Review on Factors Influencing Labour Productivity in Construction Project

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Abstract:--- Productivity in a construction project closely related to the labour. The productivity of construction industry has a significant impact on the cost and profitability. A variety of previous studies on the identification of the factors that affect construction labour productivity (CLP) has been carried out by researchers in many countries. This study aims to critically examine the factors that influence labour productivity and classify these factors into groups of factors based on previous studies. Drewin's Open Conversion System is a theoretical framework used to classify those factors in this study. Based on this theory, there are three key factors, namely input, internal environment and exogenous. The input category consists of labour, finance, material, and equipment. Design, health and works safety, supervision, organization, scheduling, project, leadership and coordination, management, motivation, technology, socio-psychology, communication are the internal environment category. The exogenous category includes weather, government regulations, site conditions, economic conditions and public. In this critical review, 175 factors have been identified affecting the productivity of construction labour which is classified in the framework of the Drewin theory.

Keywords: Construction, labour, productivity, CLP, review.

I. INTRODUCTION

The construction industry in Indonesia is growing rapidly from year to year. This industry not only supports other industries but also contributes globally to economic growth. The construction industry accounts for 10% of national income in developing countries [1]. Based on data from Indonesia's statistical center, for the last five years, from 2013 to 2017 the construction industry in Indonesia contributed more than 10% of gross domestic product from the total national income and this value is expected to increase every year. Therefore, the construction sector is a sector that must be taken into account in developing countries, especially in Indonesia. However, in spite of the economic support in developing countries, the construction industry still confronts problems in low productivity, limited mechanism and inexperienced and unprofessional labour [2]. The main problem that must be solving in the construction industry is productivity both in performance and standards [3].

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Productivity is one of the crucial problems that must be considered in the construction industry, because productivity is used to measure the efficiency of a construction project. The construction industry is defined as a labour-intensive industry [1],[4]. The cost spent on labour are 30% to 50% of the total project costs [5]. Due to the significant influence of construction labour productivity towards the project cost and the profitability of construction companies will ultimately affect the completion of the project [6]. Thus, productivity improvement in the construction industry continues. However, to increase the productivity, the construction workforce needs an improvement strategy. One of these strategies is to understand the parameters of both factors and practices that can give the influence and measure how much influence of these factors and the practices on the construction labour productivity [7]. Currently the topic for Construction labour productivity is widely researched in various countries in the world. Since in the construction industry, labour productivity is the major source of construction risk, and the construction labour productivity is the biggest variable compared to other construction resources [6]. In addition, the improvement of construction labour productivity will contribute significantly to the state income. The understanding, reviewing and evaluating factors that affect the labour construction productivity is an important issue in research and for industrial practitioners [1]. Therefore this study aims to critically examine the factors that influence labour productivity and classify these factors into groups of factors based on previous studies conducted earlier in various countries, especially in developing countries, which this category later will be beneficially use in construction of building projects in Palembang, South Sumatra, Indonesia.

II. LITERATURE REVIEW

A. Definition

Productivity in general is used to describe the relationship between output and related input used in production process [8],[9]. [10] defines productivity as the amount of goods and services produced by productive factors in unit of time. In other words, according to [11] productivity is defined as the ratio of output quantity to quantity of inputs. In short, based on previous research construction labour productivity is defined as achieved working units (output) divided by working hours (input) to produce high productivity and the efficiency of the factors that affect productivity, which is by intensive use of scarce resources that convert inputs into

outputs. Therefore the measurement of efficiency according to [10] is stated in the following equation:

$$Efficiency = \frac{Output}{Input} \qquad (1)$$

However, if all inputs are rated (labour, equipment, material, energy, capital, etc.) then the Total Productivity Factor can be calculated with the following equation [7],[10],[12]:

$$TFP = \frac{Total\ Output}{Labour+equipment+material+energy+capital+design} \qquad (2)$$

Hence to compare productivity, it is important to determine the measured input and output. Whether it measures the combined productivity of all input factors (labour, materials, equipment, capital, design, etc.) or measures one factor only..

