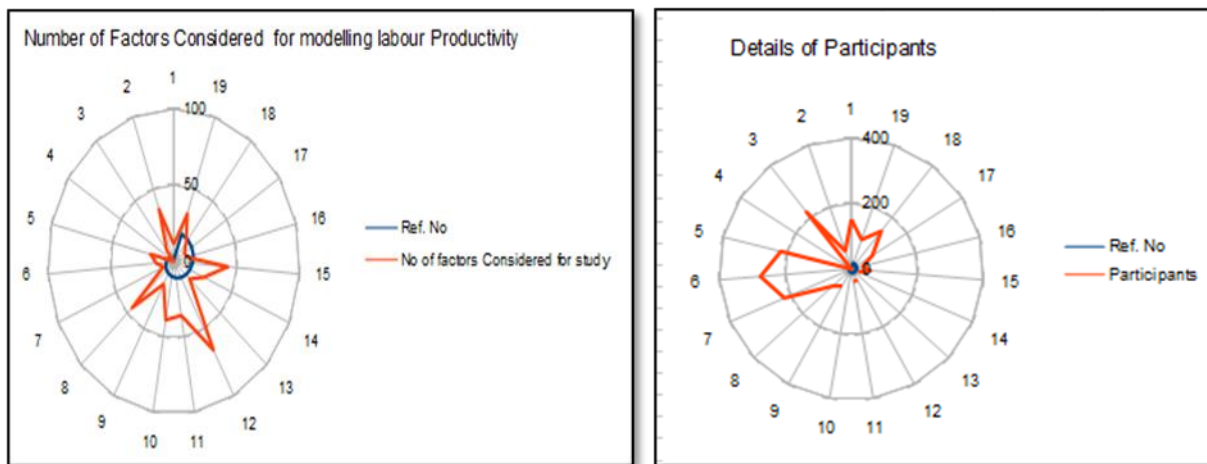

Figure No.1 Factors considered for modelling labour Productivity & Details of participants

Also, Figure No 1 represents details of participants in the study.

In most of the studies, the participants based on their experience, age, type of project, nature of work & position in the organization.

In India, it was found that(Hemanta Doloi,(2011) critical factors like lack of commitment, inefficient site, management, poor site coordination, improper planning, lack of clarity in project scope, lack of communication & substandard contract plays important role in lowering productivity.

If material management is implemented on the multi-story building construction site, then the labour productivity will get improved. Argaw Tarekegn Gurmu,(2018).

For data analysis, various tools like ANN, BIM, SPSS, SVM & RF, FUZZY, Microsft Excel was adopted. In some studies, manual calculations also carried out by the researchers.

It was observed that nearly 45% & 15% of researchers preferred SPSS & ANN for the analysis. The details are given in Figure No 2.
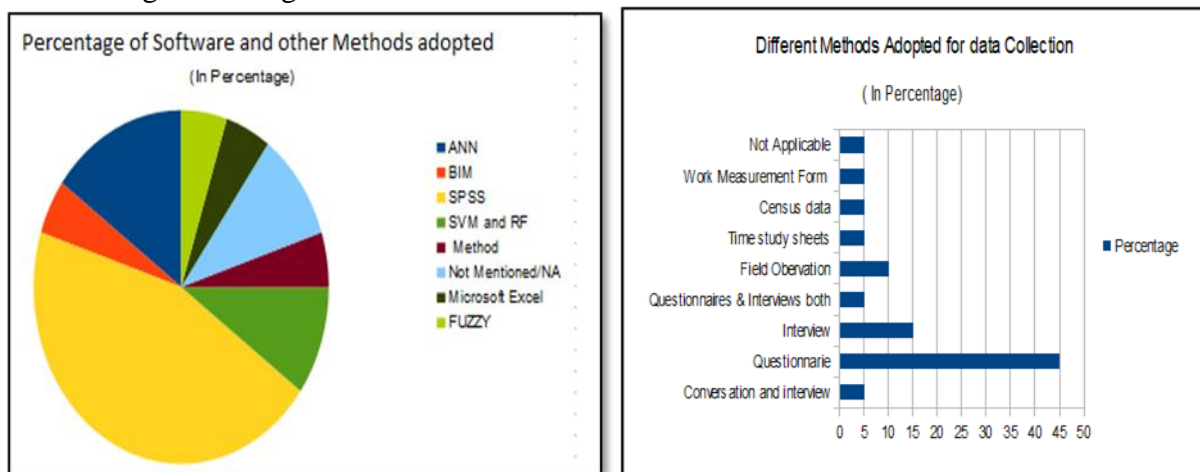

