EVALUATION OF COST VARIATION IN SUBSTRUCTURAL WORKS OF BUILDINGS (CASE STUDY OF KATSINA MASS HOUSING ABUJA)

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ABSTRACT

No matter how detailed and precise a Bill of Quantities (BOQ) is, variations are inevitable. Information regarding the extent to which these variations affect construction cost are very scanty especially for sub structural works. This research evaluates the cost variation in sub-structural works of building projects (Katsina mass housing estate). Systematic random sampling technique was used and a total of 74 numbers of duplexes was taken as the sample size out of 107. Data were sorted from the BOQ for the project and thorough physical re-measurement of sub-structural works was estimated. Consequently the mean of each sub structural works were calculated from which the percentage cost variation of each item of work in substructure were determined. Sub-structural components which are largely dependent on prices of goods like cement and reinforcement had marginal variation while others which are dependent on ground conditions like back filling, laterite filling had gross variations. Comparing the means for both measured and re-measured costs showed that the difference was significant.

Keywords: Bill of Quantities, Provisional Items, Variation Order

INTRODUCTION

The current economic recession in the country (Nigeria) has given rise to clients becoming more aware and concerned regarding the cost of construction projects. This in turn, has made funds unavailable and inadequate as capital for construction purpose. Hence, it becomes necessary for clients to ensure that, the amount available for construction is optimally utilized. Clients are often concerned with three key issues; the quality of construction work, the cost and the duration of works. In terms of cost, Quantity Surveyors are employed because they

ISSN: 2277-0097

provide a variety of services both at the design and construction stages to forecast the probable cost of the project and the final cost of the construction project respectively. For these reasons clients are demanding for a better cost control technique to arrive at a logical and balanced cost amongst all elements within a building and also the total construction cost.

No matter how detailed and precise a BOQ is, variation is inevitable. Variation is the alteration or change in the original scope of works, which could be in form of addition or omission. It is also known as variation order, change order or variation instruction. Once a construction contract is finalized or completed, alteration in any form in the contract will be referred to as variation, unless the said contract has provided for such variation prior to the contract agreement or alternatively the parties to the contract makes a further valid agreement to counter this variation (Allan & Keith, 2002). Variation could be as a result of poor ground condition, design changes, and provisional sums among others. One cannot rule out the possibilities of site condition been different as to what was anticipated, largely due to unforeseen circumstances.

Thus, it is quite difficult to estimate accurately the cost of construction, as it usually varies between the estimated cost and the final cost of a construction project (Kodwo & Allotey, 2014).Quantity Surveyors prepare Bill of Quantities (BOQ) for construction project, which is the probable cost of projects, but these BOQ do contains sums which are not of exact measurement yet these sums take reasonable percentage of the total cost of construction. These sums include; provisional quantities, provisional sums, prime cost sum and contingency sum. The above listed sums are meant for items of work that are uncertain, though measured, items of work that are unknown, works that are not executed by the contractor, and works that might have been overlooked respectively (Ikpo, 2008). The more the provisional sums and quantities are inserted into contract bills, the less the precise and realistic will be the initial contract sum with respect to the final cost. An ideal bill of quantities is that which contain neither prime cost, provisional sum nor provisional quantities (Ogunsemi, 2007).

Thus, it is a known fact that there are variations in final cost of construction project largely due to incorporation of provisional sums and quantities in the BOQ; however, the extent to which these variations affect the construction project cost is by and large unreported. Hence, the title evaluation of cost variation in sub-structural works of buildings" The study is further guided by the following objectives;

I. To identify causes of variation in substructure of building projects.
II. To determine the cost of measured and re-measured quantities of substructure in four bedroom duplexes and their percentage cost variation.
III. To determine the extent of variations between measured and re-measured cost of sub structural works of building projects

The following are the null and alternative hypotheses

H_0: There is no significant variation between measured and re-measured cost of sub-structural work of building projects.

