

A REVIEW ON PRODUCTIVITY IMPROVEMENT IN CONSTRUCTION INDUSTRY

Shinde V. J.¹, Hedao M. N.²

¹ Research Scholar V. J. Shinde, Civil Engineering Department, Government College of Engineering, Karad, India

² Associate Professor M.N. Hedao, Civil Engineering Department, Government College of Engineering, Karad, India

Abstract - The productivity level of construction industry is mostly depending upon three factors they are labour characteristics, management systems and external issues. Different researchers have determined different factors that influence construction productivity. Understanding the level of productivity, it is important to develop innovative practices to improve construction productivity. This paper includes systematic literature reviews on productivity in construction industry the paper gives an review on different method which are used for measurement of construction productivity, factors affecting and theories on improvement of construction productivity such as labour factor, management factors and external factors, the paper further reviews on the different innovations which are made for improvement in construction productivity. On reviews it is noted that there are lot of different methods and strategies for improvement of construction productivity but they differs from site conditions and the factors which influence construction productivity.

Key Words: Labor¹, productivity², Management³, Construction⁴, Thermal environment⁵, Materials tracking⁶, Motivation⁷, Safety⁸

1. INTRODUCTION

Construction industry is world's most largest and challenging industry. Human resource has a strategic role in increasing productivity in construction industry. With the effective and optimum use of human resources can help in productivity growth. The construction projects are mostly labour based with basic use of hand tools and equipment's in which labour cost consists of about 30% to 50% of total project cost [1] (Vekaria, S.G.). Indian construction industry is one of fastest growing sector globally. The construction sector gives second largest employment after agriculture. India shares about 8% of total GDP and also provides employment to around 35 million peoples directly or indirectly [2] (Yogendra kumar et al, 2013). In construction industry one of the biggest problems faced is of unskilled labour which implies in productivity loss and impacts on cost overrun and schedule daily. Labour productivity is one of important factor which affects physical progress of construction project. To perform effective job, construction labour should be familiar with materials, tools and machineries that they use.

Many researchers have shown that poor construction management practices leads to poor performance, wastage

of efforts in different phases of construction projects. Researchers tried to overcome some of challenges by adding their efforts in construction project, however many problems are yet to be solved in terms of construction productivity. Identifying and analyzing the critical factor that influence construction productivity will lead to develop most effective method and strategies to improve the construction productivity in upcoming time [3] (Gorge Jergeas et al, 2004).

Construction project is said to be successful if it is completed in schedule duration and estimated cost. For that purpose productivity has to be efficient. Productivity forecasting plays an important role in strategic and operational planning. Quantitative forecasting is used for decision making process for many of complex situations [4] (Mohamed and srinavin, 2005)

Site productivity is one of difficult factor for measurement because they can be determined significantly depending upon size of site and place of measurement. Some of researchers have determine the method of measurement and analysis of site productivity for setting baseline and for the improvement of construction productivity, some of them are average labour productivity (ALP), one factor input, total productivity (multifactor), work measurement, cycle time etc. site material management can largely affect site productivity, the new automated Technologies have been emerged such as Global positioning system (GPS) and radio frequency identification (RFID) which can help in improving productivity in Material Management [5] (David Grau et al, 2009).

1. METHODS OF MEASUREMENT OF PRODUCTIVITY

[6] Murodif atfal et al (2016) research objective was to analyze the productivity with the help of work sampling method. Their data sampling method was

- 1) To classify workers activities in three groups (effective work, essential contributory work, and inefficient work)
- 2) Collection of data from field observation results in particular order.
- 3) Taking randomized observational result data.
- 4) Then checklist is created for the workers activity.
- 5) Add all checked workers activities and then percentages calculation.