Figure No 2 Percentage of software and other methods adopted for analysis & various methods used for data collection.[1 to 21]

Also, Figure No 2. Gives details about the different methods adopted for data collection. It was concluded that nearly 45% of researchers preferred questionnaires for data collection. Nearly 15% preferred Interviews for data collection. Other than the analysis of CLP, another analysis was carried out by the researchers like Model validation, Sensitivity analysis, Reliability analysis, Regression analysis & Analytic Hierarchy Process (AHP). Model validation is carried out by nearly 55% & regression analysis by 45%.
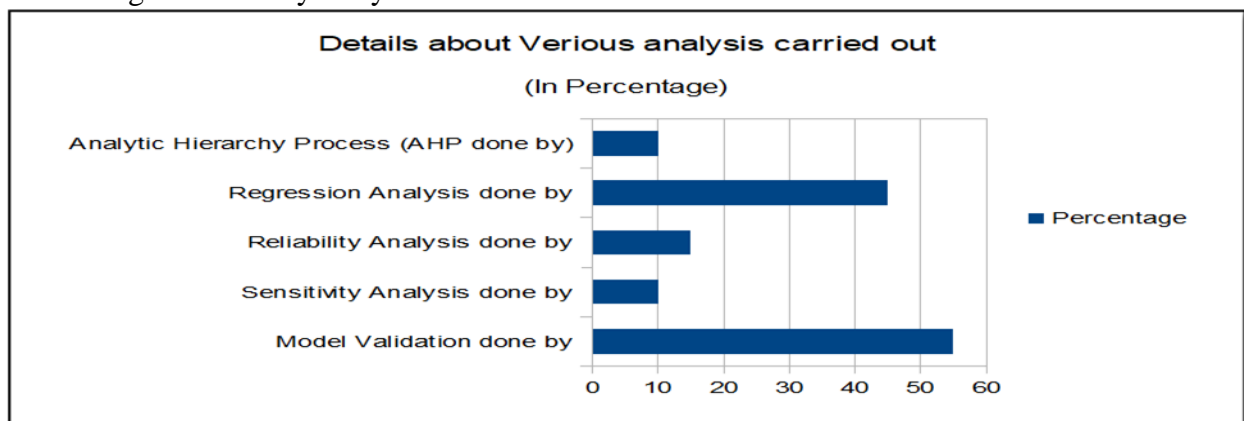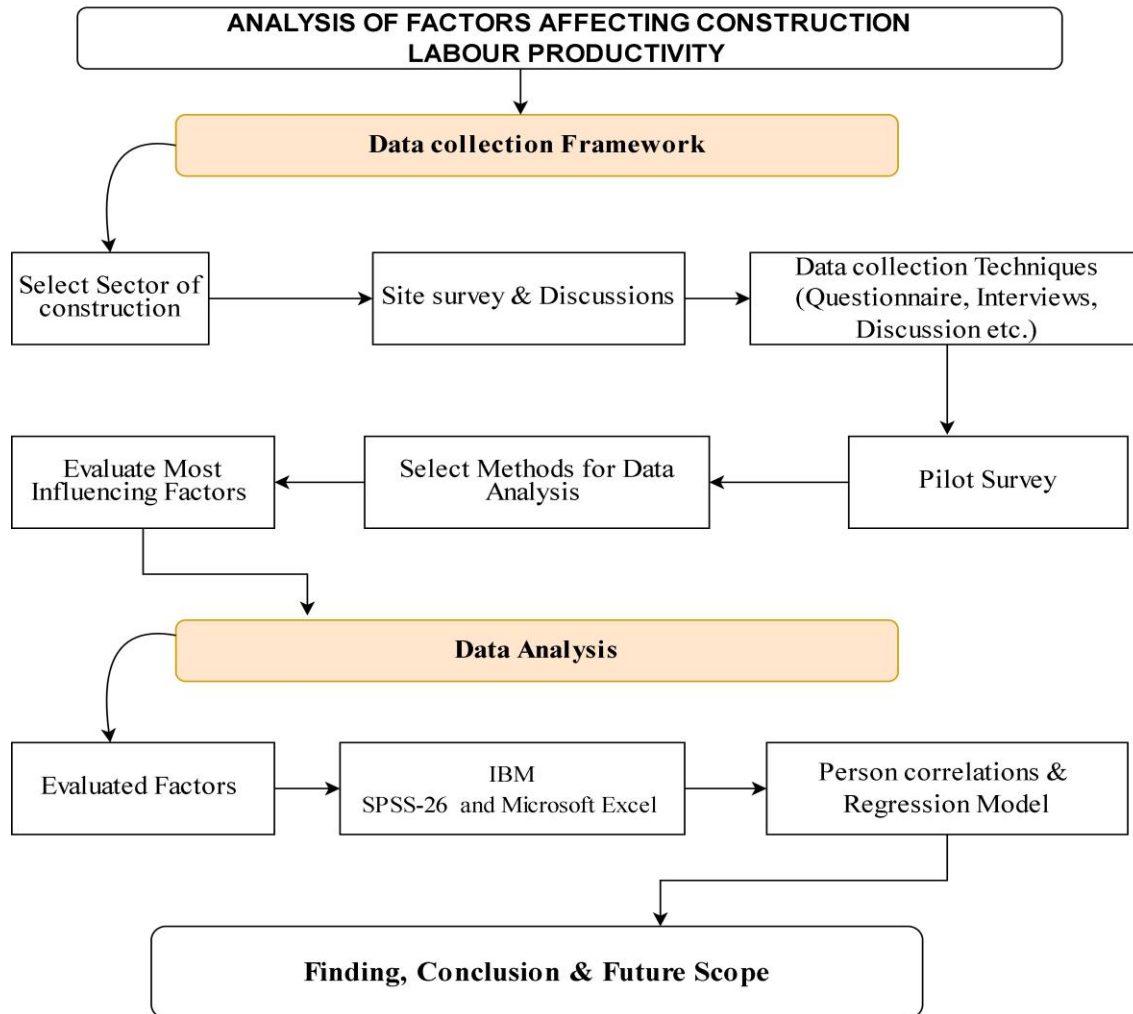
Figure No 3. Details about various analyses carried out by researchers.