H_1: There is significant variation between measured and re-measured cost of sub-structural work of building projects.

LITERATURE REVIEW

Bill of Quantities, Provisional Items

Construction industry plays a dominant role in any country's economy and it is over 50% of fixed capital product of Nigeria. It is correctly referred to as a major index of nation's economy (Obiegbu, 2002; Nkachukwu, 2008).

Construction project owners have identified some causes of cost overruns as; incomplete drawings, inadequate planning, escalating material cost, lack of timely decision and excessive change orders (Kodwo & Allotey, 2014; Robert F. Cox, 2007).

A survey conducted by Nkachukwu (2010) studied the causes of high construction cost in Nigeria. Construction professionals identified delay and cost overrun as the ultimate factor which leads to high cost of construction.

Cost overruns have obvious effects for the key stakeholders in particular and the building construction in general. To the client who could be non-construction professional, cost overruns simply is an added cost above the initially agreed sum in the pre-contract stage, while to a construction expert, cost overruns means inability to deliver value for money which could dent their image or reputations leading to loss of confidence reposed in them by clients and to the contractors, cost overrun means loss of profit for non-completion and defamation that could hinder his/her chances of winning any other contracts, if at fault. In the construction industry as whole, cost overrun could result in project abandonment and less construction activities, bad reputation and inability to secure projects at higher costs due to added risks (Kodwo & Allotey, 2014).

BOQs are generally used for numerous services such as; interim valuation, cost planning, cash flow, budgeting, and final account. They are also used in contracting firms for preparing material schedule and labour schedule. However there are some items in building projects which due to inadequate information are not measured accurately or in details in the BOQ. These sums in the BOQ are meant for items of work that are uncertain although they were measured (provisional quantities), items of work that are unknown (provisional sum), works that are not executed by the contractor (prime cost sum), and works that might have been overlooked (contingency sum). Quantity Surveyors usually allow arbitrary figures as provisional sums, provisional quantities and prime cost sum in the BOQ. They are separately described as for the defined or undefined work (Allan and Keith 2002). Provisional sums, provisional quantities prime cost sums and contingency sums are basically the key items that reduce the accuracy of Bill of Quantities (BOQ). Whenever an item of work or measured quantities is termed 'provisional in the BOQ; it means, that item of work is subject to re-measurement, as it is just an estimated quantity not the actual quantity.

Olusegun (2010) stated in his research, which examined the causes and effects of adjustments of prime cost and provisional sums on building projects in Nigeria. He collected data for the research through questionnaire and interviews, which he administered to Quantity surveyors and Architects of at least 10 years' experience who practiced in the south west of Nigeria. He used relative importance index in the analysis of his results, which signifies that adjustment to prime cost Sum, provisional sum and quantities resulted from items that were incomplete prior to tender documents preparation, haste in documentation and inadequate preparation of BOQ and designs. Resulting from his research, the negative effects are cost overrun and time overrun, while the positive effects is the fact that the contractor is paid fully for the work executed. The negative effects can be minimized through adequate pre-tender planning, consultants must not be in haste to prepare contract documents, and designs of all items must be well thought-out to be effective and efficient, from which the BOQ is prepared for the items prior to tender.

Variation Order

Variation simply means alteration or change in the original scope of works, which could be in form of addition or omission. It is also known as variation order, change order or variation instruction. Once a construction contract is finalized or completed, alteration in any form in the contract will be referred to as variation, unless the said contract has provided for such variation prior to the contract agreement or alternatively the parties to the contract makes a further valid agreement to counter this variation (Allan & Keith, 2002). It is almost inevitable for construction projects not to vary from the original work embarked upon; be it small, medium, or large projects, the design, specifications, cost, or time must have deviated from the original work. This inevitable phenomenon can be attributed to numerous factors such as; advancement in technology, changes in condition, statutory changes, inadequate specified materials, changes in design due to continuous development and lots more.

