

# A Comparative Analysis of Standard Labour Outputs of Selected Building Operations in Nigeria

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**Abstract** The study compared the labour outputs of building operatives in sixteen work items of concrete work and blockwork across the South East of Nigeria. A total of six organised building sites were selected using purposeful sampling technique. Assumed labour outputs were obtained through a questionnaire survey administered to the operatives and determined labour outputs were obtained through a detailed work study. Student t-test and Pearson correlation coefficient ( $r$ ) were implied to assess the statistical significant difference between the claimed and determined labour outputs of the operatives. The results showed that the determined labour outputs were consistently lower than the claimed outputs with varying degrees (i.e. between 5% and 50%). The results further revealed from t-values,  $r$  and p-values that the determined labour outputs were statistically different from the claimed labour outputs from the operatives at 5% significant difference and degree of freedom of 10 in all the work items considered. This pointed to the fact that cost estimates and programmes based on guess figures could be misleading and unreliable. The study has provided basis for estimating and planning using the determined labour outputs for the work items studied, and also served as a stepping stone for further escapade in other aspects of building works and building types. It therefore urged the practitioners to desist from making use of guess figures of labour output in determining the cost estimates of or designing the construction programme for building projects. It then recommended further studies where labour outputs of other building operations and building types, other than the ones considered in this study could be determined using the same process.

**Keywords** Building Operations, Construction Programme, Cost Estimation, Labour Outputs, Work Study

## 1. Introduction

There is a dearth of reliable information on output levels of building operations in Nigeria [1]. This is so because there are no established output figures for different construction operations which could be used for estimating in the country. Firms base their outputs for estimating and planning purposes on experience which at best are educated guesses [2].

Most times estimates are based on information obtained from site operatives, using similar priced Bill of Quantities of previous projects and updating the bill items by percentages or by mere physical adjustment. According to Wood [3] we should beware of readily accepting any information from an operative without being completely satisfied that he understands precisely what is meant by your question.

Although most Quantity Surveying firms maintain cost libraries [4], such as the monthly Builders and the Quantity

Surveyors' magazine which usually contain information on construction matters and current prices of labour and materials in the various states of the Federation; there is even construction price book [5] which also contains prices of labour and materials in Nigeria. None of these contains data on outputs of construction operatives except Consol's Nigerian building price book [6] which has very scanty information on Nigerian construction workers average output and local daily charges.

Attempt by Alumbugu et al. [7] yielded little improvement but could not be generalised. Standardisation in construction is primarily aimed at establishing standards in the use of labour, materials and machines. These three elements in standardisation are sometimes referred to as technological standards or constants [8]. Standards in the use of labour are standard time ( $S_t$ ) and standard output ( $S_{op}$ ). Standard time is the quantum of time which it takes a workman or group of workmen to produce a good quality product under an ideally organised labour force and working condition. Its unit of measure is hrs/m, hrs/m<sup>2</sup>, hrs/m<sup>3</sup>. Standard output is the quantum of good quality work accomplished by a workman or group of workmen in one working shift or working hour or day under ideally organised labour and working condition. The unit is usually m<sup>2</sup>/hr or m<sup>2</sup>/day, m<sup>3</sup>/hr or m<sup>3</sup>/day [8].

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Published online at <http://journal.sapub.org/ijcem>

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According to Udegbe [9], there is no known standard theoretical yardstick for determining the financial value of painters daily output. This he said leaves clients with the choice of paying any sum of money for services rendered. While it is recognised that there are no established standards for different construction operations in the country, there is no sufficient justification to leave production outputs in the realm of guesses [10].

Sometimes estimators depend on constants obtained from operatives on one site for estimating purposes. Needless to say that rash, off-the-cuff, wild guess can subsequently inflict a heavy financial punishment. To buttress this point Olomolaiye and Ogunlana, [1] aver that the outputs of joiners, bricklayers and steel fixers in seven public institution building projects in Oyo State of Nigeria, determined on the sites were lower than the claimed outputs of the operatives. The differences between claimed and determined outputs in each task vary between 3% and 42% [1]. However, this was not statistically verified in that it was based on the aggregate mean difference between the claimed and observed outputs of the operatives.

Therefore, based on the earlier work of Okoye, Ngwu and Ezeokoli [10], this study is aimed at comparing the labour outputs developed through detailed work study (determined standard output) and claimed labour outputs of operatives on different building work operations in six selected building projects in the South-East Nigeria. It also determines statistically if significant difference exist between the claimed labour output of the operatives and determined labour output in the selected building operations in the projects also selected for the study.

