

An Evaluation of the Impact of Temperature on the Productivity of Masons in Residential Building Construction in Warri Area of the Niger Delta in Nigeria

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Abstract - The impact of environmental factors such as temperature is not considered a serious factor in the constitution of wages for laborers in the construction industry in Nigeria. The statistical studies in Warri, south- south geopolitical zone of Nigeria shows that there is significantly no existing relationship between the productivity skilled laborers such as masons, carpenters, plumbers electricians etc. However, because masons have the highest duration on construction sites most of times, and have a greater percentage of work on site, they were chosen for the purpose of this study. Multiple and simple Correlation analysis tool was used to analyse the collected field data. This study is a follow up of a previously conducted research on atmospheric pressure by the same authors. An article published in December, 2017 by International Journal of Innovative Research in Science Engineering and Technology (IJIRSET). The study proves that Productivity of workmen on Hourly basis, is affected statistically by hourly temperature, the efficiency of workmen on daily basis is meaningfully affected by the years of training of the masons, day-to-day yield of workmen is considerably affected by the biological age of masons, their productivity is not considerably affected by temperature variance, and this could be explained by adaptation of masons to temperature variations, daily wage of masons significantly affects their productivity also working experience affects the daily productivity of workmen with younger ones having more productivity as compared to the older ones and competitive atmosphere has a great impact on the productivity of workmen on construction sites.

Key words - Impact, Temperature, Productivity, Masons, Residential Buildings, Construction, Warri Area, Niger Delta, Nigeria.

I. INTRODUCTION

The research work is structured such that a considerable number of workmen in different site locations is studied. Specially designed data collection forms were formulated which has spaces for the recording of different factors under consideration. The data so collected would later be collated, inspected and analyzed using statistical tool SPSS (statistical package for social sciences- correlation/regression analysis) in order to determine the types of statistical relationship that may exist between the productivity masons and atmospheric pressures etc. We shall now take a look at the background of the study.

Furthermore, the Nigerian building industry is mostly of residential bungalows, which are constructed extensively with manual labour. There are mostly of sandcrete block work and generally finished with cement and sand plastering. Housing has been built in Nigeria in an outward progression from major cities, such as Abuja, Lagos, Port Harcourt and Kano, first following rail lines and then automobile paths such as major roads, and highways. Housing in the cities are generally either single-family homes (one unit on one lot) or multifamily dwellings (multiple apartment units on a single tract of land, often of sandcrete construction).

II. OBJECTIVES OF THE STUDY

The objectives of the include;

- 1 The determination of masons' productivity changing circumstances of temperature.
- 2 The determination of the numerical values of the recognized environmental conditions of temperature through construction hours.
- 3 To relate the output of workmen hour/day to the conforming environmental of temperature.

III. FACTORS AFFECTING PROJECT DELIVERY

One of the major problems arising from the delivery of building construction projects is the inappropriate management and optimization of available labour resources on site. In order to adequately appropriate these resources in response to the dynamics of various demands on site, the following constitute the study's problems:

- i) The labour wage structuring and labour regulations in Nigeria do not take into consideration the impacts of environmental factors such as temperature and atmospheric pressure on building construction workers remuneration.
- ii) There are no reliable data available for labour regulators to harness from in the event that the impacts of environmental factors of temperature and atmospheric pressure were to be incorporated in the labour wage structure.

There is justification for the research work as it could generate accurate information on masons (who is the representative of the building construction workers) labour productivity rates under varying climatic conditions of temperature and atmospheric pressures. Also, it may aid estimators in the appropriate pricing for labour, and could aid construction managers/resource planners in optimizing job allocations/and scheduling under same identified and special conditions.

Finally, it could assist labour unions/labour authorities in their negotiations for graduating remunerations for building construction workers based on the environmental factors of temperature and pressure.

About 90 percent of building construction works carried out in Nigeria is constructed with plastered sandcrete block-work. Pilot surveys undertaken in some bills of quantities indicated that both block-work and plastering items constitute at least 35 percent of the initial construction cost of residential buildings. Generally, the net cost of block work and materials for plastering are fixed throughout Nigeria, the variable appears to be labour input. It made it imperative to carry out some scientific studies of estimating such important variable. The work is therefore aimed at;

- a) Availing all stakeholders in building construction works with constraints on mason's labour productivity taking into consideration the effects of weather factors of temperature and atmospheric pressure.
- b) Highlighting some other factors that may affect productivity of building construction workmen such as biological age, span of control, working experience, and years of training etc.

IV. METHODOLOGY

Data Collection

All data obtained from this work was received from Primary source through questionnaires/ recording and site observation. Questionnaires were well designed for the recording of the variables which included number of laid blocks /hour with corresponding temperature. Biological age of workmen, years of experience, number of supervisors and assistants, daily wage and total number of masons on construction site. There was a random selection of masons for the purpose of the study, this study was done on different sites within warri town. Two main trades were selected for this study: plastering and bricklaying.