The case of the multilinear model gives more predictable results (82.31%) and the correlation coefficient (R%) was calculated as 97.15%. the values calculated are commensurate with actual data. Yasser S. Nassar,(2018).

2.1 Methodology:

Following Methodology is adopted for the work (refer Fig No.4)

Fig No.4 Methodology adopted for the work

3. Data Collection & Analysis

Nowadays, due to the increase in population and demand for shelters, the buildings growing vertically. In this situation, it is essential to take a review of the satisfaction of the workers working on high rise buildings. For this study, two localities from Pune city were selected where major construction activities are carried out. After the selection of localities, two projects were identified having the same nature and floors. Firstly discussion was carried out with the workers working on the site and based on the same questionnaire is prepared. A total of 55 factors were identified. Secondly, a pilot survey was carried out and then the questionnaire was refined.

Thirdly, a questionnaire was circulated to 27 labours on the first site and 18 labours on the second site. The number of labours considered in this study is due to the COVID-19 Pandemic.

After data collection, the following summary is prepared for further analysis and considered as productivity influencing factors. To process input data (collected data), IBM SPSS-26 and Microsoft Excel was used for data analysis.

Table No.1 includes the topmost 13 factors considered for further analysis after screening

Table No 1 Details of topmost identified factors.

Sr No	Identification of Factor	Factor
1	X_1	Availability of new equipment for the work
2	X_2	Continuous communication of the managers to the workers.
3	X_3	School facility for the children
4	X_4	Facilities like Medical, Canteen etc. are available at the site.
5	X_5	Lunchroom, the medical facility provided
6	X_6	Security provided at the labour camp
7	X_7	Slight increase in wages at the other side(migration of workers)
8	X_8	Labours having musculoskeletal problems?
9	X_9	Weather conditions
10	X_{10}	The temperature of the site is suitable for work?
11	X_{11}	Personal protective equipment (PPE) are provided to the workers.
12	X_{12}	Working the shifts?
13	X_{13}	The equipment working at the site are safe to work with?

4. Correlation matrix for the attributes

Following correlation is observed in the factors. The analysis is done by dividing the topmost 13 factors into four groups based on the different facilities, services and opportunities provided for the workers. Finally, to check the interdependence of these factors, the Pearson Correlation coefficient has been calculated for different groups. The analysis reveals that all factors involved in the study have a great impact on the productivity of the construction site. If these facilities are not provided in a proper and sufficient manner then it may result in a decrease in productivity.

Following Table No 2 shows the group formed for the analysis and formed and details about the thinking the process behind the formation.

Table No.2 Details about the groups.

Sr. No	Group No	Group Members	Remark
1	I	X_1, X_6, X_{11}, X_{13}	This group is formed by considering the availability of facilities like new equipment for the work, security provided, personal protective equipment; equipment working at the site is safe.
2	II	X_2, X_7, X_{12}	Group II comprises of the facilities like; proper communication of managers to the workers, migration of workers and working in shifts.
3	III	X_3, X_4, X_5, X_8	Group III is formed by considering health, food, hospitality and hygiene facilities like school facility for the children, Canteen, toilet, wash places, Lunchroom, medical facility etc.
4	IV	X_9, X_{10}	Group IV is formed by considering the suitable weather conditions available for the workers.

Table No 3 Shows Person correlations between the factors which are formed as per the reference given in table no 2.

Table No 3. Pearson Correlation between the factors in the group I, II III & IV.

	X_1	X_6	X_{11}	X_{13}
X_1	1			
X_6	0.3850	1		
X_{11}	0.1056	0.7858	1	
X_{13}	0.1073	-0.3855	0.4671	1

Group-I

	X_2	X_7	X_{12}
X_2	1		
X_7	-0.5521	1	
X_{12}	0.015	0.5263	1

Group- II

	X_3	X_4	X_5	X_8
X_3	1			
X_4	0.0523	1		
X_5	-0.5928	0	1	
X_8	-0.0863	0.7704	-0.0191	1

Group- IV

	X_9	X_{10}
X_9	1	
X_{10}	-0.80	1

Group-III

5. Regression Model

In this research work, after finding the most affecting factors regression analysis is carried out and it was found that, best fit for the data in terms of a straight line which covers maximum values of the data set and the rest of the values are clustering near to the curve, which shows that the factors involved in the research are linearly related to each other and deviation among them can affect the productivity of the site.

The basic regression equation is given by, $y = b1_{X1} + b2_{X2} + a$

Following regression equations were generated between the factors and summarized in the As per the data obtained and correlation observed in the factors, Regression equations obtained for three groups and summarized in Table No.4.

Table No 4. Regression equations obtained for three groups

Sr. No.	Factors	Regression equation
1	Between X9, X10 & X7	$y = -0.01902X1 + 0.0348X2 + 73.79229$
2	Between X1, X13 & X7	$y = -0.0511X1 + 0.08062X2 + 72.53072$
3	Between X3, X4 & X7	$y = 0.0208X1 - 1.1311X2 + 162.5842$

F test results are summarized in the following table No 5 Here the difference between the standard deviation (S) of the Site A and Site B populations is not big enough to be statistically significant. i.e. The sample standard deviation (S) of Site, A population is considered to be equal to the sample standard deviation (S) of Site B population. So, it can be accepted that the null hypothesis i.e. difference between the opinion of facilities and services provided for both the survey is not considerable.

