Construction Site Management and its Influence on Project Implementation in Nairobi County

Bonface Maturi Nyabioge, Stephen Diang'a, Abednego Gwaya

Abstract: Construction site management has become more complex than ever since a number of resource flows (operatives, information, finance as well as materials) have to converge simultaneously at the workface in order to ensure successful completion of construction projects. This research sought to assess the impact of site management factors on projects implementation in Nairobi County. The selected site management aspects that were investigated in relation to project implementation included; material management, labor management, health and safety management, commercial/cost management and information management.The study utilized a survey research design and the target population was made up of commercial/ mixed urban development buildings (only projects worth more than Kenya shillings 100 million were considered) under construction in Westlands constituency. A sample of 40 projects were picked randomly and questionnaires were administered to construction project managers. The survey achieved a 68% rate of return of questionnaires. Data analysis involved cleaning, sorting and coding of raw data collected from the field and processing for purposes of interpretation by use of R software version 3.4.3. The data analysis procedures adopted used both descriptive and inferential statistical methods and the results were presented in form of statistical equation models, tables, charts and graphs in a simple and comprehensive manner. The results indicated that, the selected site management factors contribute significantly to the prediction of successful project implementation. This findings were justified by the following statement; proper health and safety management had the greatest impact on probability of successful project implementation with a probability of 99.4%, cost management had a probability of 97.4% while labour management had a probability of 83.9%. The second highest probability of successful project implementation was material management with 98.9% while information management had a probability of project success of 93.6%. Finally, a well-defined site management system was suggested to aid construction project managers in achieving control over the flow of basic resources (personnel, finance and materials) and processes, eased information exchange and increased customer and stakeholder satisfaction (as a result of meeting the project objectives).

Keywords: Construction Site Management, Project Management, Project Implementation.

I. INTRODUCTION

Despite the Project Management Institute focusing on nine distinct areas (Project integration management, scope management, time management, cost management, quality management, human resource management, communications management, risk management and finally procurement management) that require the project manager's knowledge and attention, Gwaya et al (2014) added that field/site management was also one of the major areas that needed to be addressed.

To fully understand site management, it begins with the recognition of what project management is. According to the Project Management Institute (2004), project management is the application of knowledge, skills, tools and techniques to project activities in order to meet project requirements. Hence, Olubunmi et al (2014) asserts that, site management involves mobilization and coordination of various aspects of a project as well as creation of an enabling environment for construction activities i.e. ensuring safety. Mossman (2008) stressed that a number of resource flows must converge simultaneously at the workface – operatives, information, finance as well as materials in order to create value. Therefore, proper site management can be very crucial for any project to succeed.

The need for improved and efficient project delivery has called for an integrated process to be laid in place in order to enhance project productivity. Evidence by Kimondo et al (2015) indicated that over 50% of construction projects in Kenya were failing by not meeting their cost projections, time schedules, quality demands or safety targets. These statistics informed that, high sense of management acumen, capabilities, skills and strategies were required during execution of projects. This study therefore, sought to fill the existing gap through development of a system that utilized modern technologies in managing site aspects effectively and efficiently.

II. OBJECTIVES OF THE STUDY

- ✓ To investigate how material management influenced construction projects implementation in Nairobi County.
- ✓ To find out the influence of labour management towards construction projects implementation in Nairobi County.
- ✓ To establish how health and safety management affected construction projects implementation in Nairobi County.
- ✓ To evaluate the relationship between commercial management and construction projects implementation in Nairobi County.
- ✓ To establish how management of information affected construction projects implementation in Nairobi County.

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Mr. Bonface Maturi Nyabioge, Student, Masters in Construction Project Management, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Nairobi, Kenya

Prof. Stephen Diang'a, Department of Construction Management, School of Architecture and Building Sciences (SABS), Jomo Kenyatta University of Agriculture and Technology (JKUAT), Nairobi, Kenya.

Dr. Abednego Gwaya, Department of Construction Management, School of Architecture and Building Sciences (SABS), Jomo Kenyatta University of Agriculture and Technology (JKUAT), Nairobi, Kenya.

III. RESEARCH METHODOLOGY

Considering the objectives in the current study, a survey design was deemed suitable for this research. The study was conducted in Nairobi County, Westlands constituency in particular and a sample size of 40 construction project managers randomly selected from 40 on-going commercial/ mixed urban development projects (only projects worth more than Kshs100 million were considered) was utilized in this research. The response rate by the construction project managers indicated an overall percentage of 68% which was satisfactory to provide necessary information for the analysis. Data analysis was carried out using both descriptive and inferential (binary logistic regression) statistical methods.