With the help of specially trained technicians and time clerks, data was collected, the observations were collected in a way they to satisfy 95% interval of confidence and \pm 5% error.

Analysis and discussions based on the Variables identified above.

A total of nine statistical tests were carried out and the following results and discussions were obtained. The table showing the experimental values for the pilot survey

Number of Blocks Laid correlated against the Average Day Temperature.

Results: The correlation coefficient indicates r-value of -0.326 and P-value of 0.358 with the total number of observations.

Discussions: The r-value of -0.326 indicates an inverse relationship though low, between the two variables. This shows that as the average day temperature increases the number of blocks laid reduces and vice a viz. The p-value of 0.358 which is higher than the acceptable 0.05 value at 95% confidence level confirms the low statistical inverse relationship.

Number of Blocks Laid correlated against the Average Day Atmospheric Pressure.

Results: The correlation coefficient indicates r-value of 0.081 and P-value of 0.824 with a total number of observations as in p8.

Discussions: The r-value of 0.081 indicates an insignificant linear relationship between the two variables. This shows that as the average day atmospheric pressure increases the number of blocks laid was indifferent to the pressure changes. The p-value of 0.824, which is very high compared to acceptable 0.05 values at 95% confidence level, confirms the low statistical relationship.

Number of Blocks Laid correlated against the Age of Mason.

Results: The correlation coefficient indicates r-value of -0.591 and P-value of 0.072 with a total number of observations.

Discussions: The r-value of -0.591 indicates an inverse relationship between the two variables. This shows that as the average Age of Mason increases the number of blocks laid reduces and vice a viz. The p-value of 0.072 which is slightly higher than the acceptable 0.05 value at 95% confidence level confirms the inverse statistical relationship.

Number of Blocks Laid correlated against the number of years of Work Experience

Results: The correlation coefficient indicates r-value of 0.019 and P-value of 0.958 with a total number of observations.

Discussions: The r-value of 0.019 indicates a very weak relationship between the two variables. This shows that as the number of years of work experience increases the number of blocks laid reduces slightly increases or of no consequence. The p-value of 0.958 which is higher than the acceptable 0.05 value at 95% confidence level confirms the very weak statistical relationship.

Number of Blocks Laid correlated against the Wage/Day

Results: The correlation coefficient indicates r-value of 1.00 and P-value of 0.000 with a total number of observations as in p8.

Discussions: The r-value of 1.000 indicates a perfect linear relationship between the two variables. This shows that as the average Wage/Day increases the number of blocks laid increases at the same rate. The p-value of 0.000 is extremely perfect compared to the acceptable 0.05 value at 95% confidence level confirms the perfect relationship.

Number of Blocks Laid correlated against the Masons Years of Training.

Results: The correlation coefficient indicates r-value of 0.07 and P-value of 0.849 with a total number of observations.

Discussions: The r-value of 0.07 indicates a very weak relationship between the two variables. This shows that as the years of training increases the number of blocks laid increases slightly or of little consequence. The p-value of 0.849, which is much higher than the acceptable 0.05 values at 95% confidence level, confirms the low statistical relationship.

Number of Blocks Laid correlated against the Number of Supervisors.

Results: The correlation coefficient indicates r-value of -0.326 and P-value of 0.358 with a total number of observations.

Discussions: The r-value of -0.031 indicates an inverse relationship though very low, between the two variables. This shows that as the average number of supervisors' increases the number of blocks laid reduces slightly or of little consequence. The p-value of 0.933, which is much higher than the acceptable 0.05 values at 95% confidence level, confirms the low statistical inverse relationship.

Number of Blocks Laid correlated against Number of Masons working on site.

Results: The correlation coefficient indicates r-value of -0.136 and P-value of 0.708.

Discussions: The r-value of -0.136 indicates an inverse relationship though very low, between the two variables. This shows that as the average Number of Masons Working on Site increases the number of blocks laid reduces slightly or of little consequence. The p-value of 0.708 which is much higher than the acceptable 0.05 value at 95% confidence level confirms the low statistically inverse relationship. The table 1.00 below shows the general summary for the pilot survey results.