B. Factors affecting construction labour productivity

Labour productivity in construction is a function of various different factors from each controlled and uncontrolled construction project [13]. By identifying the productivity influencing factors of construction labours, both factors which give positive and negative effects will improve productivity [14]. [15] Identified 5 factors which influenced construction productivity in wastewater treatment projects in Southern USA; labour skill and experience, job planning, worker motivation and material availability. The study found that the skills and experiences of the workforce were the most effectual factors on construction productivity in wastewater treatment projects [16]. Meanwhile, some studies in Turkey aimed to determine the influencing factors of productivity for construction workforce in Turkey. 82 construction companies in Turkey were involved in filling out the questionnaire. Based on literature study, 37 factors were determined and categorized into 4 factors, namely organizational, economical, physical, and socio-physiological factors. Furthermore, by using statistical analysis relative importance index, the study obtained 10 most influential factors. They were quality of site management, material management, on- time payment, systematic flow of work, supervision, site layout, work discipline, amount of pay, occupational education, training, and working in similar activities. In addition, [17] it was identified there were 15 factors that could affect labour productivity in Iran. The results showed that labour competency, poor decision making, work motivation, appropriate site layout, and proper planning were the most influencing factors of the construction labour productivity in Iran.

[18] These are the factors that influence construction labour productivity (CLP) in Palestine from contractor's point of view. There were 31 factors from 5 categories were identified to had influenced the construction labour productivity according to the Importance Index Analysis. The results showed that the top five factors that negatively affect labour productivity in building construction were: rework, lack of cooperation and communication between the construction labour, sx owner's financial status, inexperienced labour, and lack of material. Then [19] conducted study in India to identify the relative influence and basic relationship of productivity influencing factors in India using importance index analysis, frequency index and

severity index, and factor analysis of 44 from 10 identified factor categories. The results showed that the problems related to materials were the most critical factors that affect labour productivity in India. In addition, political and Hartart strikes, extreme weather, frequent image revisions, working shift and worker absence as the most common problem in construction projects in Kerala India.

[4] In Egypt identified 30 items on influencing factors of construction labour productivity. This study analyzed by using relative importance index analysis and showed that the labour' s experience and skills, incentive programs, materials supply and ease of handling, leadership and construction management competencies of labour supervision were the most influential factors in construction labour productivity. Furthermore, [20] identified 29 factors from 6 categories of construction major constraints in Malaysia. Using SEM, the final result showed a massive influence of management team's competence and labour quality could enhance labour productivity

C. Factor groups that influence the productivity of construction labour

Construction labour productivity is influenced by different factors from one project to another. Although some factors are found to have equal effect on the results of the productivity of given task, impact level on productivity can be different or varied [9],[21]. Based on previous research, the influencing factors of construction labour productivity were grouped into factor categories, and each factor category consists of factor an item that makes up the formation of categories. Category is a group of large factors made based on factor items which relates to one category. Therefore, the factor items that considered related to one category will be grouped into the same category.

No [22] classified influencing factors CLP in Indonesia into 15 factor category from 113 factors, namely design, execution plan, material, equipment, labour, health and safety, supervision, working time, project factors, quality, finance, leadership and coordination, organization, owner / consultant, external factors. Furthermore, [23] divided into four categories of factors which to identify and retain an influence on CLP, namely management, technology, human / labour and external. These 4 factors were the result of the distribution of 45 identified factors that affect CLP in Kuwait. Another study was conducted in Egypt by [4] about the CLP influencing factors in Egypt. Around 3 factor categories were accomplished, namely management, human / labour and industry. These three categories consisted of 30 influencing factors of labour productivity. [24] Identified factors that influence labour productivity in Gaza. To achieve this goal, 45 identified factors were grouped into 10 factor categories, namely man power, leadership, motivation, time group, material / tools, supervision, project, safety, quality, external. In 2013 [25] conducted research by identifying 23 factors that were considered to influence the motivation of mastercraftmans in carrying out their work. As the result, motivation category factor was the only factor used in this research.