Variation instruction brings about disputes among individuals involved in a project and could subsequently affect a project. Therefore, it becomes necessary to control variation order through identification of its causes and effects on construction projects.

Aftab, et al., (2014) used a well-structured questionnaire for data collection and an average index analysis the data collected. Results showed construction projects in Malaysia always experience variations in JKR projects. In their research the most important causes were; design complexity, poor workmanship, poor equipment, schedule changes and hindrances towards making decision.

Variations in substructure of buildings can be tied to so many causes, which are further categorized in to; client's causes, consultants, contractors and other causes. Sunday et al., 2010, Muhammad et al., 2010, Ismail et al., 2012, Menon et al., 2014, highlighted numerous causes of substructure variation in building projects as;

Ground Condition and Substructure of Buildings

Prior to the commencement of design for any construction project, it is expected that geotechnical investigation to be carried out. The investigation is strictly for design purposes which will enable engineers determine the most suitable and appropriate design for a particular location. Assessment of site condition and its stability is very important for an Engineer to determine the appropriateness of a site for a particular construction work. Economy can be achieved in foundation cost of buildings through proper evaluation of allowable bearing pressure of the soils by ensuring adequate geotechnical investigation prior to the commencement of the BOQ. Soils of low bearing capacity or ground instability may result to minor or major failure of a building or structure. The bearing capacity of a soil lies in its ability to withstand both dead and life load without appreciable settlement. The bearing capacity of soils defers, depending on the type of soil. Peats, sand, and expansive clay all have very low bearing capacity.

However, these soils with low bearing capacity can still carry load of buildings depending on the foundation type designed to suit the soil in question. Soil with good bearing capacity usually are not difficult to identify, they have some characteristics which include;

1. If the foundations of adjacent buildings show no signs of settlement
2. There is no evidence of landslides in the vicinity.
3. There is no evidence of buried services.
4. There is no organic soil, peat or soft clay.

Alexander, et al., 2012, stated explicitly in their research on the assessment of building collapse in Nigeria that collapsing of buildings could be as a result of many factors among which i highlighted few that are paramount to my research, they are; adoption of wrong foundation, lack of approved structural design, poor building material specifications, poor concrete mix, ineffective supervision and inadequate preliminary works.

METHODOLOGY

This research used quantitative approach in obtaining data. Data collection was in two stages; office data and field/site data. Office data entails extraction of measured quantities and its corresponding cost of sub-structural works from the prepared Bill of Quantities for the entire project. Field data was collected on site, through physical measurement of the substructure of some buildings within the estate. The required sample size for this research was determined using this formula: n= p (1-P) ÷[(e^2/Z^2) + P (1-P)/N] ÷R (Watson, 2001). A systematic random sampling technique was employed in this study to have an unbiased selection of buildings and contractors within the estate. There is no specific percentage that is accurate for every population but what matters is the actual number or sample size (Watson, 2001), using the formula below:

$N = p\,(1-P) \div [(e^2/Z^2) + P\,(1-P)/N] \div R$
(1)

Where;
n = sample size required,
N = population size,
P = estimated variance in population, as a decimal: (0.5 for 50-50, 0.3 for 70-30),
e = Desired Precision, expressed as a decimal (i.e., 0.03, 0.05, 0.1 for 3%, 5%, 7% etc.),
Z = Confidence level: 1.96 for 95% confidence, 1.64 for 90% and 2.58 for 99% and
R = Estimated Response rate, as a decimal (50% = 0.50, 75% = 0.75)

Using: $n = p\,(1-P) \div [(e^2/Z^2) + P\,(1-P)/N] \div R$
P = 0.3, e = 0.07 Z = 1.64 N = 107 R = 0.75
$n = 0.3\,(1 - 0.3) \div [(0.07)^2/ (1.64)^2 + 0.3\,(1 – 0.3)/107] \div 0.75$
$n = (0.21) / (1.82 \times 10^{-3} + 1.96 \times 10^{-3}) \div 0.75$
$n = (0.21) / (3.78 \times 10^{-3}) \div 0.75$
$n = 55.55 \div 0.75 = 74.07$
n = 74
Based on equation (1) above the sample size required for this research is 74.