## 2. Methodology

Six building sites were first surveyed in the South East States of Nigeria to determine quantifiable construction activities, sites located in a planned environment, organised sites with almost the same working practices, sites with reputable indigenous contractors, and sites in stages of construction suitable to the processes under investigation. These would facilitate the comparative study and analysis for acceptable results.

Concrete work and blockwork in superstructure were the building processes studied. They were broken down into operations to facilitate subsequent synthesis. Concrete work involved operations like batching of materials into a mixer, transportation, placing and compaction. Blockwork operations include batching of materials into a mixer, transportation of mortar, placing of mortar and setting of blocks in place. Each operation involves certain number of tradesmen and labourers to carry them out.

Furthermore, activity sampling was carried out, particularly field counts. The processes where field count was carried out in this study included concreting, carpentry, cutting, bending and fixing of reinforcement, and block laying; each with a given number of operatives made up of

skilled manpower and labourers which form the gang. Field counts, that is a quick count at random intervals of the number of operatives working and not working at a given time were observed and recorded. An indication of the performance such as:

$$\text{Activity rating} = \frac{\text{Number of active workers}}{\text{Total number of workers}} \times \frac{100}{1} \quad (1)$$

Thereafter, a full time scale time study was carried out using stop watch for each operation that makes up the activity for each process by observing and recording the start and finish duration of each operation per shift for different cycles. According to Harris and McCaffer [11], time study is the measurement of the time required to perform a task so that an output standard of production of a worker or group of workers may be established. It is the application of techniques designed to establish the time for a qualified worker(s) to carry out a specified job at a defined level of performance [12, 13].

Such information is required in the estimating process, in setting financial incentives, as part of the data in method study, and can also be used to monitor actual performance against the standard expected. Therefore, the quantity of work carried out by each gang per eight-hour working day was subsequently measured and recorded in the time observation sheet.

The ratio of masons to labourers for reinforced concrete floor slab was two masons to thirteen labourers, seven labourers to two masons for reinforced concrete columns, two iron benders for reinforcements; seven carpenters for formwork to suspended slab; two carpenters for formwork to sides of column and one labourer to two masons for blockwork. The uniformity of gang size and mode of operation made comparative analysis possible. For each operation that make up an activity and on each site time study was carried out randomly on chosen days (not less than three times) during the entire investigation period in order to obtain different durations and quantity of work completed.

The tradesmen through the site engineers were asked to respond through the questionnaire on the estimated quantity of work they carried out randomly on chosen days for an eight-hour working day. This was to enable data to be generated, computed and analysed for the claimed labour outputs. The questionnaire contained information on the area of floor slab; height of designated columns; number of planks used for the designated columns and slab; lengths of reinforcements and their diameter cut and fixed in position; number of cut and bent stirrups; and number of blocks laid per a given period (usually eight-hour working day). Standard output given as:

$$\text{Standard output} = \frac{Q}{t} \quad (2)$$

Where  $t$  is the time taken to accomplish quantum of work  $Q$  in an eight-hour working day.

To statistically determine if significant difference exist

between the claimed labour output and determined labour output, the mean outputs of the two sample groups were compared using student t-statistic testing, since the sample size for each the study was less than 30.

Thus, student t-statistic is given as:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{S_p^2 \left[ \frac{1}{n_1} + \frac{1}{n_2} \right]}} \quad (3)$$

Where  $\bar{X}_1$  and  $\bar{X}_2$  are sample means for claimed and determined labour outputs respectively;  $S_1^2$  and  $S_2^2$  are sample variances;  $n_1$  and  $n_2$  are sample sizes, and

$$S_p^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2} \quad (4)$$

$$\text{Degree of freedom (df)} = n_1 + n_2 - 2 \quad (5)$$

$$S_1^2 = \frac{\sum (x_1 - \bar{x})^2}{n_1 - 1} \quad (6)$$

$$\bar{X} = \frac{\sum x_1}{n} \quad (7)$$

Thus, let the claimed labour output be  $X_1$ , and the determined labour output be  $X_2$ .

Also let the variances of claimed labour output in existence be  $S_1^2$ , and the determined labour output be  $S_2^2$ .

**Decision:** Reject  $H_0$  if t-calculated is greater than

t-tabulated at 5% significance difference and degree of freedom of 10; otherwise accept  $H_0$ .

However, it is not enough determining the significance difference of the group means using only simple t-test, there is need to establish significance of variability of the differences by measuring the effect size. An effect size is simply an objective and standardized measure of the magnitude of observed effect [14]. In this case, the strength of the differences between the means was determined using Pearson Correlation Coefficient ( $r$ ). Pearson Correlation Coefficient ( $r$ ) expresses the relationship between the groups and the outcome variable.