A study conducted by [6] to identify the relevant major parameters to the analyzed context. Thus, to achieve this goal, it requires a critical and careful consideration of the parameters that affect the productivity of the construction labour, which are multilevel, complex and project / context dependent. From identification result, it was obtained 169 parameters (factors and practices) that concern the construction labour productivity. 169 Parameters were divided into six levels; activity, project, organization, province, national and global with 18 parameter categories and each parameter category was broken down into 169 parameters and adjusted according to classification level. On the activity level, the parameter category consists of workers & crew, materials & consumables, tools & equipment, property assignments, location properties, foremen, techniques & instructions. On the level category, the parameter consists of project & contract delivery, health, safety & environment, project management practices, project best practices, the character of project owner, project complexity, and project management. Lastly, on the organizational level the parameter category was the organization, and on the provincial category level the parameter category was the province, the national level with the national category, and the global category.

III. THEORETICAL FRAMEWORK OF FACTOR CATEGORIES THAT INFLUENCE THE PRODUCTIVITY OF CONSTRUCTION LABOUR

Theoretical framework is a schematic diagram which shows the relationship between interrelated variables and it will be used in this study. The theoretical framework in this study was established based on CLP influencing factors. The theoretical framework in this study was constructed by reading and understanding critically the previous research on the CLP influencing factors. Then, after obtaining this interpretation, these factors will be grouped into factor categories. In previous studies conducted by different researchers in different locations, found similar factors with similar meaning. Those factors will be combined into one and grouped under category factor to develop the theoretical framework of factor category.

This theoretical framework adopts Drewin's Open Conversion System (DOCS) as the basic of theoretical framework. This system was introduced by [10] which described the entire construction process. This system described the input and output of a construction process [26]. Based on DOCS this productivity is considered identical to production. The amount of production can be increased by enhancing one of the input factors. Therefore, it is important to determine the measured input and output in comparing productivity.

Figure 3.1 described the DOCS in the form of labour, capital, energy, material and equipment. To obtain output as product and project, accordingly through a conversion process related to complex construction, influenced by many connected factors and complex relation. In Figure 3.1 stated that to achieve the output, there is an internal environment after the input. In the form of organization structure, supervision, management, working rules, etc. Furthermore, there are some exogenous factor caused by elements beyond

the construction process though give an impact to the construction process such as, weather, financial situation, labour union, government policy, etc. In construction project, both internal environment and external factors need feedback and have its own interruption. DOCS in Figure 3.1 contributes partially to the complexity of the conversion process which illustrates the complexity in a construction process to determine the result as an output which is the result of a process from various related and connected productivity factors. Drewin's Open Conversion System (DOCS) is a theoretical framework used to classify those factors in this study. Based on this theory, there are three key factors, namely input, internal environment and exogeneous.

A. Input Factor

In this study the input factor is the first input in a construction project that cannot be fully controlled by the construction party. The party outside the construction also has significant role. This study consists of four factor categories, of which are based on a critical understanding of previous research [1], [4], [13], [18], [19], [20], [22], [24], [27], [28], that affect construction labour productivity. The four categories of factors are labour, finance, materials and equipment. Labours are individuals or groups of people who are involved in a construction project, carry out the work in accordance with their expertise and skills, and assigned to work based on the planning of the project owner. In this study the labour factor category consists of 23 factors that can affect the labour productivity in a construction project. The other issue is the material. This matter related to ordering, procurement, availability, delay in materials and so on that are used for the purpose of carrying out construction projects up to completion. This material factor category consists of 7 factors based on previous research which influence the material at the project site. Equipment is needed in all forms of equipment to complete the work on a construction process. The equipment category in this study consists of 5 factors which affect equipment at the project site. Then financial matter is to finance in the process of carrying out construction up to completion. Finance consists of 8 constituent factors based on previous research. In Figure 3.3, we can see four categories of input factors consisting of 43 factor items which constitute the formation of factor categories based on previous research that originated from reputable journals.