From a list of 107 numbers of duplexes (population for the study) where all sub-structural works were remeasured, calculated sample size is 74 numbers of duplexes, which is selected from the total population for the study, by picking every 4th duplex on the list of 107 duplexes. The selections are as follows; 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52, 56, 60, 64, 68, 72, 76, 80, 84, 88, 92, 96, 100, 104, 3, 7, 11, 15, 19, 23, 27, 31, 35, 39, 43, 47, 51, 55, 59, 63, 67, 71, 75, 79, 83, 87, 91, 95, 99, 103, 2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, 54, 58, 62, 66, 70, 74, 78, 82, 86

DATA COLLECTION

Data collection process carried out in this study was in two stages; office data and field/site data. Office data involved in the extraction of measured quantities and its corresponding cost of sub-structural works for the selected sample size, from the prepared Bill of Quantities for the project. The re-measured quantities with its corresponding costs for phase I and II were extracted from valuation, which is also an office data. Field data were collected on site by the researcher, through physical measurement of the actual depth, width, volume of concrete in foundation, number of blocks used, volume of backfill etc. The researcher examined and measured all of the above listed items of work in substructure for phase III of the project for the selected sample size within the estate

ANALYSIS AND DISCUSSION OF RESULTS

A bar chart showing the average measured and re-measured cost of substructure of 74 numbers of duplexes

