MODELLING CONSTRUCTION LABOUR PRODUCTIVITY FROM LABOUR'S CHARACTERISTICS

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DEDICATION

This thesis is dedicated to my father, mother and sister who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to all Telfordians and Toastmasters, who taught me that even the largest task can be accomplished if it is done one step at a time and with passion. Finally, this is dedicated to all those who believe that anything is possible in life with hard work, dedication and faith in the Almighty.

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ABSTRACT

Labour is a fundamental input to any construction project to achieve the highest level of productivity. Productivity remains as one of the most important ways to measure the overall performance of construction project. Construction productivity is directly related to labour and thus, it is mainly dependent on human effort and performance. Improvement of Construction Labour Productivity (CLP) can directly help to improve the performance of construction companies, become more competitive, besides contributes to national economy. The aim of the research is to develop and introduce a new framework for systematic assessment of the factors influencing construction labour productivity and use the collected data to create models by applying state-of-art techniques and comparing the accuracies in predicting the labour productivity in construction. The scope of the study was limited to Malaysia only. A thorough literature survey was conducted to list the factors related to CLP with different studies throughout the globe. The factors were filtered using two-stage procedures - first the factors were shortlisted based on the relevance of labour and then a survey was conducted among project managers to rank the factors based on the importance of Malaysian context using a 3-point Likert scale on each factor. The ranks of the factors were analysed using statistical tools. The top class factors were identified using Jenks Optimization Techniques. The classified CLP factors were used to design a field survey to collect data from construction workers. Five state-of-arts of models were developed to predict the CLP from the factors including three data mining models, one conventional model and one multi-criteria model. Salary of labour was considered as a proxy to the productivity to develop the models. The performance of the models were assessed using five categorical indices. The results of literature review revealed that a total of 112 factors related to productivity in construction industry have been identified throughout the globe. Ten factors were identified through the analysis of preliminary survey data using different methods. Among them, seven factors were found common for all the methods which were identified as the important CLP factors for Malaysian construction industry. The factors are (1) Lack of Work Experience (2) Job Category (3) Education/Training (4) Nationality (5) Worker Skills (6) Age and (7) Marital Status. The relative performance of different models was compared to identify the best model in term of the rate of accuracy in prediction of labour productivity. Data mining models were found to perform better compared to other models. The Percentage of Correct (PC) for data mining models were found in the range of 0.735-0.835, Probability of Detection (POD) between 0.741 and 0.911, Heidke Skill Score (HSS) between 0.792 and 0.802 and Peirce Skill Score (PSS) in the range of 0.792 to 0.799, while the False Alarm Ratio (FAR) were found in the range of 0.102 to 0.279. The values were found better than that obtained using Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) (PC=0.739, POD=0.740, HSS=0.794, PSS=0.725 and FAR=0.256) and much better than that obtained using Linear Regression (LR) (PC=0.577, POD=0.618, HSS=0.533, PSS=0.498 and FAR=0.533). Among the data mining models, Support Vector Machine (SVM) was found to provide the best results in term of all statistical metrics used. The POD for SVM was found above 90% in predicting different categories of productivity. The method discussed in this research can serve as a newly developed framework to predict the level of construction labour productivity for project.

