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Lean Production of Sandcrete Blocks: Environmental Implications of Seasonal Climatic Sequence for Waste Generation

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Abstract

A fundamental principle of lean production is anticipating the needs of production and consumption. Lean production seeks to provide a just on time supply of products without maintaining intermediate stock, which would inevitably lead to the generation of waste. This paper explores the effects of seasonality of weather conditions on the consumption of sandcrete blocks, with a view to spotlight discrepancies resulting from seasonal consumption levels. Using the t-test, the study investigates statistically significant differences between consumption and production means for dry and rainy season months on samples collected from fifty randomly selected construction sites and fifty block making industries in Port Harcourt, over a one-year period, to establish their seasonal variation. Significant discrepancies were observed between rainy season and dry season consumption, which did not match the variation in production outputs. The observed discrepancy in consumption and production implies that producers of sandcrete blocks do not fully anticipate consumption demand during the rainy season, leading to excess stock and wastage. The study outcome provides an empirical platform for establishing productivity goals for the production of sandcrete blocks necessary to avoid wastage under unfavourable weather conditions.
Keywords: Climate, Lean Production, Sandcrete Blocks, Season

Introduction

Sandcrete blocks have for many decades been a popular and commonly used walling material, with wide spread production in Nigeria by both small-scale industries and large construction companies (Baiden and Tuuli, 2004). The production of sandcrete blocks in general, is executed in outdoor environment, and is affected by climatic conditions. Weather impact, particularly in humid climates has been reported to be one of the main factors causing productivity losses in construction projects (Mosheli et al, 1996). Port Harcourt is known geographically for its humid climate, frequent down pours of torrential rains (Amadi, 2009). Given this climatic setting undertaking any form of outdoor production is not likely to be without problems. This is because it is a requirement that freshly moulded blocks on pallets, are left in the open field under the sun to cure (Anosike and Oyebade, 2012). The onset of rains will therefore destroy newly moulded wet blocks yet to cure. Inclement weather thus poses problem of short favourable season available for production. Extremes of humidity, are also not conducive to concentration even on congenial task of labour, and will negatively impact drying and curing of sandcrete blocks, affecting their strength, and may lead to wastage during transportation (Weslley and José, 2015). This is because blocks are mostly transported to project sites with the use of small open trucks or wooden carts on two wheels pushed manually, with the attendant risk of breakages occurring during loading and of-loading under inclement weather conditions. Furthermore, the use of sandcrete blocks in the construction, which determines its sales level in Port Harcourt, is also subject to weather conditions as inclement weather causes a lot of upset in site work: disruption of site activities and work stoppage. Synchronising production and consumption patterns, considering the seasonality of weather conditions is thus a fundamental requirement for the lean production of sandcrete blocks in Port Harcourt. The study investigates sandcrete block consumption and production patterns with a view to spotlight discrepancies resulting from seasonal consumption levels.

Sandcrete Block Production

Hodge (1999), defined blocks as those building unit used in the construction of walls and partitions, while Brett (2009) as well as the Nigerian Industrial Standard (2000), described block as a walling unit which is larger than a brick normally either concrete, natural stone or clay. Concrete blocks are extensively used for both load bearing and non-load bearing walls, externally and internally (Barry, 2004). A concrete block wall can be laid in about half the time and it costs up to half as much as a similar brick wall. Light weight aggregate concrete blocks have good insulating properties against transfer of heat and are much used for the inner skin of cavity walls either with a brick outer skin or a concrete block outer skin.

Sandcrete blocks sometimes called concrete blocks are made from a mixture of hard, durable and clean sand, cement and water, which on setting and hardening, attains sufficient strength to be used as walling units (Obabde,1996). When mixed with water, cement has the ability to bind particles of grave or sand together, and when set can perform the functions expected of building and civil engineering structures. Ordinary Portland cement is a material of major importance in construction (Ransom, 2003). Ordinary Portland cement is made into the specifications such as the Nigerian Industry Standard (NIS, 2000) No.11 or the British Standard Specifications No. 12 or some other suitable and approved specifications which may exist in other countries. Sand used for block production are sharp natural pit or river sand, of uniform amount, fine and coarse sizes, washed, screened and graded as necessary to comply with British Standard 882 (Jagboro, 1992). The presence of impurities will thus affect the mechanical properties of blocks (Baiden, and Tuuli, 2004). Furthermore, water to be used for block production, should be pure and fresh from an approved source, which shall be free from oil, acids, vegetable matters and alkaline substances in solution or suspension in appreciable quantities and shall be approved by an engineer (Obabde, 1996).