Table No 5 Details about the F Test, and analysis of variance.

Predictor	Coefficient	Estimate	Standard Error	t-static	p-value
Constant	$\beta 0$	162.5842	40.5945	4.0051	0.0279
X_1	$\beta 1$	0.0208	0.2324	0.0897	0.9342
X2	$\beta 2$	-1.1311	0.4843	-2.3356	0.1016

1.	R-Squared:r^2 =0.6452
2.	Adjusted R-Squared: r^2_{adj} = 0.4087
3.	Residual Standard error: 5.4464 on 3 degree of Freedom.
4.	Overall F-Statistic:2.7279 on 2 and 3 degree of freedom
5.	Overall P-value: 0.2113

Analysis of variance table

Source	df	SS	MS	F-statistic	p-value
Regression	2	161.842	80.921	2.7279	0.2113
Residual error	3	88.9914	29.6638		
Total	5	250.8333	50.1667		

Conclusion

This research identified the following points,

1. In group-I, a strong correlation (0.7858) between Personal protective equipment (PPE) is provided to the workers. & security provided at the labour camp. This shows the negligence of security at the entrance of the construction site. This need to be improved,

2. In group-III, a strong correlation was observed between the factors labours having musculoskeletal problems and facilities medical like Canteen, toilet, wash places shall be provided. This shows that workers do not feel comfortable on construction sites.

3. The variance between both surveys is not big enough to be statistically significant. So, Based on the survey it was concluded that different parameters of the construction site are on an average of 60 to 65% reliable or satisfactory.

4. r^2 value is obtained as 0.6452 shows considerable relationships between the considered factors.

5. In the literature survey the major focus was given towards the points like material management, coordination, improper planning but in this study, the major focus was given towards the identification of the factors contributing to the improvement of supporting facilities to the construction workers. It is concluded that, if required facilities are provided to them and this results in improvement of productivity at the construction site.

Future Scope

In this research work, the work is carried out without considering the gender. But it was observed that the problems faced by males and females are somewhat different, so the work can be carried out in that direction also.

Reference:

1. Anu V. Thomas and J. Sudhakumar,(2014) "Modelling Masonry Labour Productivity Using Multiple Regression", 30th Annual ARCOM Conference, 1-3, Portsmouth, UK, Association of Researchers in Construction Management, 1345- 1354.

2. Surabhi Sengar,(2020), "Sensitivity analysis of a complex engineering system with the application of wait in line theory" Reliability Theory & Applications, No 4 (59), 2020, 27-34.

3. Homyun Jang, Kyonghoon Kim, Juhyung Kim,Jaejun Kim,(2011) "Labour productivity model for reinforced concrete construction projects", Construction Innovation,Vol. 11 No. 1,92-113.

4. Osama Moselhi and Zafar Khan,(2010) "Analysis of labour productivity of formwork perations in building construction", Construction Innovation,Vol. 10 No. 3, 286-303.

5. Panas, A. and Pantouvakis, J. P.(2010), "Evaluating Research Methodology in Construction Productivity Studies", The Built & Human Environment Review, Volume 3, Special Issue 1, 63-85.

6. Mohammed Hamza Momade, Shamsuddin Shahid, Mohd Rosli bin Hainin,Mohamed Salem Nashwan & Abdulhakim Tahir Umar,(2020) "Modelling labour productivity using SVM and RF: a comparative study on classifiers performance", International Journal of Construction Management, ISSN: 1562-3599,1-12.

7. Ehab A. Mlybari,(2020)" Application Of Soft Computing Techniques To Predict Construction Labour Productivity In Saudi Arabia", ISSN: 2186-2982 (P), International Journal of GEOMATE, Vol.19, Issue 71, 203 – 210.

8. Sasan Golnaraghi, Zahra Zangenehmadar , Osama Moselhi, and Sabah Alkass,(2019) "Application of Artificial Neural Network(s) in Predicting Formwork Labour Productivity", Hindawi,Advances in Civil Engineering,Volume, Article ID 5972620, 1-11.