B. Internal Environment Factor

Internal environment factor in this study is defined as everything in the form of inputs related to construction activities controlled and managed entirely at the construction site by the construction party. This is based on the theoretical framework stated in this study which based on Drewin's Open Conversion System in 1982. Internal environment factor is one of the important inputs that affect construction labour productivity, and controlled by the construction party during the construction project until the completion. Internal environment consists of twelve

categories of factors selected based on previous researches [1], [4], [13], [14], [16], [17], [18], [20], [23], [24], [25], [28] [29]. These internal environment factor categories completely controlled by the construction in the terms of controlling and improving construction labour productivity (CLP).

In Figure 3.4 it can be observed that internal environment factor category consists of design, health and work safety, supervision, organization, scheduling, leadership and coordination, management, motivation, project, technology, socio-psychology and communication. These 12 internal environment factor categories are then broken down into 119 factors that can influence the internal environment factors in improving the productivity of construction labour. 119 identified factors that capable of influencing on each factor category within the internal environment factors based on critical understanding of previous research in several countries, especially in developing countries.
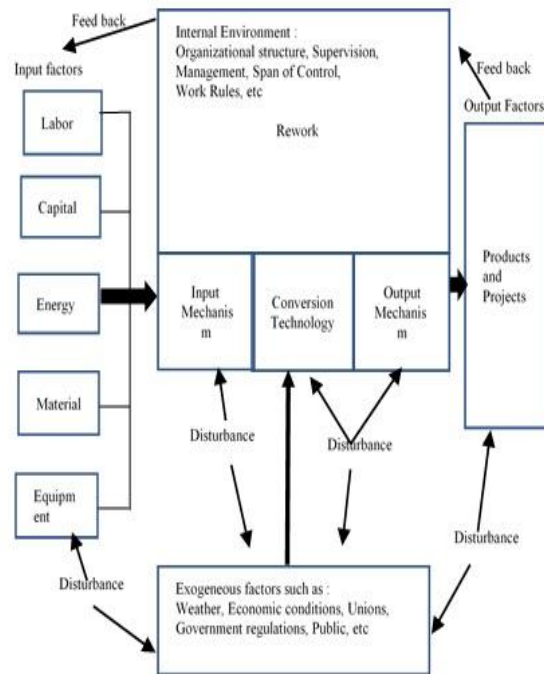

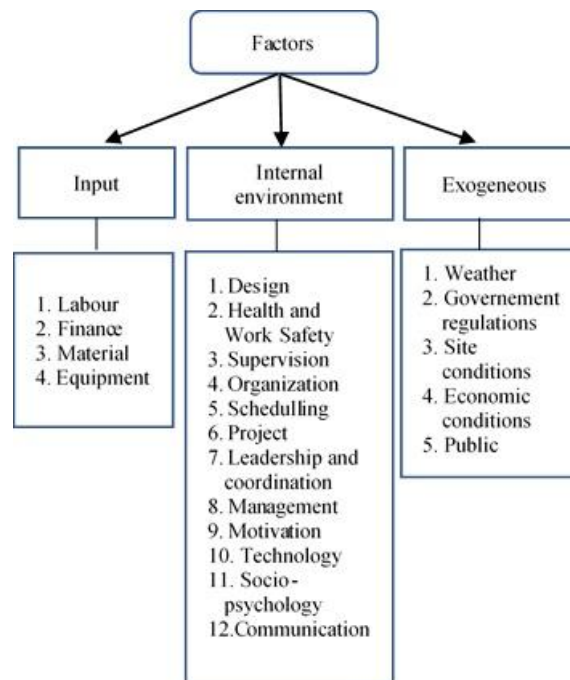**Fig. 3.1** Drewin's Open Conversion System (DOCS) Source: Drewin, 1982