Table 1.00: Experimental coefficients for the pilot survey

| Experiment | Variables | R-Value | R2-Value | P-value | Inference | Observation |
|----------------|---|---------|----------|---------|-----------------------------|--|
| Experiment 1.0 | Number of Blocks Laid/Day vs Daily Temperature | -0.33 | 0.11 | 0.36 | Statistically Insignificant | Very weak inverse relationship not enough to conclude that temperature affects productivity significantly |
| Experiment 2.0 | Number of Blocks Laid/Day vs Biological Age of Masons | -0.59 | 0.35 | 0.72 | Statistically Insignificant | Very weak inverse relationship not enough to conclude that biological age of mason affects productivity significantly |
| Experiment 3.0 | Number of Blocks Laid/Day Vs Masons Working Experience | 0.02 | 0.00 | 0.96 | Statistically Insignificant | Very weak linear relationship not enough to conclude that masons working experience affects productivity significantly |
| Experiment 4.0 | Number of Blocks Laid/Day vs Wage/Day | 1.00 | 1.00 | 0.00 | Statistically Insignificant | Very strong linear relationship enough to conclude that daily wage affects productivity significantly |
| Experiment 5.0 | Number of Blocks Laid/Day vs Years of Training | 0.70 | 0.49 | 0.85 | Statistically Insignificant | Very weak linear relationship not enough to conclude that years of training affects productivity significantly |
| Experiment 6.0 | Number of Blocks Laid/Day vs Number of Supervisors | -0.03 | 0.00 | 0.93 | Statistically Insignificant | Very weak inverse relationship not enough to conclude that number of supervisors affects productivity significantly |
| Experiment 7.0 | Number of Blocks Laid/Day vs Number of Masons Working on Site | -0.14 | 0.02 | 0.71 | Statistically Insignificant | Very weak inverse relationship not enough to conclude that number of masons working on site affects productivity significantly |

Source; Field Study, 2017.

Table 2.0: General Summary of Analysis

| Experiments No. | Variables | R Value | R2 Value | P Value | Inference | Observations |
|-------------------------|--|---------|----------|---------|-----------------------------|--|
| Experiments 3.01 | Hourly Number of Blocks laid Vs Hourly Temperature Variation | -0.795 | 63 | 0.01 | Statistically Significant | Very strong inverse statistical relationship to conclude that the productivity was actually affected with change in hourly temperature, as productivity reduces with hourly increase in temperature. |
| Experiments 3.02 | No. of Blocks Laid/Day vs Average Daily | -0.233 | 5.43 | 0.22 | Statistically Insignificant | Weak inverse statistical relationship, not strong enough to conclude that temperature affects productivity significantly, may due to acclimatisation of workmen over a period |

| | | | | | | |
|-------------------------|--|--------|-----|-------|------------------------------------|---|
| Experiments 3.03 | Temperature No. of Blocks Laid/Day vs Biological Age of Mason | -0.812 | 66% | 0 | Statistically Significant | of time. Very strong inverse statistical relationship to conclude that the productivity was actually affected with change in age of masons, as productivity reduces with increase in biological age |
| Experiments 3.04 | No. of Blocks Laid/Day vs Working Experience | -0.477 | 17% | 0.009 | Statistically Significant | Very strong inverse statistical relationship to conclude that the productivity was actually affected with change in working experience, as productivity decreases with increase in age |
| Experiments 3.05 | No. of Blocks Laid/Day vs Average Daily Wage | 0.932 | 87% | 0 | Statistically Significant | Very strong linear statistical relationship to conclude that the productivity was actually affected with change in daily wage, as productivity increases with wage increase. |
| Experiments 3.06 | No. of Blocks Laid/Day vs Years of Training | 0.39 | 15% | 0.04 | Statistically Significant | Very strong linear statistical relationship to conclude that the productivity was actually affected with change in years of training, as productivity increases with increase in years of training. |
| Experiments 3.07 | No. of Blocks Laid/Day vs Number of Assistants | 0.686 | 47 | 0 | Statistically Significant | Very strong linear statistical relationship to conclude that the productivity was actually affected with change in change in number of assistants, as productivity increases with increase in the number of assistants |
| Experiments 3.08 | No. of Blocks Laid/Day vs Number of Supervisors | 0.327 | 11 | 0.08 | Statistically Insignifican t | Very weak linear statistical relationship to conclude that the productivity was actually affected with change in number of number of supervisors, as productivity did not significantly improve with increase in number of supervisors |
| Experiments 3.09 | No. of Blocks Laid/Day vs Number of Masons on Site | 0.542 | 29 | 0 | Statistically Significant | Very strong linear statistical relationship to conclude that the productivity was actually affected with change in number of masons working on site, as productivity increases with increase in the number of masons on site. This might be due to increase competition, ego needs, etc |
| Experiments 3.10 | Area of Wall Plastered vs Average Daily Temperature | 0.209 | 4 | 0.34 | Statistically Insignifican t | Weak inverse statistical relationship, not strong enough to conclude that temperature affects productivity significantly, may due to weather acclimitisation of workmen over a period of time. |
| Experiments 3.11 | Area of Wall Plastered vs Average Daily Atmospheric Pressure | -0.648 | 42 | 0.01 | Statistically Significant | Very strong inverse statistical relationship to conclude that the productivity was actually affected with change in atmospheric pressure, as productivity reduces with increase in pressure |
| Experiments 3.12 | Area of Wall Plastered vs Biological Age of Masons | -0.76 | 58 | 0 | Statistically Significant | Very strong inverse statistical relationship to conclude the productivity was actually affected with change in Biological age, as productivity reduces with increase in age of mason |
| Experiments 3.13 | Area of Wall Plastered vs Masons Working Experience | -0.664 | 45 | 0 | Statistically Significant | Very strong inverse statistical relationship to conclude the productivity was actually affected with change in masons working experience, as productivity reduces as masons gets older. |
| Experiments | Area of Wall | 0.395 | 16 | 0.62 | Statistically | Very strong linear statistical relationship to |