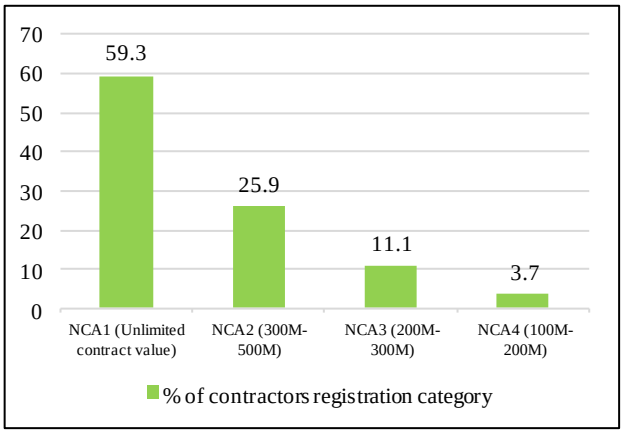
Codes ranging from 1 to 5 were assigned to each variable and average scores were computed to create latent variables (material management, labour management, cost management, health & safety management and information management) used in logistic regression analysis. These latent variables where broken down into two categories by their respective medians. The two categories per variable were poor management coded as 0 and proper management coded as 1. The logit model took the form as illustrated below:

$$ln\left\{\frac{p}{(1-p)}\right\} = \beta_{1X_1} + \beta_{2X_2} \ldots\ldots\ldots \beta_{nX_n} + \beta_0 + \varepsilon_i \quad (1)$$

Whereby;
ln = the natural logarithm, $\log_{exp}$, where exp = 2.71828……
p = the probability that the event Y occurs, p(Y=1)
Y = Outcome variable (successful project implementation)
β = Regression coefficient estimates
$\mathbf{x_{1...n}}$ = Site management factors (material, labour, health & safety, cost & information)
$\underline{\varepsilon_i}$ = Error term

IV. RESEARCH FINDINGS

A. Demographic Characteristics of the Respondents

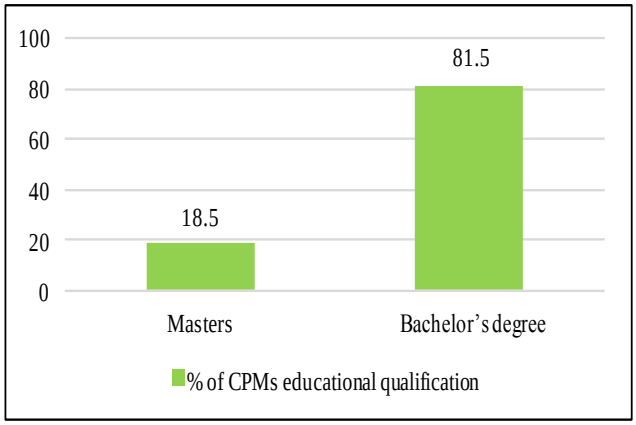


Source: Field survey, 2017

Fig 1: Contractors' Registration Category

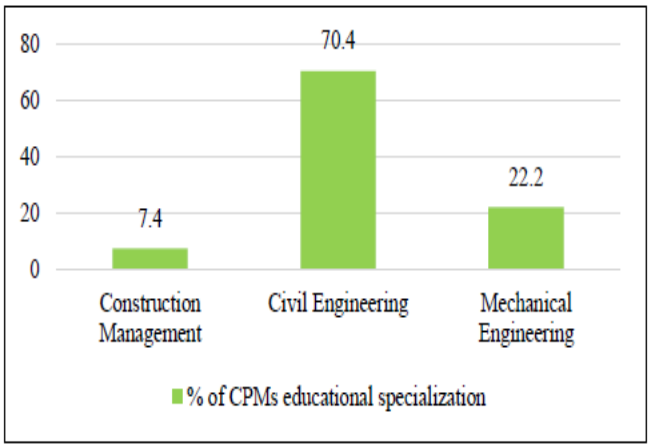
Fig 1 shows the percentage distribution of contractors' registration category according to the National Construction Authority. Virtually 59.3% of the contractors are registered as large contractors (NCA1) handling projects with unlimited contract value, 29.5% are NCA2 contractors handling projects that cost Kshs 300 million to Kshs 500million, while the remaining 11.1% and 3.7% are NCA3 and NCA4 contractors handling projects costing between Kshs 200-300 million and between Kshs 100-200 million respectively. This results revealed that, the construction project managers' organizations handle large projects which involves site management complexities and as such are more experienced to respond to this study enquiry.