ABSTRAK

Tenaga pekerja merupakan input asas kepada projek pembinaan bagi mencapai produktiviti. Produktiviti merupakan cara paling penting untuk mengukur prestasi projek pembinaan. Produktiviti pembinaan berkait dengan sumber tenaga kerja secara langsung bagi menilai prestasi manusia. Penambahbaikan Produktiviti Pekerja Pembinaan (CLP) dapat membantu untuk menambah baik prestasi kerja syarikat pembinaan, menjadikan syarikat pembinaan kita lebih berdaya saing dan mampu menyumbang kepada pembangunan ekonomi negara. Tujuan penyelidikan ini adalah membangunkan dan memperkenalkan rangka kerja baharu dengan menilai faktor yang mempengaruhi produktiviti buruh pembinaan secara sistematik dan membuat model kajian dengan menggunakan teknik moden dan membandingkan ketepatan dan keberkesanan teknik dalam meramalkan produktiviti buruh pembinaan berdasarkan data yang dikumpul. Skop kajian ini hanya meliputi di negara Malaysia sahaja. Kajian literatur yang teliti telah dilakukan dengan menyenaraikan faktor yang berkaitan dengan CLP yang dikenal pasti daripada kajian yang berbeza di seluruh dunia. Faktor tersebut telah ditapis menggunakan prosedur secara dua peringkat: faktor tersebut disenarai pendek berdasarkan kaitannya dengan buruh terlebih dahulu. Kemudian, satu kaji selidik telah dijalankan antara orang berkalangan pengurus projek untuk menentukan faktor berdasarkan kepentingan mereka dalam konteks Malaysia menggunakan skala 3-point Likert bagi setiap faktor. Kedudukan factor tersebut dianalisis dengan menggunakan alat-alat statistik. Faktor berkepenthgan dikenal pasti dengan kaedah Teknik Jenks Optimization. Faktor CLP yang diklasifikasikan telah digunakan beg merancang tinjauan lapangan untuk mengumpulkan data daripada pekerja pembinaan. Lima model telah dibangunkan untuk meramalkan CLP daripada faktor yang diperoleh dengan penggunaan tiga model perlombongan data, satu model konvensional, dan satu model multi-kriteria. Gaji buruh dianggap sebagai proksi untuk produktiviti semasa pembamgvnan model. Prestasi model dinilai dengan menggunakan lima kategori indeks. Hasil daripada kajian literatur, sejumlah 112 faktor yang berkaitan dengan produktiviti dalam industri pembinaan telah dikenal pasti di seluruh dunia. Sepuluh faktor telah dikenal pasti melalui analisis daripada pelbagai kaedah bancian data pada peringkat awal. Tujuh daripada faktor tersebut telah dikenal pasti sebagai faktor CLP yang penting dalam industri pembinaan Malaysia daripada semua kaedah. Antara faktornya ialah (1) Kekurangan Pengalaman Pekerja (2) Kategori Pekerjaan (3) Pendidikan/Latihan (4) Kewarganegaraan (5) Kemahiran Pekerja (6) Umur dan (7) Status Perkahwinan. Prestasi relatif yang dikaji menggunakan model yang lain juga dibandingkan untuk mengenal pasti model yang paling berkesan untuk meramalkan produktiviti pekerja secara tepat. Model perlombongan data telah dikenal pasti sebagai model yang terbaik untuk mengendalikan analisis ini. PC untuk model perlombongan data didapati dalam lingkungan 0.735-0.835, POD di antara 0.741 dan 0.911, HSS di antara 0.792 dan 0.802, dan PSS dalam lingkungan 0.792 hingga 0.799, manakala FAR didapati dalam lingkungan 0.102 hingga 0.279. Hasil daripada kajian melalui kaedah ini didapati adalah lebih baik daripada hasil kajian yang diperoleh daripada penggunaan kardah TOPSIS (PC=0.739, POD=0.740, HSS=0.794, PSS=0.725 and FAR=0.256) dan jauh lebih baik daripada penggunaan kaedah LR (PC=0.577, POD=0.618, HSS=0.533, PSS=0.498 and FAR=0.533). Antara pelbagai model perlombongan data yang digunakan, kaedah SVM didapati memberi hasil kajian yang paling baik dari segi metrik statistik yang diguna pakai. POD bagi kaedah SVM didapati mampu mencapai tahap prestasi lebih daripada 90% dalam ramalan kategori produktiviti yang berlainan. Dengan itu, Metod yang dibahaskan dalam kajian ini dapat menjadi sebagai suatu rangka kerja yang baharu untuk meramalkan tahap produktiviti pekerja pembinaan bagi sesuatu projek pembinaan.