| | | | | | | |
|-------------------------|---|-------|----|------|---|--|
| 3.14 Experiments | Plastered vs Daily Wage No. of Blocks Laid/Day | 0.842 | 71 | 0.00 | insignificant Statistically Significant | conclude that the productivity was actually affected with change in daily wage, as productivity increases with wage increase. |
| 3.15 | vs Average daily temperature, Average daily atmospheric pressure and Age of mason | | | | | Very strong linear statistical relationship to conclude that the productivity was actually affected Average daily temperature, Average daily atmospheric pressure and Age of mason |

Source; Field Study, 2017.

V. CONCLUSION

1. Productivity of workmen on Hourly basis, is affected statistically by hourly temperature variation as shown by the high R^2 value of 63% in the table above.
2. Efficiency of workmen on daily basis is meaningfully affected by the years of training of the masons.
3. Day-to-day yield of workmen is considerably affected by the biological ages of masons with R^2 66%.
4. Everyday throughput of workmen is not considerably affected by temperature variance, and this could be explained by adaptation of masons to temperature variations.
5. Daily wage of masons significantly affects their productivity as shown by R^2 value of 87%.
6. Working experience affects the daily productivity of workmen with younger ones having more productivity as compared to the older ones.
7. Competitive atmosphere has a great impact on the productivity of workmen on construction sites.

(2) The analysis that was based on area of wall plastered by workmen led to the following conclusions;

- (a) Workmen productivity was not significantly affected by the daily temperature variation with R^2 value of 4%.
- (b) Workmen productivity is significantly affected by the biological age of mason, daily atmospheric pressure, and working experience shown by R^2 value of 58%, 42% and 45% respectively.
- (c) Workmen productivity was not significantly affected by daily wage with R^2 value of 161%.

VI. RECOMMENDATIONS

Based on the findings generally, temperature and atmospheric pressure significantly has effect on the workmen productions and since these effects are typically present in most Nigerian building sites, the following are recommended;

- 1) The hourly temperature/atmospheric pressure variations should be studied for geographical zone before construction work commences so that labour rates could be effectively graduated for favourable/unfavourable weather conditions.
 - 2) Labour rates should be marked up to reflect the productive rate of younger workmen between the ages of 35-45 who are more productive on building construction sites than older workers.
 - 3) Adequate time should be allowed for workmen to adapt to weather conditions when there is a need for importation of labour force from outside the climatic zone of the workmen before job allocation commences.
 - 4) As the research showed that there are some adverse effects on workers predominantly by temperature and pressure, it is recommended that all construction sites should be adequately provided with: a) first aid apparatus, b) sufficient drinking water to avoid dehydration, c) workers canteen with sufficient energy building diets.
 - 5) Workmen wages should be based on their productivity and not arbitrary flat rate per day. Such units of measurement as units/day, area in square meter could be adopted.
 - 6) Adequate years of training of personnel should be considered when employing labour.
 - 7) A maximum of 2 numbers of assistants per each workman for skilled job is recommended.
 - 8) A ratio of 1:5, i.e. one supervisor to five skilled labour should be adopted for relatively small site supervision work
- The above recommendations could be implemented in the following ways.

VII. IMPLEMENTATION

In other to implement the above recommendations so as to efficiently deploy labour resources on building construction sites, the following strategies are recommended;

- Seminars, conferences and symposium should be organized for findings to be discussed and contributions obtained from professionals.
- The research findings will be made available to labour consultants and government departments like Federal Ministry of Labour and Productivity for implementation.

VIII. AREAS FOR FURTHER STUDIES

The following could constitute areas for further studies;

- The same study could be carried out in the other zones of the federation that are situated towards the various temperature/pressure area north of the study area.
- Similar studies could also be extended for multi storey buildings and also basements.
- Also, studies for blocks of different sizes, weight, and shape could be carried out.

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