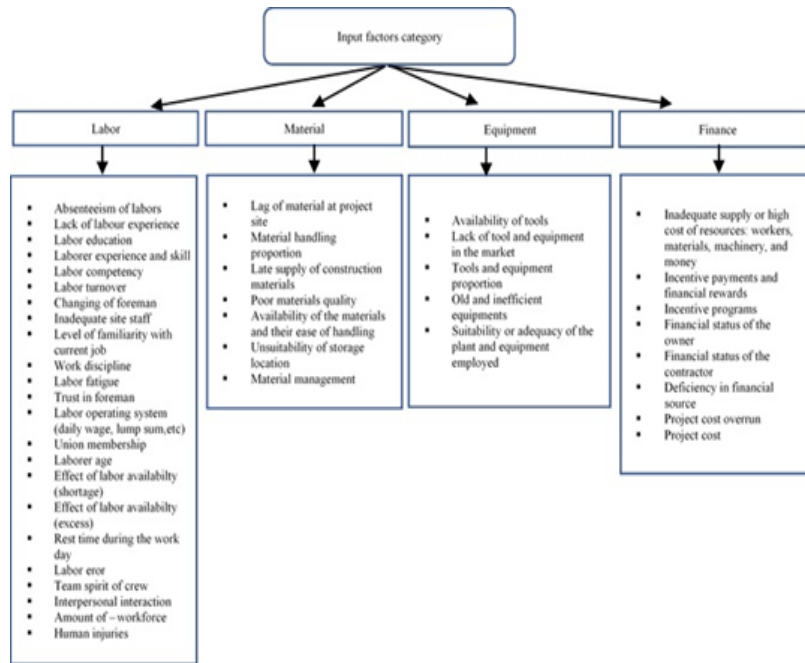**Fig. 3.2** The Theoretical Framework For Factor Categories
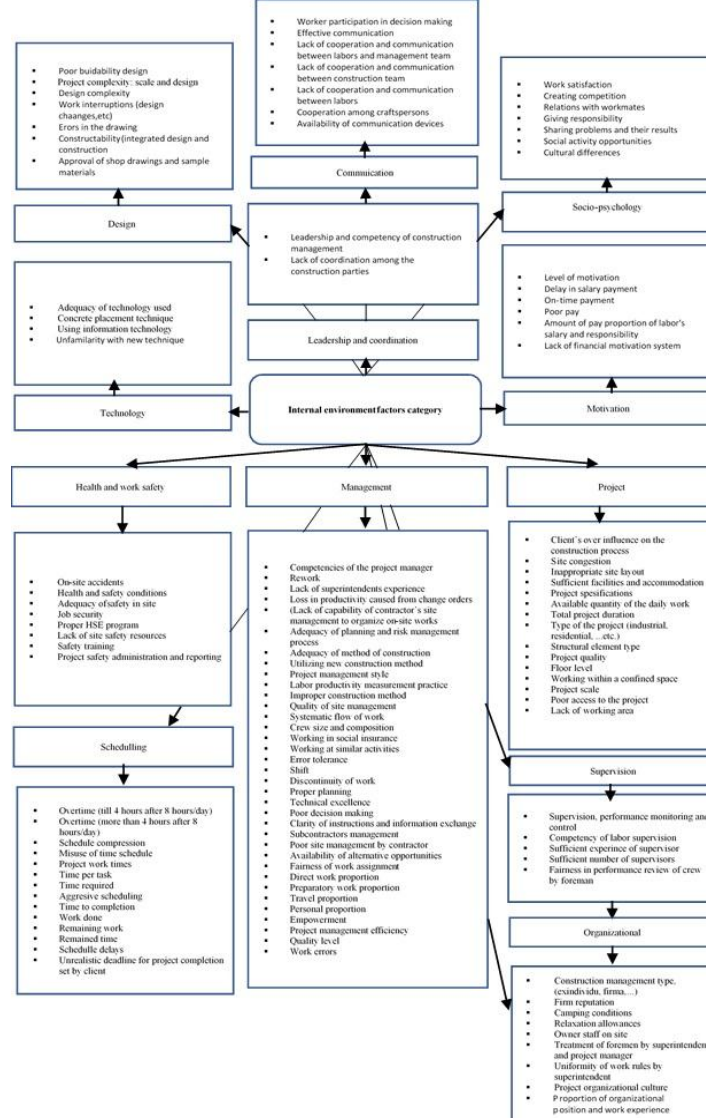
Fig. 3.3 Input factors category