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LIST OF ABBREVIATIONS

UTM	-	Universiti Teknologi Malaysia
AHP	-	Analytic Hierarchy Process
TOPSIS	-	The Technique for Order of Preference by Similarity to Ideal Solution
CLP	-	Construction Labour Productivity
SVM	-	Support Vector Machine
RF	-	Random Forest
US	-	United States
GDP	-	Gross Domestic Product
LOP	-	Loss of Productivity
UK	-	United Kingdom
UAE	-	United Arab Emirates
ID	-	Identification
PPE	-	Personal Protection Number
QWL	-	Quality of Working Life
DBOT	-	Design/Build/Operate/Transfer
EPC	-	Turnkey/Engineering, Procurement And Construction
ANN	-	Artificial Neural Network
FL	-	Fuzzy Logic
CART	-	Communication Access Real-Time Translation
SDBC	-	Sum of Squared Deviations Between
SDAM	-	Sum of Squared Deviations from the Array Mean
SDCM	-	Sum of the Squared Deviations from the Class Means
GVF	-	Goodness of Variance Fit
MLR	-	Multiple Linear Regression
SPSS	-	Statistical Packages for Social Sciences
LASSO	-	Least Absolute Shrinkage and Selection Operator.
BA	-	Boruta Algorithm
MZSA	-	Maximum Z Score among Shadow Attributes
GLM	-	Generalized Linear Model

GAM	-	Generalized Additive Models
RSS	-	Residual Sum of Squares
LM	-	Linear Method
ASCE	-	American Society of Civil Engineers
SLFN	-	Single-Hidden Layer Feed forward Neural Network
SRM	-	Structural Risk Minimization
OOB	-	Out of Bag
AHP	-	Analytic Hierarchy Process
MCDM	-	Multiple-Criteria Decision-Making
PIS	-	Positive Ideal Solution
NIS	-	Negative Ideal Solution
FN	-	Number of Instances That Predicted Incorrectly As Gullies
TN	-	Number of Instances That Predicted Correctly as Non-Gullies
FP	-	Number of Instances That Predicted Incorrectly as Non-Gullies
TP	-	Number of Cases That Predicted Correctly as Gullies
PC	-	Percentage of Correct
POD	-	Probability of Detection
HSS	-	Heidke Skill Score
FAR	-	False Alarm Ratio
PSS	-	Peirce Skill Score
CIDB	-	Construction Industry Development Board
RM	-	Ringgit Malaysia

LIST OF SYMBOLS

%	-	Percentage
=	-	Equal Sign
/	-	Slash
K	-	Kernel function
α_i	-	Parameters
b	-	Parameters
N	-	Number of Training Data
x_i	-	Vectors
x	-	Independent Vector
n_1	-	Number of Respondents
X_i	-	Correlation Coefficient
Y	-	Correlation Coefficient
X_j	-	Predictor Set
n	-	Number of Predictors
α	-	Model Parameters
Σ	-	Sigma
β_i	-	Strength of the Influence of X
$CLPt$	-	Construction labour productivity for the project, t

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The productivity of a major industry like construction is of significant importance for the economic growth of a nation (Naoum, 2016). The construction sector not only makes a remarkable contribution to the performance of the overall economy, but it also serves as a significant source of employment (Giang and Pheng, 2011). Labour is a fundamental input to any construction project to achieve the highest level of output in terms of the level of productivity (Hwang and Soh, 2013, Gerek et al., 2015). Labour is part of, but distinct from, other resources, because it has specific characteristics (Kaming et al., 1998). It constitutes the largest portion of the project cost. Studies show that it shares about 20-50% of total project cost (Buchan et al., 1993; Zakeri et al., 1997; Kaming et al., 1998), and therefore the project costs can be reduced significantly by improving labour productivity (Kazaz and Ulubeyli, 2004; Kim et al., 2015). The importance of construction labour productivity (CLP) in success for construction project has been reported in numerous studies (Neelima, 2018; Sweis et al. 2009; Fayek and Tsehayae, 2012; Ma et al., 2016). CLP has been reported as one of the key components and an effective indicator of efficiency in construction industry. It has a direct impact on the competitiveness of small and medium enterprises. Labour will continue to be a key factor for the success of construction projects in future (Tsehayae and Robinson Fayek, 2014). Therefore, improvement of CLP would be a major issue of concern in future as it is now (Attar et al., 2012).