9. Hemanta Doloi, Anil Sawhney, (2012) K.C. Iyer , Sameer Rentala, Analysing factors affecting delays in Indian construction projects, International Journal of Project Management 479–489.

10. Lingguang Song, M.ASCE; and Simaan M. AbouRizk, M.ASCE, (2008) Measuring and Modeling Labor Productivity Using Historical Data, Journal of Construction Engineering And Management, , 134(10): 786-794

11. Abraham Assefa Tsehayae, and Aminah Robinson Fayek,(2016) "Developing and Optimizing Context-Specific Fuzzy Inference System-Based Construction Labor Productivity Models", J. Constr. Eng. Manage.,. 142(7): 04016017

12. Argaw Tarekegn Gurmu,(2019) "Tools for Measuring Construction Materials Management Practices and Predicting Labor Productivity in Multistory Building Projects", J. Constr. Eng. Manage., , 145(2): 04018139.

13. Argaw Tarekegn Gurmu, and Citra S. Ongkowijoyo,(2020) "Predicting Construction Labor Productivity Based on Implementation Levels of Human Resource Management Practices", J. Constr. Eng. Manage,146(3): 04019115.

14. Ugulu, R., Arewa, A. & Allen, S. (2019), " Relationship between labour productivity and curved wall construction in high-rise building projects", 35th Annual ARCOM Conference, 2-4, Leeds, UK, Association of Researchers in Construction Management, 125-133.

15. Farnad Nasirzadeh, Mozhdeh Rostamnezhad, David G. Carmichael, Abbas Khosravi & Brad Aisbett,(2020) "Labour productivity in Australian building construction projects: a roadmap for improvement", International Journal of Construction Management, ISSN: 1562-3599 (Print) 2331-2327 (Online), 1-9.

16. Nurulzatushima Abdul Karim ,Siti Hafizan Hassan ,Juzailah Nur Yunus, Mohamad Zain, Hashim,(2012), Factors influence labour productivity and the Impact on construction Industry",Awam International Conference on Civil Engineering (AICCE'12),Geohazard Information Zonation (GIZ'12),Park Royal Penang Resort 28 th – 30 th August 2012, 724-732.

17. Yasser S. Nassar and Tareq A. Khaleel,(2019) "Building Model To Predict Labour Productivity Using Multiple Linear Regression Technique For "Formwork Concrete Columns",Kufa Journal of Engineering,Vol. 10, No. 2, 12-26

18. Jisha Chakkappan , Lakshmi G Das,(2016) "Labour Productivity Analysis Using Multi-variable Linear Regression Technique",International Research Journal of Engineering and Technology (IRJET),Volume: 03 Issue: 09, 870-872.

19. İbrahim Halil Gerek , Ercan Erdis , Gulgun Mistikoglu, Mumtaz Usmen,(2015), "Modelling Masonry Crew Productivity Using Two Artificial Neural Network Techniques",Journal Of Civil Engineering And Management ISSN 1392-3730 / eISSN 1822-3605, Volume 21(2): 231–238.

20. Jin Hong Wong, Ali Rashidi,and Mehrdad Arashpour,(2020) "Evaluating the Impact of Building Information Modeling on the Labor Productivity of Construction Projects in Malaysia),2020, Article-Building (MDPI),Buildings, 10, 66; doi:10.3390/buildings10040066.

21. K. Choi and M. Haque,H. W. Lee,Y. K. Cho,Y. H. Kwak, (2013),"Macroeconomic Labor Productivity and Its Impact on Firm's Profitability" Journal of the Operational Research Society, 1-22.

22. Rahul S.Chaudhari, Dr.P.P.Bhangale,(2020) "Factors Affecting Labour Productivity in Building Construction Sector, An Analysis by Relative Importance Index Method", Wutan Huatan Jisuan Jishu, ISSN:1001-1749, Volume XVI, Issue IX,1-9.

Declarations

1. **Funding** 'Not applicable'

2. **Conflicts of interest/Competing interests** 'Not applicable'

3. **Code availability** 'Not applicable'