Fig 2 below is a representation of the construction project managers' highest educational qualification. 81.5% of the respondents hold Bachelor's degrees while 18.5% of the project managers hold Master's degrees. This results confirms that most of the construction project managers are knowledgeable and competent enough to manage contractors' project contracts.



Source: Field survey, 2017

Fig 2: Construction Project Managers' Educational Qualification



Source: Field survey, 2017

Fig 3: Construction Project Managers' Educational Specialization

Fig 3 above reveals that, 70.4% of the respondents specialized in civil engineering, 22.2% were mechanical engineers while only 7.4% of the construction project managers specialized in construction management. This informed that, all the construction project managers were educated on core construction courses hence, competent to respond to this study enquiry and this ensured the content validity of the data obtained.

Table 1: Construction Project Managers Experience

Experience (yrs.)	Mid value (X)	Frequency(F)	FX
Less than 5	2.5	7	17.5
5-10	7.5	10	75
10-15	12.5	8	100
Over 15	15.0	2	30
Total		**27**	**222.5**
Mean Years of Experience = ΣFX/ΣF=8.24			

Source: Field survey, 2017

Table 1 depicts that, the construction project managers had a mean of 8.24 years of experience. The experience of the respondents supports the belief that, people with long experience are more conscious and conversant with strategies of handling site management challenges. A similar view is held by Kibe (2016) who found out that, working experience is likely to influence health and safety management (this was one of the variable investigated in this study) implementation as workers with long experience are more conscious of health and safety risks associated with construction works.

B. Binary Logistic Regression

The hypothesis tested is;

Null hypothesis:

Site management factors do not contribute significantly to the model or the site management factors have no significant relationship with successful project implementation. The null hypothesis can be statistically stated as;

$$\mathbf{H_o: \beta_1 = \beta_2 = \ldots\ldots \beta_n = 0} \quad \mathbf{(2)}$$

Alternative hypothesis:

At least one of the site management factors contributes significantly to the model or at least one of the site management factors has a significant relationship with successful project implementation. This can be statistically stated as;

$$\mathbf{H_a: At\ least\ one\ \beta_n \neq 0} \quad \mathbf{(3)}$$

The initial analysis of the logistic regression equation (Model 1) included the site management factors as per the questionnaire and the equation is as shown below;

$$\mathbf{Success = \beta matmgt + \beta lmgt + \beta cmgt + \beta hsmgt + \beta imgt + \beta_0 + \underline{\varepsilon}_I} \quad \mathbf{(4)}$$

Whereby;

Success = Successful project implementation
matmgt = Material management
lmgt = Labour management
cmgt = Cost management
hsmgt = Health & safety management
imgt = Information management

The above equation did not provide an overall good fit for the data with a Hosmer Lemeshow goodness of fit test of χ^2 at d.f = 3, 11.58, p-value = 0.008976 (p<.01) of which implies that at $\alpha = 0.05$ the model does not fit the data.

However, during analysis it was discovered that the failure of Model 1 to fit the data was due to the exclusion of an important interaction term. This interaction term (interaction between health & safety management and information management) was subsequently introduced into the model. The following logistic regression equation (Model 2) was the final equation used for analysis and it included an interaction term between health & safety management and information management.

$$\mathbf{Success = \beta matmgt + \beta lmgt + \beta cmgt + \beta hsmgt + \beta imgt + hsmgt : imgt + \beta_0 + \underline{\varepsilon}_I} \quad \mathbf{(5)}$$

The above equation fits the data well at $\alpha = 0.05$ with a Hosmer Lemeshow goodness of fit test of χ^2 at d.f = 3, 7.67, p-value = 0.0534 (p>.05). A summary of both models is as illustrated in table 2.