There are many challenges facing the construction industry, but one of the most significant is low levels of productivity (Jarkas and Bitar 2011). Construction industries in many countries across the world are greatly concerned about low level of productivity (Lim and Alum 1995; Egan 1998; Thomas and Sudhakumar 2013; Ayele and Fayek 2019). There is nothing as dangerous to an economy as a decrease in

productivity because it creates inflationary pressure, social conflict and mutual suspicion (Drucker 2012; Dixit et al. 2019; Shoar and Banaitis 2019). By acknowledging the factors that cause low levels of construction labour productivity, project managers can address the problems at an early stage, thus minimise the time and cost overruns (Kaming et al. 1997; Kaming et al. 1998; Abdul Kadir et al. 2005; Palikhe et al. 2019; Seddeeq et al. 2019). CLP significantly influences the profitability of construction companies; however, CLP exhibits the highest variability among project resources and thus is a major source of project risk (Tsehayae 2015). Labour in projects is also the most difficult element to define, manage and quantify on their impact. In this sense, it still remains important to determine the factors affecting labour-productivity to manage labour-forces effectively (Kazaz and Acıkara 2015).

CLP has been identified as one of the major factors related to project delay and loss of finance. Hence, slight advancement in the level of CLP on construction projects will enhance the contractor's profit and serve the national economy (Abdel-Razek and Abdel-Hamid, 2007). The evaluation of CLP rates and identification of factors affecting CLP are critical in project control and improvement of productivity in construction. CLP is the dominating aspect in the construction industry as it encourages cost savings and effective utilization of resources (Alaghbari et al., 2019). It is a key element in determining the success and failure of any construction project (Golnaraghi et al., 2019). This is the main reason why CLP related research has benefited from a lot of attention in the industry/academia in past and recent years (Abraham, 2005; Moselhi et al., 2005; Muqeem et al., 2012; Gundecha, 2013; Gupta and Kansal, 2014; Gerek et al., 2015; Tsehayae and Fayek, 2016; Parthasarathy et al., 2018; Hamza et al 2019).

Understanding critical factors that affect CLP can help to develop strategies to reduce inefficiencies and to more effectively manage construction labour forces. This will not only improve the project performance of construction companies, but also make them more competitive and consequently increase the chances of survival within this highly competitive sector (Wilcox et al. 2000; Ailabouni et al. 2007; Robles et al. 2014; Langmade 2017). The factors related to CLP can be used for the development of CLP models for estimation and prediction of CLP from different factors (Kim et al.,

2015; Ma et al., 2016; Tsehayae and Fayek, 2018). The CLP prediction models can be used in construction planning and scheduling and eventually in improvement of CLP. Besides, the models are often used as an effective tool in the estimation and monitoring of manpower and equipment resources in construction (Parthasarathy et al., 2018).