Pearson Correlation Coefficient ( $r$ ) can be easily obtained from common test statistics. Therefore,  $r$  is a function of the observed t-value and the degree of freedom on which it is based [14]. Pearson Correlation Coefficient ( $r$ ) is given as:

$$r = \frac{t}{\sqrt{t^2 + df}} \quad (8)$$

Where  $r$  is correlation coefficient,  $t$  is t-value and  $df$  is degree of freedom.

The value of  $r$  ranges from 0 to 1, where 0 means there is no effect and 1 represents a perfect effect.

**Decision:** Reject  $H_0$  if p-value is less than 0.05 ( $p < 0.05$ ) at 5% significance difference and degree of freedom of 10; otherwise accept  $H_0$ .

Both the determined and claimed outputs were computed, analysed and compared in tables 1 and 2.

**Table 1.** Results of computed average claimed and determined labour outputs for different building work operations

| S/N | Building Work Operation  | Unit           | Labour Outputs<br>(unit/m- hr) |            | % Difference |
|-----|--|----------------|--------------------------------|------------|--------------|
|     |  |                | Claimed                        | Determined |              |
| 1   | 150mm thick reinforced insitu concrete 1:2:4 – 20mm agg. in slab (first floor)                   | m <sup>3</sup> | 2.12                           | 1.57       | 25.9         |
| 2   | 150mm thick reinforced insitu concrete 1:2:4 – 20mm agg. in slab (second floor)                  | m <sup>3</sup> | 1.99                           | 1.49       | 25.1         |
| 3   | Reinforced insitu concrete 1:2:4 – 20mm agg. in columns (size 450 x 450 x 3000mm) (first floor)  | m <sup>3</sup> | 0.56                           | 0.33       | 41.1         |
| 4   | Reinforced insitu concrete 1:2:4 – 20mm agg. in columns (size 450 x 450 x 3000mm) (second floor) | m <sup>3</sup> | 0.41                           | 0.31       | 24.4         |
| 5   | 16mm diameter high yield bars in columns (size 450 x 450 x 5000mm (first floor)                  | kg             | 44.05                          | 40.09      | 9.0          |
| 6   | 16mm diameter high yield bars in columns (size 450 x 450 x 5000mm (second floor)                 | kg             | 43.09                          | 39.21      | 9.0          |
| 7   | Fix 10mm diameter high yield bars in stirrups in columns   | kg             | 6.18                           | 4.81       | 22.2         |
| 8   | Cut and bend 10mm diameter high yield bars as stirrups   | kg             | 18.17                          | 16.89      | 7.0          |
| 9   | Sawn Formwork to suspended floor slab (first floor)  | m <sup>2</sup> | 8.43                           | 6.50       | 22.9         |
| 10  | Sawn Formwork to suspended floor slab (second floor)   | m <sup>2</sup> | 12.47                          | 6.19       | 50.3         |
| 11  | Sawn Formwork to sides of column (size 450 x 450 x 3000mm) (first floor)                         | m <sup>2</sup> | 0.43                           | 0.25       | 41.9         |
| 12  | Sawn Formwork to sides of column (size 450 x 450 x 3000mm) (second floor)                        | m <sup>2</sup> | 0.31                           | 0.23       | 25.8         |
| 13  | 225mm thick hollow sandcrete blockwork bedded and jointed in cement mortar (1:3) (first floor)   | m <sup>2</sup> | 2.75                           | 2.57       | 6.5          |
| 14  | 225mm thick hollow sandcrete blockwork bedded and jointed in cement mortar (1:3) (second floor)  | m <sup>2</sup> | 2.74                           | 2.53       | 7.7          |
| 15  | 150mm thick hollow sandcrete blockwork bedded and jointed in cement mortar (1:3) (first floor)   | m <sup>2</sup> | 2.79                           | 2.64       | 5.4          |
| 16  | 150mm thick hollow sandcrete blockwork bedded and jointed in cement mortar (1:3) (second floor)  | m <sup>2</sup> | 2.77                           | 2.59       | 6.5          |

### 3. Results and Discussions

Table 1 depicted the computed average claimed and determined labour outputs of the building operatives on different work operations in six selected building projects across the study area. The claimed labour outputs were computed from the results of the questionnaire administered to the site operatives regarding their output level on different work sections. These figures were taken to be assumed or guess from their experiences over the years. However, the determined labour outputs were the results of the detailed work study of the labour output of the same operatives on the same building projects and work operations for a determined period of time in a day (usually eight-hour work).