Then after labour utilization rate (LUR) is calculated in percentage. The results of LUR analysis where obtained was for formwork it was 47.32%, for reinforcement it was 43.17% and for concreting it was 49.76%. The total value of LUR of all three works was 45.60%. [7] Nazarko and Chodakowska (2015) presented an article on use of DEA and Tobit regression for productivity analysis. They calculated labour productivity with the help of DEA method, change in efficiency over the period of 2006-12 was calculated by malmquist index & Tobit regression explores the impact on an economic performance of labour productivity. DEA model was built on assumption that has min input value for input & max output value for outputs. They concluded that multistage combination of non-parametric DEA malmquist index & parametric regression model has allowed to adjust DEA score and opened more new possibilities of research. Malmquist index found possible new technologies change in analysis period. They also found that regression analysis calculation of efficiency scores without having general economic conditions can lead to inappropriate decisions. Reliable monitoring of performance change allows identifying better practices & perfect decision making.

[8] Tarek M. Zayed et al (2005), [9] Shashank K. et al (2014) they put a theoretical model for productivity improvement as reliability analysis, factor analysis, and multiple linear regression analysis. They conducted a questionnaire survey in which they got 53 responses out of 60 questioners after that reliability analysis was conducted to find out average correlation between data the method used for that is split-half method. Then factor analysis that is statistical technique which identifies the common component then followed by multiple regressions & hypothesis testing. On the above study they concluded that there are eight independent groups that affect labour productivity namely manpower group, managerial group, environment group, motivation group Material, equipment, schedule, safety group & quality group. [10] Jiali Liu et al (2014) Provides comprehensive & review of validation methodologies for productivity research the data collection was done using telephone, mail(post), online surveys, personnel interviews & field survey then functional demonstration of algorithm, modeling & simulation then secondary data analysis as archival data analysis. Finally comparison of validation methodology is used in CEM. The conclusion they made was to have an impact on field the researchers must understand respective structures, trends, & validation requirements. They found that 95% of confidence level is achieved by functional demonstration of validation methodology.

[11] Dolage & chan (2013) Main objective was to measurement of productivity & finding the casual relationships with productivity they studied old articles & they found that

- 1) What type of productivity is being examined?
- 2) At what level productivity is examined.
- 3) Data collection method approach.
- 4) Main objectives of investigation.

They found that research objectives are of six different groups as measurement, assessment of improvement, identification & ranking of factors, influence & relationship. They concluded that there is a lack of positive approach in the earlier research & the methodologies that are used are not up to date for exact findings. [2] Yogender Kumar et al (2013) their main aim was to analyze the labour productivity & relation between direct works in small construction project. Data collection was done by personal interviews with onsite personnel work sampling. Work measurement and actual observation on site. The work sampling was done for 2 hrs. With 2 min interval from that they got crew work sampling data, percentage of direct & indirect & work not done time. The result they got was 32 to 44.6% of direct work done, 40.4 to 44% of indirect work-done & 15 to 24 % of no-work done. They concluded that the percentage of no work done can be reduced by using skilled worker in place of unskilled one & from that the productivity can be improved.

[4] Mahamed S. & Srinavin k. (2005) They used PMV index model for productivity forecasting for developing of PMV model there is combination of Arousal theory (effect of physical environment on productivity) & first law of thermodynamics (thermal balance between human body and environment). PMV value requires large amount of data. So 200 datasets which represents seven different construction activities were taken (manual execution, steel erection, masonry, electrical, carpentry, labour & equipment operating). then the comparative analysis was done of Koehn's & Thomas models & they found that productivity prediction using PMV model gives high value below 15°C and lowest value above 35°C. They concluded that heavy rain can stop the work & that can be predicted in schedule but thermal variation; reduces the labour efficiency which can be effectively predicted by using PMV model.

2. FACTORS AFFECTING PRODUCTIVITY

2.1 Management

2.1.1 Management System

The Decision making on the site is as important of actual construction work. So for high productivity proper decisions should be taken. [12] Fulford & standing (2013) focused on collaborative practices in construction for activity productivity. They selected a government project as a case study. They found that a single company has some strength & weakness in process. And other companies are very good at their weakness so the decision was taken to make collaboration between different companies to achieve productivity but they do found some limitation in this decision that there are many controversies between different companies & may face project breakdown. [13] Ranasinghe upul et al (2012) created a new framework to improve productivity on site to make process more sustainable, systematic & accountable. They planned to appoint a decision maker on site as a construction productivity improvement

officer (CPIO). The officer will identify the problems on site & find the solution at the same time. The decision will be implemented for 10 week cycle & if the decision gives good impact on decision than it will be implemented for the further process in the case study they found 6.72% of time saving.