Table 2: Logistic Regression Models

	Model 1				Model 2			
Variables	**β**		**SE**	**OR**	**β**		**SE**	**OR**
Constant	-5.5261	***	1.0960	0.00	-7.7618	***	1.2935	0.00
Material Management	2.8050	***	0.6676	16.53	4.5104	***	0.8758	90.96
Labor Management	1.7991	**	0.5654	6.04	1.6480	**	0.5349	5.20
Commercial/Cost Management	2.9503	***	0.6430	19.11	3.6407	***	0.6775	38.12
Health & Safety Management	1.3620	**	0.5394	3.90	5.1175	***	1.3151	166.92
Information Management	1.1408	**	0.5337	3.13	2.6848	***	0.7014	14.66
Health & Safety Management: Information Management					-5.5167	***	1.5543	0.00
-2LL	31.48				39.98			
χ^2	62.97, df = 5, p<.001.				79.96, df = 6, p<.001.			
Nagelkerke R^2	49.91%				59.84%			
Hosmer Lemeshow test	p = 0.0090				p = 0.0534			

Notes:
**=p<.05; **=p<.01, ***=p<.001.*
SE = Standard Error
OR = Odds Ratio
Source: Field survey, 2017

C. Regression Output Interpretation

From the final logistic regression equation (Model 2), the following interpretation was made regarding the site management factors relationship with the outcome variable (successful project implementation). The overall significance of the logistic model given by the Likelihood Ratio Test (LRT) was χ^2 at d.f = 6, 79.96, p-value = p>.001 implying that at $\alpha = 0.05$ the site management factors contribute significantly to the prediction of successful project implementation. We therefore concluded that there was a statistical significance for all factors under equation analysis. This was further confirmed using Wald tests that are used to evaluate the significance of a single coefficient in a model. The Wald tests for each of the coefficients in the model were as indicated in table 3.

Table 3: The Wald Tests

Coefficients	χ^2	d.f	Wald		95% confidence interval	
Constant	36.0	1	-6.00	***	0.000026	0.004329
Material Management	26.5	1	5.15	***	18.8307	596.2195
Labor Management	9.5	1	3.08	**	1.8693	15.4626
Commercial/Cost Management	28.9	1	5.37	***	11.2363	164.9062
Health & Safety Management	15.1	1	3.89	***	16.5970	3048.343
Information Management	14.7	1	3.83	***	3.9695	63.6993
Health & Safety Management: Information Management	12.6		-3.55	***	0.000139	0.066216

Notes: **=p<.05; **=p<.01, ***=p<.001.*
Source: Field survey, 2017

The logistic regression coefficients give the amount of log odds increase in successful project implementation when site management factors are properly managed. They can be converted to odds ratios for easy interpretation whereby they would suggest an increase in odds of successful project implementation given that the site management factors are properly managed. The following is an interpretation of the odds ratio from table 2 as well as the probabilities of successful project implementation for each of the site management factors.

- ***Material management***

Odds of successful project implementation are 90.96 times higher when there is proper material management compared to poor material management holding all other factors constant.

- ***Labour management***

Odds of successful project implementation are 5.2 times higher when there is proper labour management compared to poor labour management holding all other factors constant.

- ***Commercial/cost management***

Odds of successful project implementation are 38.12 times higher when there is proper cost management compared to poor cost management holding all other factors constant.

- ***Health and safety management***

Odds of successful project implementation are 166.92 times higher when there is proper health and safety management as opposed to poor health and safety management holding all other factors constant.

- ***Information management***

Odds of successful project implementation are 14.66 times higher when there is proper information management compared to poor information management holding all other factors constant.

- ***Health and safety management and information management interaction term***

Interaction occurs when the presence of one factor modifies the effect of another i.e. the effect of one factor differs according to which category of the other factor is being examined. It is an important property of a relationship between two factors and their influence on an outcome variable. When interaction is present, variation between stratum-specific rate ratios is not simply due to chance (as may be in confounding). i.e. there's significant difference in the stratum specific rate ratios beyond what is explainable by chance/random error.

The coefficient for the interaction is the difference in the effect of health & safety management between levels of poor management and proper management of information. So, the effect of moving from poor management level to proper management of health & safety management when we have proper information management is 10.6342 (5.1175 - -5.5167) whereas, the effect of moving from poor management level to proper management level of health & safety management when we have poor information management is 5.1175. This means that log odds of project success increases by almost twice when we have proper information management and proper health & safety management in a project in comparison to when you have poor information management and proper health & safety management.

- ***Intercept***

The intercept (constant) represents the logit of probability of successful project implementation if all the site management factors are absent. Therefore, the coefficient for the intercept represents a decrease in the log odds of successful project implementation by -7.7618 given that all the other site management factors are absent.