Hypothetically, the equation of productivity is the output of production per unit of input. At the industrial level, the equation of productivity remains the same as the ratio between total product output and total input resource from an economic perspective (Hanna et al., 2005, Ayele and Fayek, 2019). The composition of personnel in construction projects and its connection to various networks make CLP very difficult to measure and understand the concept of productivity and find the correct correlation (Bernstein, 2003). The construction projects even of identical type and nature carry an uncommon site, design methods, which makes the assessment of CLP very difficult to measure. Productivity models are even more problematic and laborious to create, especially due to its dependency on various environmental, physical, economic, social and behavioural factors. In addition, to date, there has been no line drawn on the correct interpretation and meaning of work activities nor a standard productivity measurement system (Park et al., 2005). Hence, identification of productivity factors and modelling of productivity in construction is a major challenge in the construction industry. A number of studies have been conducted in recent years where different methodologies have been used for assessment of different aspects of construction productions and influential factors responsible for productivity in different socio-economic contexts have been identified (Wilcox et al. 2000; Ailabouni et al. 2007; Robles et al. 2014; Langmade 2017; Afolabi et al. 2018; Ohueri et al. 2018; Momade 2019; Alaghbari et al. 2019; Palikhe et al. 2019). The CLP models can be used for forecasting activity durations and thus, project scheduling. It can help in efficient planning and management of construction project in order to improve overall productivity of project.

1.2 Problem Statement

Application of computer in construction has increased rapidly with the increase of computational capacity and ability to solve construction-related challenges. Considering productivity as the major challenge in construction, sufficient advancements have also been achieved in computational modelling of construction productivity. Different methods in including fuzzy logic, neural network, etc. have been used for modelling labour productivity from various productivity-related factors. However, choice of appropriate modelling tools and selection of labour-related factors remain major challenges (Portas and AbouRizk, 1997; Tsehayae and Fayek, 2016; Golnaraghi et al., 2019; Shoar and Banaitis, 2019). There are many influential factors that determine labour productivity in the construction sector. The factors may change depending on market conditions, social context and geographical location of the construction project. Therefore, labour productivity factors should be linked to the surrounding environment. Screening out the factors based on their relevance and significance according to location and socio-economic context is often disputable. A systematic framework for the selection of appropriate factors relevant to labour productivity is therefore sought.

A large number of factors related to labour are responsible for productivity. A parsimonious system should be able to predict productivity from a minimum number of factors. Therefore, identification of most influencing factors from the whole set of labour factors responsible for productivity is a challenging task. The approach generally used are highly subjective and biased to human judgement. Therefore, finding factors that most suitable for the development of a good production model remains a challenge in construction productivity modelling. There is a need to explore a new method for the identification of the optimum number of factors which can avoid subjectivity in the selection of factors.

The major goal in any construction project is to improve productivity. A CLP model can help to stimulate the productivity from labour characteristics to optimize the work schedule and maximize the benefit. Researchers to date have used different forms of linear regression-based models which are not able to capture the non-linear

relationship between labour related factors and productivity. Non-linear models can be used for better simulation of construction labour productivity from labour related factors. However, the relationship between the labour factors with productivity is often highly complex which emphasizes the need for exploration of a new method for the improvement of the performance of CLP models.

There are many CLP models available which can be used for prediction of labour productivity. The performance of the CLP model depends on the distribution and variability of labour-related factors used for the development of CLP model. Thus, the performance of the CLP model varies widely for different sets of data. This indicates the necessity of assessment of the comparative performance of different CLP models to identify the best model for the reliable prediction of productivity. Besides, the performance evaluation of CLP models should be based on different characteristics such as reliability and precision in prediction for a perfect measure of model performance for predicting productivity. This emphasizes the need for comparative evaluation of different state-of-art CLP model using robust performance evaluation metrics for the selection of the best model to be proposed for use in the construction industry.