[14] Oral mustada et al (2011) presented supervised vs. supervised learning for crew & in supervised learning they used neural networks as decision making as

- 1) Feed forward back propagation (FFBP)
- 2) General regression neural networks (GRNN)
- 3) SOM.

Which has a great accuracy they found that artificial support system predicts the accurate solution of the problems on site. They found that self-organizing map has a great performance than (FFBP) & GRNN for crew productivity. George Jergeas et al Conducted an pilot study with 20 industry experts in which they found 35 factors that affect productivity which are related to management and much of factors that are related to poor decision making, poor inspection, discontinuity in crew makeup, multiple shifts out of sequence work etc. in which they found that lack of detailed planning is most critical factor for that they developed an best practices practical guide for improvement of productivity on construction site. [15] William lbbs et al & [16] Beza Abbasnejad put a concept of loss of productivity they used mechanical contractor association of America product of loss of productivity (MCAA). They found 16 different factors which are evolved in loss of productivity. They found that 30% of the productivity loss due to excessive working hours, overcrowding & material & storage & they came of conclusion that concentrating on few factors can get high productivity.

2.1.2 Design

[17] Edgar & Morwar (2016) had concentrated on jobsite design, in which they discussed on temporary facilities, construction equipment, material storage areas, workplaces, access roads, site objects. They used rule thumb, Ad-hoc approach & first come-first serve technique while designing they concentrated on contractor (39%), consultant (30%) & designer (26%). The priority is mainly given to tower crane location vehicular access and material storage locations. Wiesel & aztemir (2004) used 2 concepts

- 1) Index of complexity (IC)
 - 2) Work load indicator (WLI).
- To resolve the Design complexity as they compared

2D & 3D design they found that 2D design increases 5% of designing time but reduces time spend on engineering by 15%, reduces installation time by 15%, reduces installation time by 5-20% & about 35% of the time reduced by change order.

2.2.3 Material

Material management is a worldwide problem & research is going on which highlights effects on site productivity. [5] David grau et al (2009) Studied on impact on productivity due to atomization in identifying & localizing the components on site. They recorded the time taken for traditional site material tracking process & the same process. Using radio frequency identification (RFID) & global positioning system (GPS). The time taken by traditional process was 36.80 minutes for 400 steel components whereas automated tracking process took 4.56 minutes. The total number of unidentified components was 36 in traditional (9.52%) & 2 in automated (0.54%).

2.1.4 Variation order

The variation affects efficiency of workers by rework, disruption & presence due to change work. [18] William lbbs (2012) had studied on variation order they collected the database from 226 projects. The data was containing original cost, estimated labour hours and original duration. They recognize the average amount of change in projects was 8%. This figure was obtained by labour hours. They found that average PI (planned productivity divided by actual productivity) was 0.82 meaning an 18% of total loss of productivity they concluded that the projects having small amount of change can cause worse cost and drastic change in schedule performance than budgeted.

2.2 Labour

2.2.1 Lack of Measurement

There are many labour factors that affects construction project. For improvement of labour productivity the activities on site should be measured and record should be kept on regular basis and should always be compared with a standard acceptable benchmark. This will give a proper baseline productivity of previous projects having same conditions. [19] Rateb J. sweis et al. (2009) do agrees that such records are used for estimation of labour productivity in the upcoming projects. They also distinguished the labour in different ranges and set baseline for that Rangers. They use the record for improving the productivity in different ranges by solving the labour problems. They concluded that the proper measurement and record keeping can improve productivity. According to [20] Mostafa E. Shehata et al. (2012) measurement is very important part of productivity improvement. They used project management index (PMI) as state of the art technique for productivity measurement. They mostly focused on work load and work output. And they found that project management index is a proper productivity measurement tool which can give accurate measurement details. [21] Attar A.A. et al says that lack of measurement is main problem involved in productivity improvement. They focus on obtaining data from inputs and outputs to evaluate change in productivity. From that

difference they focus on the important factor which affects the productivity. And resolve that problem using different methods.