Fig 3.4 Internal Environment Factors Category

C. Exogenous Factor

Exogenous factor is a factor that cannot be controlled by the construction party in the process construction work, but exogenous factor can cause or affect the overall construction implementation process. Based on Drewin's Open Conversion System, the exogenous factor is an inseparable part in the terms of productivity. Productivity can be calculated by considering the value of inputs through the process and obtaining output from a job. Thus to go through this process to obtain output in the form of work or project results, it is not possible to release the output factors that are very likely to occur in the implementation of a construction project. In this study the exogenous factor is the last factor category that was included in this study. The exogenous factor is the result of previous studies regarding the output factors that affect CLP. Some previous studies discussed exogenous influencing CLP, among others [1], [4], [13], [14], [17], [18], [20], [28] [30], [31]. In this study selected and identified the output factors in five factor categories. The five categories of factors were weather, government regulations, site conditions, economic conditions and public.

Weather is anything that relates to weather conditions that occur at the location and around the construction project site, which includes rain, high temperatures, sand storms, high winds, and can affect the implementation of construction Eyes projects. Furthermore, the site conditions are all matters relating to the site conditions which may interfere with the implementation of the construction process. Site conditions consist of 6 factor items. Government regulations are all matters relating to government regulations and policies that can influence construction projects. Government regulations consist of slow local authority approval and stopping work order due to of infringement of government regulation. Economic conditions are all things related to the economic condition of a country. In this study the economic conditions consist of oil price fluctuation and natural gas prices. Public is another factor which affects the construction project. The public consisted of surrounding events and unfavorable external conditions. In Figure 3.5 can be seen each category of exogenous factors with the items of the constituent factors
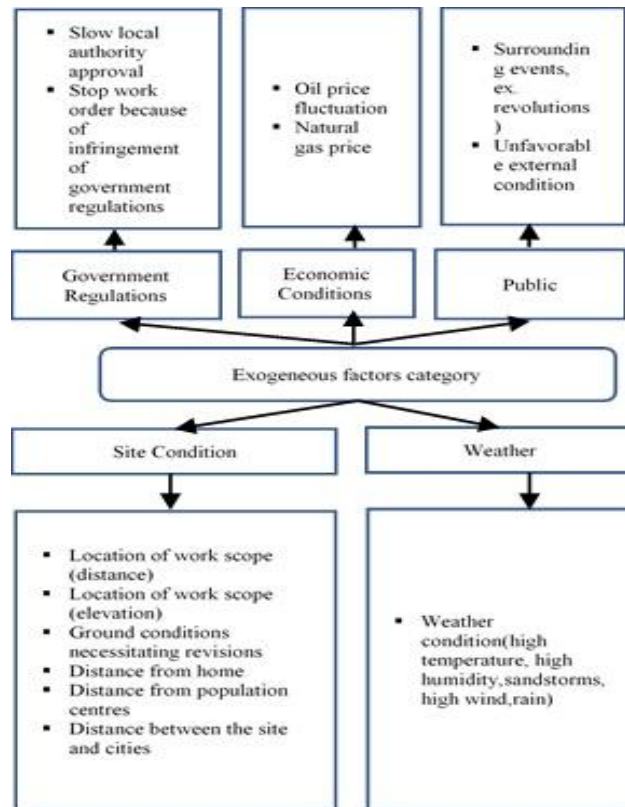

Fig 3.5 Exogeneous Factors Category

IV. CONCLUSION

The construction industry is defined as labour intensive industry, therefore the productivity in construction projects is closely related to labour. The costs spent on labour were 30% to 50% of the total project costs. Due to the significance influence of the construction labour productivity on project costs and profitability ultimately the completion of the project will be affected. Hence, the productivity betterment in the construction industry continues. Increasing the productivity of construction labour will contribute greatly to state revenue. Interpreting, reviewing and evaluating the influence factor of construction labour productivity is an important issue in research and for industrial practitioners. Although this kind of research has been done in many countries, however the influence magnitudes of these factors are both positive and negative on construction productivity.