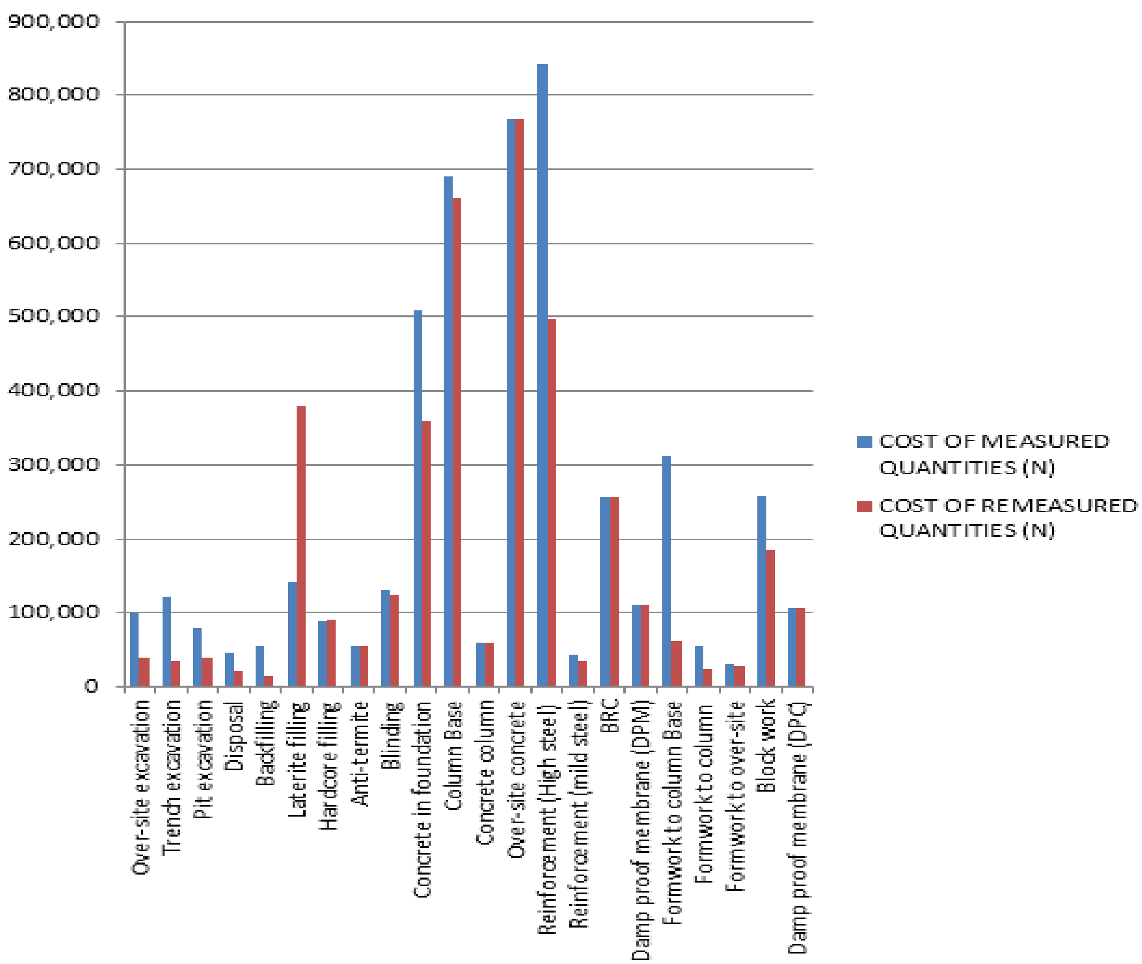

Figure 1: Bar Chart Showing Variations in Sub-Structural Works

Similarly, a ratio of the total variation cost of sub-structure, figure 2 illustrates the percentage cost of each item of work in substructure to the total variation cost of substructure. Reinforcement, formwork to column base and laterite filling takes up to 77.9% of the total variation cost of substructure while other items shared 22.09% of the remaining cost of substructure.