2.2.2 Motivation and Safety

The lack of motivation in workers will leads to take them in anti-work behaviors which leads to negligence of their duties, coming late to work, failures to meet deadlines, absentees, frustrations on job site which affects the labour productivity. [22] Khan Ahsan Ali (2015) conducted a questioner survey in which they conducted four tests

- 1) Data reliability and validation.
- 2) Interpretation of motivational factor.
- 3) Shapiro wilk test
- 4) Kruskal Wallis test

And they found that many of organizations are not interested in motivating their workers, which affects their productivity and they conclude that the basic motivational facility should be provided for enhancing the labour productivity. The construction site where are the safety measures are not used face the productivity problems [23] Shree raja gopal .T.G and Murali K. conducted secondary data analysis which consists of

- 1) Constant comparison analysis,
- 2) Classical content analysis,
- 3) Domain analysis.

From that they found that ignorance of safety precautions, inadequate light, doesn't have safety Engineer at site causes accidents which causes productivity loss.

2.2.3 Skills and Ability

The personal attributes of workers contributes more of the factors that directly affect the productivity. The factors are as.

- 1) Worker skills, experience, training and qualification,
- 2) Physical and mental ability,
- 3) Use of both skills and ability for the production process.

High skilled workers can achieve high ability than unskilled workers. [24] Laura florez (2016) collected the multiple Masons having different skills, personalities and capabilities for a Complex masonry job. They were implied to do job for several days. And she got a conclusion as the different skills of workers balance the complexity characteristics of those jobs on site.

[25] Ghate prachi .R et al and [26] Mistry R.B. et al both the papers states that skills and ability of workers are main factors that affect productivity. They conducted study on columns construction in which the same work was given to skilled and unskilled workers and cost comparison was carried out. The results were skilled labours reduce the time

by 5 days and labour cost by 45600/- for the same work. Gupta .V and Kansal .R conducted and questionnaire survey of 37 construction industries and by using relative importance factor (RIF) found that 69.72% of skill and ability factors affects the productivity. There is increase in demand of skilled labour due to use of latest technology on construction sites as computerized and Hi-tech machines and plants increase productivity.

2.3 External issues

There are some other issues than labour and management that harms productivity in high manner, such as social factor, economic factor, weather conditions, labour unions, legal issues etc. [27] Xiaodong li et al. (2016) had studied on high temperature stress on labour productivity. They collected data in two phases first in June for 27days and in July-August for 27 days by taking eight rebar workers for field measurements with grate Body Mass Index (BMI). The readings were taken at every 10 minutes interval with temperature checks. The results were found that 7:00 to 8:00 time shows lowest day temperature of 24.72o c and 14:00 to 15:00 shows 28.88o c. From above they found that period of 7:00 to 9:00 is safest time to work. 7:00 to 8:00 shows 3.57% hazards and 8:00 to 9:00 shows 7.14% hazards which are safe, but the period of 14:00 to 15:00 most hazardous and dangerous time which shows 57.14% of hazards.

Abrey and smallwood had a descriptive survey at east cap master builders association (ECMBA). Their silent findings were excessive noise level, non-achievement of quality, material shortage etc. the data collection was conducted by questionnaire survey. The questionnaire list was sent by post or emails. Their research findings were Poor health and safety which increases accidents. Unsatisfactory working conditions as high noise level, high temperature result in productivity loss. Over exposure to harsh environment causes dehydration. They concluded that unsatisfactory site conditions lead to increase the probability of Health and safety hazards. [28] Naoum et al and [29] Alinaitwe et al reviewed papers related to environmental and external issues that affect productivity. In which they found that Harsh working condition, economic conditions and social factors affect construction productivity. They also found that technology changes and weather changes also affects the productivity.

3. CONCLUSIONS

From the above literature it is concluded that there are many methods of increasing productivity in construction industry. There is enormous study on the methods which improve the productivity which consists of material tracking, healthy and safe working condition and effective management systems.

It is seen that some methods are more efficient in the context of increasing productivity like

1. automatic materials tracking
2. work sampling method
3. collaboration between industries
4. construction productivity improvement officer

There is a need for exploring more efficient strategies for improving the productivity. It has been noted that increasing the productivity by such above methods have reduced cost and time but haven't create an effective baseline in the field of construction industry.