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The factors that affect construction labour productivity in various countries are still being carried out. This can be carried out by utilizing the factors that are identified positively to the productivity and by controlling or eliminating negative productivity. Definitely is useful to increase construction productivity, and if all affected factors can be identified, the productivity can be predicted in the future.

This study aims to critically examine the factors that influence labour productivity and classify these factors into groups of factors based on previous studies in various countries. Based on critical understanding of previous research and by using Drewin's Open Conversion System (DOCS) there are three key factors in order to achieve goals, namely input factors, internal environment factors and exogenous factors. The input consists of a factor category, namely labour, finance, material and equipment. Internal environment consists of factor categories namely design, health and work safety, supervision, organization, scheduling, project, leadership and coordination, management, motivation, technology, socio-psychology, communication. Besides that, for the category of exogenous factors consists of weather, government regulations, economic conditions, site conditions and public. In this critical review, 175 factors have been identified affecting the productivity of construction labour which is classified in the framework of the Drewin's theory.

V. ACKNOWLEDGMENT

REFERENCES

1. Kazaz, A., Ulubeyli, S., Acikara, T. & Er, B. 2016. Factors Affecting Labor Productivity: Perspectives of Craft Workers. Procedia Engineering, hlm. 28 – 34. doi:10.1016/j.proeng.2016.11.588
2. Doloi, H., Sawhney, A. & Iyer, K. C. 2012. Structural equation model for investigating factors affecting delay in Indian construction projects. Construction Management and Economics 30: 869–884. doi:10.1080/01446193.2012.717705
3. Shehata, M. E. & El-Gohary, K. M. 2011. Towards improving construction labor productivity and projects' performance. Alexandria Engineering Journal 50: 321–330. doi:10.1016/j.aej.2012.02.001
4. El-Gohary, K. M. & Aziz, R. F. 2014. Factors Influencing Construction Labor Productivity in Egypt. Journal of Management in Engineering. doi:10.1061/(ASCE)ME.1943-5479.0000168
5. Jarkas, A. M., Kadri, C. Y. & Younes, J. H. 2012. A survey of factors influencing the productivity of construction operatives in the state of Qatar. International Journal of Construction Management 12(3): 1–23.
6. doi:10.1080/15623599.2012.10773192
7. Tsehayae, A. A. & Robinson Fayek, A. 2014. Identification and comparative analysis of key parameters influencing construction labour productivity in building and industrial projects. Canadian Journal of Civil Engineering 41: 878–891. doi:10.1139/cjce-2014-0031
8. Thomas, H. R., Maloney, W. F., Horner, R. M. W., Smith, G. R., Handa, V. K. & Sanders, S. R. 1990. Modeling Construction Labor Productivity. Journal of Construction Engineering and Management 116(4): 705–726. doi:10.1061/(ASCE)0733-9364(1990)116:4(705)
9. Fwu-Shiun Liou, J. D. B. 1986. W o r k sampling c a n predict u n i t rate productivity. Journal of Construction Engineering & Management 112(1): 90–103
10. Gerek, İ. H., Erdis, E., Mistikoglu, G. & Usmen, M. 2015. Modelling masonry crew productivity using two artificial neural network techniques. Journal of Civil Engineering and Management 21(2): 231–238. doi:10.3846/13923730.2013.802741
11. Drewin, F. J. 1982. Construction Productivity; measurement and improvement through work study. Amsterdam: Elsevier science publishers B.V.
12. Song, L. & AbouRizk, S. M. 2008. Measuring and Modeling Labor Productivity Using Historical Data. Journal of Construction Engineering and Management 134(10): 786–794. doi:10.1061/(ASCE)0733-9364(2008)134:10(786)
13. Ghoddousi, P., Poorafshar, O., Chileshe, N. & Hosseini, M. R. 2015. Labour productivity in Iranian construction projects. International Journal of Productivity and Performance Management 64(6): 811–830. doi:10.1108/IJPPM-10-2013-0169
14. Nasirzadeh, F. & Nojedehi, P. 2013. Dynamic modeling of labor productivity in construction projects. International Journal of Project Management 31: 903–911. doi:10.1016/j.ijproman.2012.11.003
15. Ghoddousi, P. & Hosseini, M. R. 2012. A survey of the factors affecting the productivity of construction projects in Iran. Technological and Economic Development of Economy 18(1): 99–116. doi:10.3846/20294913.2012.661203
16. Mojahed, S. & Aghazadeh, F. 2008. Major factors influencing productivity of water and wastewater treatment plant construction: Evidence from the deep south USA. International Journal of Project Management 26: 195–202. doi:10.1016/j.ijproman.2007.06.003
17. Kazaz A, M. E. and U. S. 2008. Effect of basic motivational factors on construction workforce productivity in Turkey. Journal of Civil Engineering and Management 14(2): 95–106.
18. Heravi, G. & Eslamdoost, E. 2015. Applying Artificial Neural Networks for Measuring and Predicting Construction-Labor Productivity. Journal of Construction Engineering and Management. doi:10.1061/(ASCE)CO.1943-7862.0001006
19. Mahamid, I. 2013. Contractors perspective toward factors affecting labor productivity in building construction. Engineering, Construction and Architectural Management 20(5): 446–460. doi:10.1108/ECAM-08-2011-0074
20. Thomas, A. V. & Sudhakumar, J. 2013. Critical Analysis of the Key Factors Affecting Construction Labour Productivity –An Indian Perspective. International Journal of Construction Management 13(4): 103–125. doi:10.1080/15623599.2013.10878231