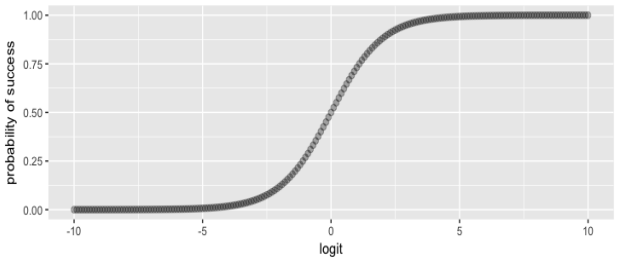


Fig 4: Conversion of Logit (Coefficients) to Probabilities
Source: Field survey, 2017

From fig 4 we can conclude that proper health and safety management has the greatest impact on probability of successful project implementation with a probability of 99.4%, cost management has a probability of 97.4% while labour management has a probability of 83.9%. The second highest probability of successful project implementation is material management with 98.9% while information management had a probability of project success of 93.6%.

V. PROPOSED SYSTEM FOR CONSTRUCTION SITE MANAGEMENT

ID	Site Factor	Recommendations
1	Material management	➢ Use of Oracle prime in scheduling ➢ Tracking deliveries done by GPS & DR ➢ Protection from theft and bad weather done using UAVs, RFID & WSN ➢ Waste mgnt catered with Oracle prime, RFID & WSN ➢ Inventory control done by Oracle prime, RFID & UAVs
2	Labour management	✓ Use of Oracle prime in scheduling, quality control and work monitoring. ✓ Use of RFID, UAVs & 4D simulations to complement Oracle prime in tracking work progress
3	Health & safety management	➢ A health & safety officer with a diploma as the minimum educational qualification. ➢ Use of Oracle prime, RFID & UAVs to monitor site activities ➢ 4D simulations using Navisworks software to manage site space for safe operations.
4	Commercial/cost management	✓ Variations & cash flows to be managed using Oracle prime Projects cloud service. ✓ 5D simulations using Navisworks software to visualize the project status. ✓ Payment management done using Oracle Textura cloud service
5	Information management	➢ Use of Oracle prime Projects to store information in the cloud. ➢ Collaboration can be enhanced through use of Oracle prime, Oracle Textura, Revit & Skype

Source: Field survey, 2017

Fig 5: Construction Site Management System Architecture

Where;

DR: Dead reckoning, **GPS:** Global positioning system, **RFID:** Radio Frequency Identification Device, **UAVs:** Unmanned aerial vehicles (drones), **WSN:** Wireless Sensor Network System

✓ *Material Management*

With the right scheduling technology (Oracle Prime Projects Cloud Service) ordering and supplier's error due to inaccurate data can be minimized (ORACLE, 2017). According to Fadiya (2012), use of GPS alone suffers from signal masking and multipath error in dense urban areas, hence a combination of two technologies (GPS & DR) in tracking deliveries. Materials can be tagged using RFID technology, allowing managers to see actual products moving on site while WSN technology can help protect materials from damage by real-time measurement of temperature and humidity (Fadiya, 2012). Drones can be used to monitor and track workers on site hence, controlling theft of materials (Higgins, 2017). Additionally, drones can be mounted with the right computing tools to carry out volumetric measurements of materials such as sand and gravel (Dillow, 2016).

✓ *Labour Management*

Oracle Prime Projects Cloud Service has the capability of breaking down activities into smaller tasks with role requirements enabling field workers to decide the best way to execute their work with maximum efficiency and minimal waste (ORACLE, 2017). In addition, the root causes of delays and incomplete work are easily identifiable while using the cloud solution since the project team enters/ logs in the reasons for missed commitments for incomplete tasks.

Use of drones to supervise construction sites by taking high resolution photos and video footage of the work progress keeps project managers constantly informed on the progress of their projects without having to make regular trips on site (McPartland, 2017). By utilizing RFID technology, construction project managers can capture the identity of each worker entering or leaving a site by means of tags attached to hardhats. 4D simulations using Navisworks software can be embraced for visualized planning (Chau et al, 2004).

✓ *Health and Safety Management*

The Oracle Prime risk management capabilities provides the necessary tools that develops risk-response plans where post-response scenarios are compared with pre-response results (ORACLE, 2017). RFID technology provides information of all workers and their location thus, in the event of an emergency, supervisors would know, in real time, who is where for safe evacuation. Drones are capable of close-up surveillance of even the tallest and most inaccessible structures and can help site managers to ensure that all work is carried out in compliance with even the most stringent health and safety regulations (Parsons, 2017). Finally, 4D simulations using Navisworks software can be used to manage site space for safe operations.