REFERENCES

- [1] S. G. Vekaria "Labour Productivity in Construction " www.ijaresm.net ISSN: 2394-1766
- [2] Yogendra Kumar, "Productivity Analysis of Small Construction Projects in India" Asian journal of applied sciences, 2013, ISSN: 1996-3343, 2013 PP-1-6.
- [3] Markus Liberda, Janaka Ruwanpura and George Jergeas "Construction Productivity Improvement: A Study of Human, Management and External Issues" ©ASCE 2003 PP 524-531
- [4] Sherif Mohamed, Korb Srinavin "Forecasting Labor Productivity Changes in Construction Using the PMV Index" International Journal of Industrial Ergonomics 35, 2005, pp- 345-351
- [5] David Grau, Carlos H. Caldas " Assessing the Impact of Materials Tracking Technologies on Construction Craft Productivity " Automation in Construction 18, 2009, pp- 903-911
- [6] Atfal Murodif, Erizal " Measurement of Productivity Using Work Sampling Method at Menara Sentraya building Project Jakarta Indonesia" Scholars Journal of Engineering and Technology (SJET) ISSN 2321-435X (Online) Sch. J. Eng. Tech, 2016, pp-244-248
- [7] Joanicjusz Nazarkoa, Ewa Chodakowskaa, "Measuring productivity of construction industry in Europe with Data Envelopment Analysis", Procedia Engineering, Vol. 122, 2015, pp. 204 – 212.
- [8] Tarek M. Zayed and Daniel W. Halpin "Productivity and Cost Regression Models for Pile Construction" Journal of Construction Engineering and Management Vol. 131, No. 7, ©ASCE, ISSN 0733-9364 July 2005, pp. - 779-789
- [9] K. Shashank, Sutapa Hazra " Analysis of Key Factors Affecting the Variation of Labour Productivity in Construction Projects " International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com ISSN 2250-2459, Volume 4, Issue 5, May 2014 pp-152-160
- [10] Jiali Liu, Arash Shahi "Validation Methodologies and Their Impact in Construction Productivity Research" Journal of Construction Engineering and Management, © ASCE, ISSN 0733-9364/04014046
- [11] A. R. Dolage, and P. Chan. "Productivity in Construction-A Critical Review of Research" ENGINEER - Vol. XXXXVI, No. 04, 2013, PP. 31-42
- [12] Richard Fulfordand, Craig Standing "Construction Industry Productivity and the Potential for Collaborative Practice" International Journal of Project Management accepted 23 May 2013 PP 1-12
- [13] Upul Ranasinghe, Janaka Ruwanpura "Streamlining the Construction Productivity Improvement Process with the Proposed Role of a Construction Productivity Improvement Officer" Journal of Construction Engineering and Management, Vol. 138, No. 6, June 1, 2012. ©ASCE, ISSN0733-9364, 2012 PP 697-706
- [14] Mustafa Oral, Emel Laptali Oral "Supervised vs Unsupervised Learning for Construction Crew Productivity Prediction" Automation in Construction, 22, 2012, pp-271-276.
- [15] William Ibbs and Xiaodan Sun "Use of Mechanical Contractors Association of America Method in Loss of Productivity Claims" J. Leg. Aff. Dispute Resolut. Eng. Constr. © ASCE 01816001-1, 2016
- [16] Behzad Abbasnejad "A Review of Challenges Associated with Productivity in Construction" International Journal of Engineering Research and Development e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com Volume 8, Issue 3, August 2013, PP.37-40
- [17] Edgar P. Small, Marwa Baqer "Examination of Job-Site Layout Approaches and Their Impact on Construction Job-Site Productivity" Procedia Engineering 164, 2016, pp.- 383 – 388
- [18] William Ibbs "Construction Change: Likelihood, Severity, and Impact on Productivity" Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, Vol. 4, No. 3, ©ASCE, ISSN 1943-4162, 2012, pp-67-73
- [19] Rateb J. Sweis and Ghaleb J. Sweis "Modeling the Variability of Labor Productivity in Masonry Construction" Jordan Journal of Civil Engineering, Volume 3, No. 3, 2009, PP 197-212
- [20] Mostafa E. Shehata and Khaled M. El-Gohary "Towards improving construction labour productivity and project's performance" Alexandria Engineering Journal, accepted 5 February 2012, PP 321-330
- [21] A .A. Attar, Gupta A. K. ,Desai D. B. "A Study of Various Factors Affecting Labour Productivity and Methods to Improve It" IOSR Journal of Mechanical and Civil