1.3 Aim & Research Objectives

The aim of the research is to introduce a new framework for systematic assessment of the factors influencing construction labour productivity and use the collected data to create models by applying state-of-art techniques and compare their accuracies in predicting labour productivity in construction. The research objectives are stated as follows:

(a) To develop a systematic framework for the selection of construction labour productivity factors by linking market conditions, social context and geographical location

(b) To apply robust statistical approaches for prioritization of construction labour productivity factors according to their importance

(c) To construct data-driven models for prediction of labour productivity in construction projects

(d) To review the performance of productivity models and identify the best approach for labour productivity modelling to be used in the construction industry for management

1.4 Scope of the Study

Initial identification of the factors which influence labour productivity was conducted through a critical analysis of literature. Data was collected through an opinion survey using a Likert Scale. The survey questionnaire was designed to calculate the effectiveness of the factors which have been identified on the topic of labour productivity for the construction industry. The questionnaire was designed in both spoken languages: English and Bahasa Malay. The survey was conducted among people working in construction project management and construction workers. The opinion data of project managers was collected to understand their perception of labour productivity. On the other hand, data was also collected through interview of construction site workers including both foreign and local to capture their views. Foreign labour from Indonesia & Bangladesh (constitute the majority of foreign construction workers in Malaysian construction projects) and local Malaysian workers involved in residential and factory projects were interviewed.

There are many methods used for modelling of CLP using influencing labour related factors. Most of the researchers in the past have used one or two models at most for CLP prediction. In the present study, five state-of-arts of models were developed to predict the CLP from the factors including three data mining models namely, Artificial Neural Network (ANN), Random Forest (RF), Support Vector Machine (SVM), one conventional model known as generalized Linear Regression (LR), and one multi-criteria model called the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS).

1.5 Significance of the Study

Labour is the major driving force in any construction project. It also shares the major cost of a construction project. The CLP prediction model developed in this study can be used for the scheduling and management of a construction project to improve the overall productivity of the construction project.

Understanding critical factors that affect labour productivity can help to develop strategies to reduce inefficiencies and to manage construction labour force more effectively. The outcome can help practitioners to develop a wider and deeper perspective of the factors influencing the productivity of operatives and to provide guidance to construction project managers for the efficient utilization of the labour force.

By understanding the influential CLP factors in the region, the factors identified can be used for the selection of labour to improve the productivity of the projects in Malaysia and in other geographical regions.

The methodology proposed in this study can serve as a framework for future studies in other geographical regions for more accurate identification of CLP factors. The methodology adopted can also serve to compare the results of the past studies in other countries by researchers.

Machine learning tools can make a great contribution in solving complex problems in civil engineering. In the last decade, the application of artificial intelligence and predictive models serve as a practical, feasible and quick tool in solving engineering problems. By applying machine learning tools in modelling and prediction, it can assist to reduce the time, manpower, and materials, resulting in a lower cost for the work done.

This study can be used, not only by academics, who are interested in the effect of the subject matter on the application of machine learning tools in construction but also by both local and international industry practitioners, who may be further keen to further understand and explore the applications of AI tools in the field. The study can

help researchers and practitioners develop machine learning tools which can improve the performance and accuracy in prediction and modelling in different aspects.

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Appendix A Questionnaire Sample

SURVEY QUESTIONNAIRE

Title of Research Study: Modelling Construction Labour Productivity From Labour's Characteristics

Your valuable participation will allow the research team to document factors affecting labour productivity in residential projects at Johor Bahru, Malaysia. The questionnaire refers to the following scale: Yes (1), No (2), Don't Know (3). The information provided will be kept confidentially and your name and affiliation will be removed from the survey data included in the published research. Thank you for your time and input.

PART 1

Name	
Age	
Gender	
Nationality / Ethnic	
Highest level of education completed	
Number of years of construction experience in Malaysia	
Current Working Position	
Current Company	

PART 2

What do you understand by the term "Construction Labour Productivity". Please Select from below or add your definition.

a. Productivity is input over output.

b. Productivity in terms of labour cost to the number of outputs produced.

c. Physical progress achieved on site

d. Rate at which work is performed

e. Relative measure of labour proficiency

f. units of production divided by the corresponding time of workers.

g. Productivity is more value-added operations and enhanced product quality.

h. Productivity is defined as the craft hours necessary to produce a unit of finished product

i. Other (Please write below)