It was observed that there is marked difference between the claimed labour output and determined labour output in all the building operations under investigation. Further analysis revealed that the difference between the claimed labour output and determined labour output of the operatives ranges

between 5% and 50% in each work item.

However, the percentages represented the minimum and maximum percentage differences between the claimed labour output and the one determined through a detailed work study.

#### 3.1. Test of Hypothesis

To determine the significant difference between the claimed labour output and determined labour output, the following hypotheses are postulated

**H<sub>0</sub>:** There is no significant difference between the claimed labour output and determined labour output of the building operatives on site.

**H<sub>1</sub>:** There is significant difference between the claimed labour output and determined labour output of the building operatives on site.

The results of this analysis are presented in table 2.

**Table 2.** Results of the t-test and correlation coefficient of the average claimed and determined labour outputs for different building work operations

| S/N | Building Work Operation  | Variance of Labour Outputs |                       | t-test value | Corr. Coeff. (r) | p-value              | Decision                          |
|-----|--|----------------------------|-----------------------|--------------|------------------|----------------------|-----------------------------------|
|     |  | Claimed                    | Determined            |              |                  |                      |                                   |
| 1   | 150mm thick reinforced insitu concrete 1:2:4 – 20mm agg. in slab (first floor)                   | 2.74x10 <sup>-2</sup>      | 2.09x10 <sup>-2</sup> | 5.005        | 0.845            | 5.3x10 <sup>-4</sup> | Reject H <sub>0</sub> significant |
| 2   | 150mm thick reinforced insitu concrete 1:2:4 – 20mm agg. in slab (second floor)                  | 2.86x10 <sup>-2</sup>      | 1.87x10 <sup>-2</sup> | 4.592        | 0.824            | 9.9x10 <sup>-4</sup> | Reject H <sub>0</sub> significant |
| 3   | Reinforced insitu concrete 1:2:4 – 20mm agg. in columns (size 450 x 450 x 3000mm) (first floor)  | 1.18x10 <sup>-3</sup>      | 3.02x10 <sup>-3</sup> | 7.098        | 0.913            | 3.3x10 <sup>-5</sup> | Reject H <sub>0</sub> significant |
| 4   | Reinforced insitu concrete 1:2:4 – 20mm agg. in columns (size 450 x 450 x 3000mm) (second floor) | 1.8 x10 <sup>-4</sup>      | 2.2x10 <sup>-3</sup>  | 4.510        | 0.819            | 1.1x10 <sup>-3</sup> | Reject H <sub>0</sub> significant |
| 5   | 16mm diameter high yield bars in columns (size 450 x 450 x 5000mm) (first floor)                 | 1.61                       | 0.18                  | 6.842        | 0.908            | 4.5x10 <sup>-5</sup> | Reject H <sub>0</sub> significant |
| 6   | 16mm diameter high yield bars in columns (size 450 x 450 x 5000mm) (second floor)                | 0.41                       | 0.16                  | 7.872        | 0.928            | 1.4x10 <sup>-5</sup> | Reject H <sub>0</sub> significant |
| 7   | Fix 10mm diameter high yield bars in stirrups in columns   | 3.36x10 <sup>-6</sup>      | 2.7x10 <sup>-3</sup>  | 35.082       | 0.992            | <0.00001             | Reject H <sub>0</sub> significant |
| 8   | Cut and bend 10mm diameter high yield bars as stirrups   | 8.53x10 <sup>-2</sup>      | 0.20                  | 4.769        | 0.833            | 7.6x10 <sup>-4</sup> | Reject H <sub>0</sub> significant |
| 9   | Sawn Formwork to suspended floor slab (first floor)  | 0.26                       | 0.11                  | 6.349        | 0.895            | 8.4x10 <sup>-5</sup> | Reject H <sub>0</sub> significant |
| 10  | Sawn Formwork to suspended floor slab (second floor)   | 1.42x10 <sup>-2</sup>      | 0.11                  | 36.288       | 0.996            | <0.00001             | Reject H <sub>0</sub> Significant |
| 11  | Sawn Formwork to sides of column (size 450 x 450 x 3000mm)(first floor)                          | 1.4x10 <sup>-4</sup>       | 9.2x10 <sup>-4</sup>  | 11.057       | 0.961            | <0.00001             | Reject H <sub>0</sub> Significant |
| 12  | Sawn Formwork to sides of column (size 450 x 450 x 3000mm) (second floor)                        | 9.4x10 <sup>-4</sup>       | 4.8x10 <sup>-4</sup>  | 4.246        | 0.802            | 0.0017               | Reject H <sub>0</sub> Significant |
| 13  | 225mm thick hollow sandcrete blockwork bedded and jointed in cement mortar (1:3) (first floor)   | 3.8x10 <sup>-4</sup>       | 1.6x10 <sup>-4</sup>  | 15.492       | 0.980            | <0.00001             | Reject H <sub>0</sub> Significant |
| 14  | 225mm thick hollow sandcrete blockwork bedded and jointed in cement mortar (1:3) (second floor)  | 1.34x10 <sup>-3</sup>      | 3.8x10 <sup>-4</sup>  | 10.127       | 0.955            | <0.00001             | Reject H <sub>0</sub> Significant |
| 15  | 150mm thick hollow sandcrete blockwork bedded and jointed in cement mortar (1:3) (first floor)   | 1.24x10 <sup>-3</sup>      | 8.8x10 <sup>-4</sup>  | 6.516        | 0.900            | 6.8x10 <sup>-5</sup> | Reject H <sub>0</sub> Significant |
| 16  | 150mm thick hollow sandcrete blockwork bedded and jointed in cement mortar (1:3) (second floor)  | 2.2x10 <sup>-3</sup>       | 1.16x10 <sup>-3</sup> | 6.211        | 0.891            | 0.0001               | Reject H <sub>0</sub> significant |