- Engineering (IOSR-JMCE) ISSN: 2278-1684,2014 PP: 11-14
- [22] Ahsan Ali Khan and Sadia Ajmal "Role of Management in Motivating Labor to Improve Labor Productivity" Journal of Advanced Management Science Vol. 3, No. 3, September 2015, PP179-185
- [23] Shree Raja T.G. Gopal, k. Murali "Secondary Data Analysis on Factors Affecting Labour Productivity in Construction" International Journal of Scientific and Research Publications, Volume 6, Issue 5, May 2016 ISSN 2250-3153 PP 401-405
- [24] Laura Florez, Jean C. Cortissoz "Defining a Mathematical Function for Labor Productivity in Masonry Construction: A Case Study" Procardia Engineering 164, 2016, pp-42 – 48
- [25] Prachi R. Ghate and Pravin R. Minde "Analysis of Labour Productivity in Construction Sector around Mumbai region" International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169 Volume: 4 Issue: 6 June 2016 PP 555 – 557
- [26] Rajen B. Mistry, Vyom B. Pathak "Assessment of Factors Affecting the Labour Productivity in Building Construction Project" www.ijaresm.net ISSN: 2394-1766
- [27] Xiaodong Li, Kwan Hang Chow, Yimin Zhu, Ying Lin "Evaluating the Impacts of High-Temperature Outdoor Working Environments on Construction Labor Productivity in China: A case study of rebar workers" X. Li et al. / Building and Environment 95 (2016) PP 42-52
- [28] Shamil Naoum and Daniel Fong "A New Framework for Determining Productivity Factors On Construction Sites" PDF, PP 109-121
- [29] Henry Alinaitwe and Jackson Mwakali "Labour Productivity in the Building Industry" <https://www.irbnet.de/daten/iconda/CIB6202.pdf> Date- 11/08/2017
- [30] Adnan Enshassi, Bernd Kochendoerfer and Karem Abed "Trends in Productivity Improvement in Construction Projects in Palestine" RIC Vol 28 Acceptation: 20/06/2013 PP 173 -206
- [31] Avi Wiesel and Ali Erhan Oztimir "The Influence of Design Methods on Construction Productivity" Construction Research Congress, © ASCE
- [32] Hee-sung park, Stephen R. Thomas and Richard L. Tucker "Benchmarking of Construction Productivity" Journal of Construction Engineering and Management, Vol. 131, No. 7, ©ASCE, ISSN 0733-9364, 2005, PP -772-778
- [33] Jan Brochner and Thomas Olofsson " Construction Productivity Measures for Innovation Projects" Journal of Construction Engineering and Management, Vol. 138, No. 5, ©ASCE, ISSN 0733-9364,2012, PP-670-677
- [34] KaWah (Calvin) Chui "On-Site Labor Productivity Measurement for Sustainable Construction" ASCE 2012 ICSDC 2011 pp 335-342
- [35] Serdar Durdyev, Syuhaida Ismail, and Nooh Abu Bakar "Construction Productivity in Turkmenistan: Survey of the Constraining Factors" International Journal of e-Education, e-Business, e-Management and e-Learning, Vol. 3, No. 1, February 2013 PP 18-23
- [36] Vaishant Gupta, R. Kansal "Improvement of Construction Labor Productivity in Chambal Region" IJRET: International Journal of Research in Engineering and Technology ISSN: 2321-7308 Volume: 03 Issue: 10 Oct-2014, PP 34-37
- [37] Reza Akhavian and Amir H. Behzadan "Productivity Analysis of Construction Worker Activities Using Smartphone Sensors" http://www.see.eng.osakau.ac.jp/seeit/icccbe_2016/Proceedings/ Full_Papers/ 135-060.pdf Date- 07/08/2017