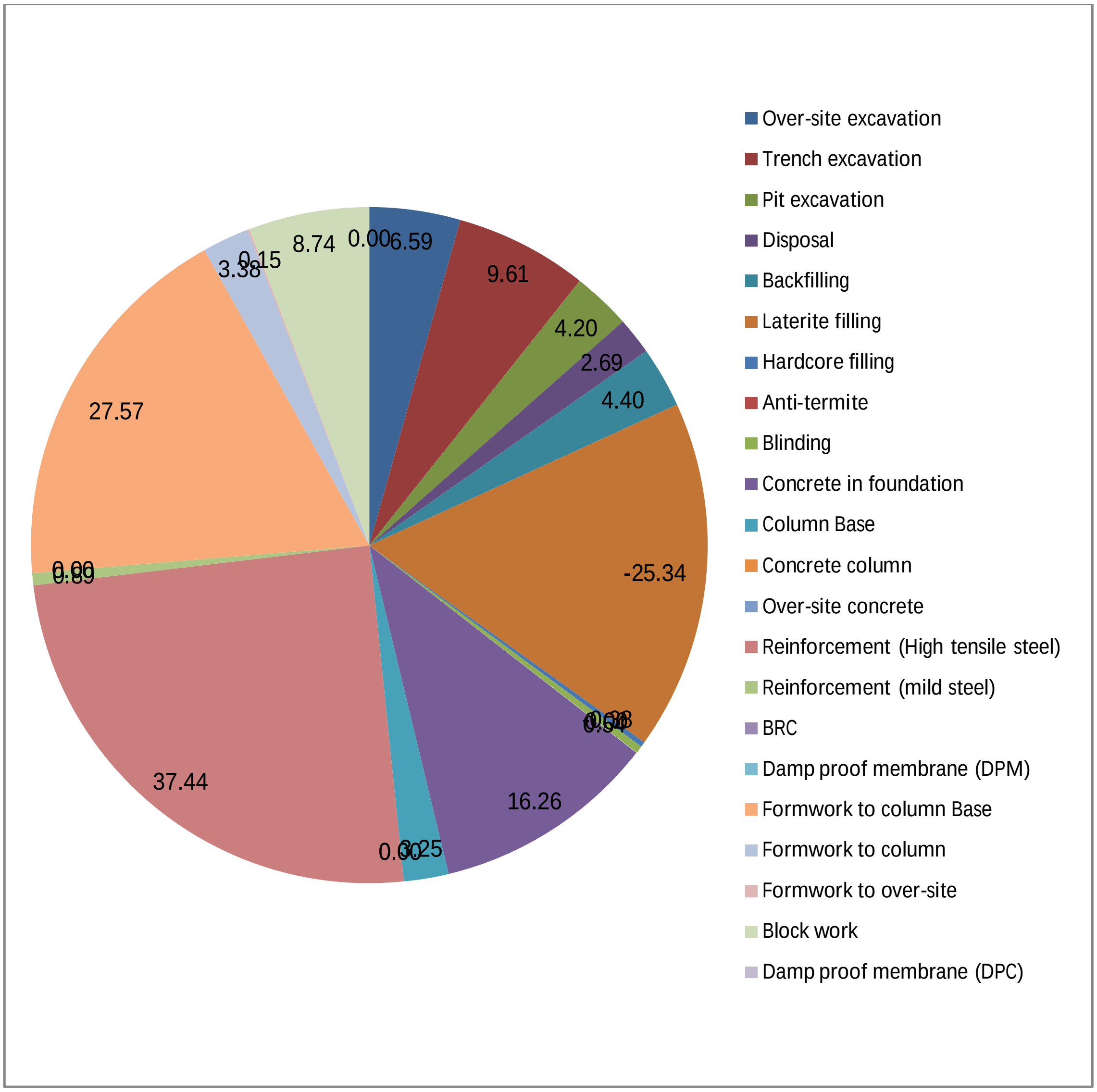

Figure 2: Pie Chart showing Percentage Cost of each Item of Work in Sub-Structure

Paired sample T-test was used to determine the level of significance between the cost of measured and re-measured works in duplexes, with a 95% confidence interval. The results of the T-test are summarised in table 1 below.

Table 1: Summary T – Test Result

Analysis no	Variables X_1	X_2	Inferences Mean Values	T_{cal}	T_{tab}	Remark
1	Cost of Measured Substructure Works	Cost of Remeasured Substructure Works	X_1 =220921.7 X_2 = 180,005.9	1.777	1.721	SSD

KEY:
SSD = Statistically Significant Difference

In the paired sample T – Test employed, the mean cost observed for the measured substructure works was =₦220, 921.70, while the mean cost for the remeasured substructure works was =₦180, 005.9. The observed T calculated value from the analysis was 1.777, while the T tabulated value from statistics table was 1.721. Since the value of T calculated was shown to be greater than the T tabulated value, then there is significant difference between the measured and remeasured cost of substructure works. Alternatively, the calculated p-value was found to be 0.09, while the established p-value for this research is 0.05. Therefore, since the calculated p-value is greater than the established p-value, then there is significant variation between measured and remeasured cost of substructure works for the 74 projects studied. The null hypothesis was therefore rejected and the alternative hypothesis accepted.

CONCLUSION

This research evaluated the extent of cost variation in sub-structural works of building projects. The research concluded that, the difference is significant between measured and remeasured cost of sub-structural works and thus have a great impact on the final construction cost. However, more attention should be given to earth works, as laterite filling had the highest cost variation and the only item of work with a negative cost variation. It is therefore, recommended as a precondition that, proper soil investigation should be carried out before estimating the cost of substructure to avoid such disparities.

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Reference to this paper should be made as follows: Abdulrahman Rilwan Shuaibu & Abdulrahman Hassan Shuaibu (2016), Evaluation of Cost Variation in Substructural Works of Buildings (Case Study of Katsina Mass Housing Abuja). *J. of Environmental Sciences and Resource Management,* Vol. 8, No. 2, Pp. 43– 51.