Table 2 showed the results of student t-test and Pearson correlation coefficient ( $r$ ) computed on the assumed and determined labour outputs to determine the statistical difference or otherwise of the values of the two outputs on the same work operations. The results revealed that in all cases, the computed t-test is greater than the t-critical (3.169) at 5% significance difference and degree of freedom of 10. However, the t-test values from the analysis ranged between **4.246** for sawn formwork to sides of column (size 450 x 450 x 3000mm) (second floor), and **36.288** for sawn formwork to suspended floor slab (second floor).

Likewise, the coefficients of correlation indicated a very strong effect in all cases at the same 5% significance difference and degree of freedom of 10. From the result, the correlation coefficient ranges between **0.802** for sawn formwork to sides of column (size 450 x 450 x 3000mm) (second floor), and **0.996** for sawn formwork to suspended floor slab (second floor). This implies a very strong variability between the group means. It was also observed that the p-value is less than 0.05 ( $p < 0.05$ ) in all cases.

The implication is that the null hypothesis ( $H_0$ ) is rejected in all cases. Statistically, this indicated that there is significant difference between the assumed labour outputs of the building operatives and the determined outputs obtained through a detailed work study for the same items of work on the same building sites. This statistical significance differences are further substantiated by the values of variances of the claimed and determined labour outputs of the building operatives on different work operations in the six selected building projects and the percentage differences between the mean values of different operation (5% to 50%) which also pointed to the fact that there is significance difference between the two labour outputs.

## 4. Conclusions

The dearth of reliable information on output level of building operatives in Nigeria has continued to resonate concerns among the practitioners and other concerned stakeholders in the building industry. The act of using guess data based on experiences or information from the site operatives for cost planning, construction programming and cost estimates have proved to be unreliable, unrealistic and misleading. Thus, the purpose of work study which is to provide factual data to assist management in making decisions and to enable them to utilise with the maximum efficiency all available resources (that is labour, plant, materials, and management) by applying systematic approach to problems instead of using intuitive guess work has provided a reliable alternative.

To this end, this study has presented the results of the assumed labour output of the operatives of building works and determined labour output through a detailed work study on the same building works and projects. It went further to comparing the two outputs, and determined statistically the difference in the two labour outputs. This study has

demonstrated significant difference between the assumed labour output and the determined labour output in building operations studied.

The study has further highlighted the dangers of using guess figures in estimating building works and also underpins the importance of a detailed work study in realisation of acceptable labour constants for building works. It has therefore, provided basis for estimating and planning, using determined labour outputs for the work items studied. It has also given inkling for further escapade in other aspects of building works and building types.

Indubitably, the study has broaden the scope of knowledge in this field of study in the sense, that researchers can now work on the results of the study to further their course of study. Practitioners would also rely on the results of this work to produce a reliable cost estimates and construction programmes for building projects. Finally, the results of this study would minimised the challenges of accurate cost estimate, construction programme, project planning and control, and pricing of bills of quantities through realistic determination of optimal labour output in the execution of building projects.

Based on the enormous potentials of this study, it is recommended that practitioners should desist from making use of guess figures of labour output in determining the cost estimates or designing the construction programme for building projects. Further studies are also recommended, where labour outputs of other building operations and building types other than the ones considered in this study could be determined using the same process.

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