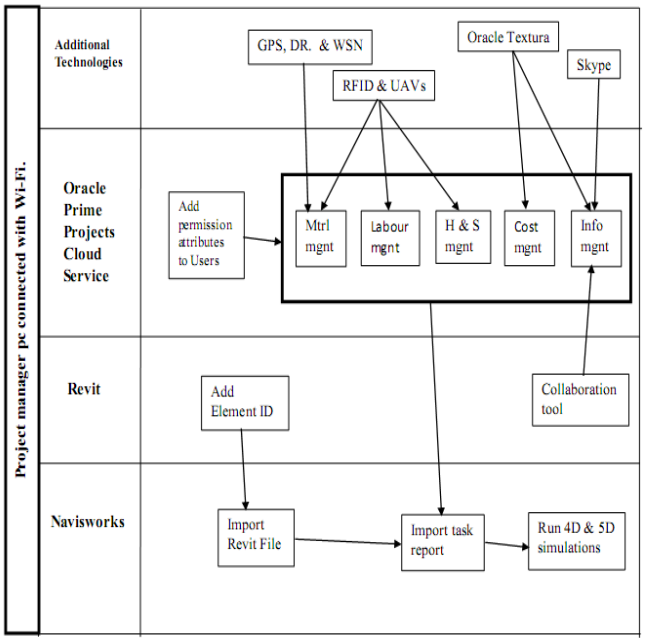
✓ *Commercial/Cost Management*

Oracle Prime Projects Cloud Service allows project managers to utilize a spreadsheet-like interface for cash flow management and the social features in the cloud service, including discussions and share functionality, enable users to review files, communicate changes and have greater context for more informed decision making (ORACLE, 2017). 5D simulations using Navisworks software can be embraced to visualize the project status (Wong et al, 2014). Oracle Textura Payment Management Cloud Service offers optional early payment to contractors and subcontractors hence, addressing the cash flow and working capital challenges arising from the industry's long and inconsistent payment waiting times (ORACLE, 2016).

✓ *Information Management*

Oracle Prime Projects Cloud Service eliminates the obstacles of paper work on the jobsite by enabling project managers and field teams to create and manage project documents in the cloud (ORACLE, 2017). The collaboration tab in Revit software can be used by the project team members to co-author models using the Building Information Modeling (BIM) process thus, giving the team members faster access to the most current models. Instead of having the project team to come to site for meetings,

Skype for business application has been recommended as a convenient and inexpensive way to communicate. Finally, Oracle Textura Payment Management Cloud Service enables users to sign and exchange documents electronically (ORACLE, 2016).



Source: Field survey, 2017

Fig 6: Integration of Modern Technologies in Site Management

VI. CONCLUSIONS AND FUTURE RESEARCH

The findings indicated that, the site management factors under equation analysis contribute significantly to the prediction of successful project implementation. The proposed site management system will undoubtedly aid construction project managers to achieve control over the flow of basic resources (personnel, finance and materials) and processes, eased information exchange and increased customer and stakeholder satisfaction (as a result of meeting the project objectives).

This study recognized from its findings, areas of concern and importance to construction site management that could not be studied appropriately in the course of this work, hence are worthy for further study.

- ✓ Since this study addressed the subject of site management in building construction projects, it would be interesting to study the subject of site management in civil construction projects and compare the results.
- ✓ Future studies are required to further advance the capability of the proposed site management system, including a more comprehensive testing of the system in real construction sites.

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AUTHORS PROFILE

Mr. Bonface Maturi Nyabioge, Student, Masters in Construction Project Management, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Nairobi, Kenya

Prof. Stephen Diang'a
A. Academic Professional Qualification
B. Architecture (U.O.N), M. Arch (U.O.N), PhD (Kwazul Natal), RSA
B. Specialization
Construction Project Management, Construction Contract, Documentation, Project Risk Management, Architecture

Dr. Abednego Gwaya
A. Academic Professional Qualification
B.A (Bldg. Econ.) Hons; University of Nairobi, MSc. (Civil Eng.); Makerere, Ph.D (Constr. Eng. & Mngt.); Jomo Kenyatta University of Agriculture and Technology (JKUAT) M.A.A.K. (Q.S); C.I.Q.S.K; Registered Q.S.
B. Specialization
Construction Project Management, Civil Engineering Construction, Contract Documentation, Project Management Modelling, Project Procurement Systems and General Quantity Surveying.