21. Serdar Durdyev, Syuhaida Ismail, N. K. 2018. Structural Equation Model of the Factors Affecting Construction Labor Productivity. Journal of Construction Engineering & Management 144(4). doi:10.1061/(ASCE)CO.1943-7862.0001452.

22. Sonmez, R. & Rowings, J. E. 1998. Construction Labor Productivity Modeling with Neural Networks. Journal of Construction Engineering and Management 124(6): 498–504. doi:10.1061/(ASCE)0733-9364(1998)124:6(498)

23. Soekiman, A., Pribadi, K. S., Soemardi, B. W. & Wirahadikusumah, R. D. 2011. Factors relating to labor productivity affecting the project schedule performance in Indonesia. Procedia Engineering, hlm. 865–873. doi:10.1016/j.proeng.2011.07.110

24. Jarkas, A. M. & Bitar, C. G. 2012. Factors affecting construction labour productivity in Kuwait. Journal of Construction Engineering and Management 138(July): 811–820.

25. doi:10.1061/(ASCE)CO.1943-7862.0000501.

26. Enshassi, A., Mohamed, S., Mustafa, Z. A. & Mayer, P. E. 2007. Factors affecting labour productivity in building projects in the Gaza strip. Journal of Civil Engineering and Management XIII(4): 245–254. doi:10.1080/13923730.2007.9636444

27. Jarkas, A. M. & Radosavljevic, M. 2013. Motivational Factors Impacting the Productivity of Construction Master Craftsmen in Kuwait. Journal of Management in Engineering. doi:10.1061/(ASCE)ME.1943-5479.0000160

28. Sweis, G., Sweis, R., Abu Hammad, A. & Shboul, A. 2008. Delays in construction projects: The case of Jordan. International Journal of Project Management 26: 665–674. doi:10.1016/j.ijproman.2007.09.009

29. Jang, H., Kim, K., Kim, J. & Kim, J. 2011. Labour productivity model for reinforced concrete construction projects. Construction Innovation 11(1): 92–113. doi:10.1108/14714171111104655