PART 3

S/N	Factors affecting Labour Productivity	Scale		
		1	2	3
		Yes	No	Neutral
1	Lack of work experience			
2	Job Category			
3	Education/Training			
4	Nationality			
5	Skills			
6	Age			
7	Marital Status			
8	Supervision delays			
9	Inadequate transportation facilities for workers			
10	Training sessions			
11	Lack of required construction material			
12	Incomplete details provided			
13	Accidents during construction			
14	Change orders from the designers			
15	Working overtime			
16	Lack of required tools or equipment			

17	Poor site conditions			
18	Quality of required work			
19	Disputes with the designers			
20	Variations in the drawings			

S/N	Factors affecting Labour Productivity	Scale		
		1	2	3
		Yes	No	Neutral
21	Payment delays			
22	Misunderstanding among labourers			
23	Poor access within construction job site			
24	Project objective is not well defined			
25	Differing site conditions from the plan			
26	Material storage location			
27	Complex designs in the provided drawings			
28	Rework			
29	Change orders from the owners			
30	Misunderstanding between the owner, the contractor and the designer			
31	Disputes with the owners			
32	Increase in the price of materials			
33	Violations of safety laws			
34	Insufficient lighting			
35	Implementation of Government Laws			
36	Weather conditions			
37	Shortage of water or power supply			
38	Inadequate construction method			

39	Design changes			
40	Inspection delays			

Please add other CLP factors which in your opinion are influential in Malaysian Context

1	5	9	13	17
2	6	10	14	18
3	7	11	15	19
4	8	12	16	20

Appendix B Data Collection Field Survey Questionnaire

SURVEY QUESTIONNAIRE

Tajuk Penyelidikan Penyelidikan: Pembinaan Pekerja Produktiviti - Penyiasatan Demografi

Penyertaan berharga anda akan membolehkan pasukan penyelidik untuk mendokumenkan petunjuk penyelidikan yang mempengaruhi produktiviti buruh pembinaan dari perspektif kakitangan pembinaan. Maklumat yang diberikan akan disimpan secara rahsia dan nama dan gabungan anda akan dikeluarkan daripada data tinjauan yang dimasukkan dalam penyelidikan yang diterbitkan. Terima kasih kerana masa dan input anda.

Bahagian 1

i	Nama				
ii	Lelaki/Perempuan				
iii	Bilangan tahun pengalaman kerja pembinaan				
iv	Kedudukan kerja semasa				
v	Nama syarikat				
vi	Umur				
vii	Warganegara	Malaysian	Indonesian	Bangladeshi	Lain-lain:
viii	Pendidikan	Tiada persekolahan	Diploma	Ijazah/Degree	Lain-lain:
ix	Status Perkahwinan	Single	Berkahwin	Bercerai	Lain-lain:
x	Gaji/Day (8hrs)	RM 30 – RM 50	RM 51 – RM 60	RM 61 – RM 70	RM 71 – RM 80
	RM 81 – RM 90	RM 91 – RM 100	RM 101 – RM 110	RM 111 – RM 120	RM 121 atas

LIST OF PUBLICATIONS

Title	Journal	Status
Problems Affecting Squatter Settlements in Nampula, Mozambique	International Journal of Engineering & Technology	Published on March 2019
Review of Sustainable Construction Practices in Malaysian Construction Industry	International Journal of Engineering & Technology	Published on March 2019
Identifying Motivational and Demotivational Productivity Factors in Qatar Construction Projects	Engineering, Technology & Applied Science Research	Published on April 2019
Construction Labour Productivity: Review of Factors Identified	International Journal of Construction Management	Published on June 2019
Challenges in water resources of Lagos mega city of Nigeria in the context of climate change	Journal of Water and Climate Change	Published on September 2019
Modelling Labour Productivity using Support Vector Machine and Random Forest Classifiers	International Journal of Construction Management	Under Review

Comparative Modelling of Construction Labour Productivity Factors in Malaysian Residential Projects	Architectural Engineering and Construction	Under Review