Andrezj et al. (2004), classified blocks into two main types: the Lightweight and dense blocks. Lightweight blocks are made either with light weight aggregate or with aerated concrete. Sandrete blocks can be categorised in to three types; Types A, dense concrete blocks, density not less than 1500kg/m and type B and C, lightweight concrete blocks, density less than 1500kg/m but more than 625kg/m. The three types are as follows. The standard dimension of Type-A dense aggregate concrete blocks for general use in building including below ground is 390mm long x or 190mm high x 75mm, 90mm, 140mm, 190mm or 215 thick. The blocks are made of cement, natural aggregates or blast-furnace slag. The usual mix is 1 part of cement to 6 or 8 parts of aggregates by volume. These blocks are as heavy per cubic metre as bricks, they are not good thermal insulators and their strength in resisting crushing is less than that of most well-burned bricks. The colour and texture of these blocks is far from attractive and they are usually either painted or covered with a coast of cement rendering. These blocks are used for internal and external load bearing walls. The standard dimensions of Type B: lightweight aggregate concrete blocks for general use in building including below ground, internal walls and inner leaf of cavity walls are 390mm long x 190mm high x 75mm, 90mm, 100mm, 140mm and 190mm thick; or 440mm long x 190mm, 215mm or 290mm high x 75mm, 90mm, 100mm, 140mm, 190mm and 215mm thick; or 590mm long x, or 215mm high and 75mm, 90mm, 100mm, 140mm, 190mm and 215mm thick.

The blocks are made of ordinary Portland cement and one of the following lightweight aggregates, well burnt clinker, saw dust, foamed slag sintered fly and expended clay. Anosike (2011) opined that these types of blocks are not in common use in Nigeria yet, but as most of the materials are by-products of industrial production, they are bound to gain popularity as the nation. The dimensions for type-c: lightweight aggregate concrete blocks primarily for internal non-load bearing walls are 390mm long x 190mm high x 60mm or 75mm thick; 440mm long x 190mm; 215mm and 290mm high x 60mm and 75mm thick. The blocks are made with the same lightweight aggregate as those in type B. These blocks are more expensive than dense aggregate blocks and are manufactured as solid, hollow or cellular depending largely on the thickness of the blocks, the thin blocks being solid and the thicker either hollow or cellular to reduce weight and the drying shrinkage of the blocks (Andrezj et al., 2004).

However**,** a variety of sizes exist locally, some being made to suit the owners handling convenience (Baiden and Tuuli, 2004; Ojo, 2016). These are non-standard though they are factory produced (Akanya, 2008). Most of the blocks produced in Nigeria are of this category (Jagboro, 1992). Commercial blocks in Nigeria are produced to meet standard sizes with varying thickness: 225mm (9 inches), 150mm (6 inches), 125mm (5 inches) and 10mm (4 inches) (Foraminifera, 2014). Blocks of this category are made in accordance with Nigeria's Industrial Standard 13. The actual dimensions are without joints, while the normal dimensions allow for the thickness of joints. Ojo (2016) reported findings on the measurements of blocks produced by 143 block making industries which showed that 31.47% of the respondents adhered to only the external dimensions of the blocks but reduced the thickness of the blocks, while 25.17% made blocks of the correct length and width but reduced the height by 12mm (1/2 inch) as well as the thickness. Ojo (2016) opined that these irregularities in the block dimensions are caused by the non-standardized sizes of moulds, constituting a source of concern amongst clients.

A great number of blocks are wasted during the cutting of halves and other required pieces. With Obabde (1996) suggesting that to avoid this wastage, block manufacturers should be consulted so that halves, three quarters or as would be required on the job, are made. Such consultation is also necessary at the design stage so that the layout of the walls can as possible make use of full and half-length units, ensuring economy in construction.

The production of sandcrete block may be carried out manually or mechanically. The first stage in the production of sandcrete blocks involves the batching of materials (Figure 1). This is carefully determining the proportion of the mix in order for the resultant blocks to meet specific standards. Batching can be carried out either by weight or by volume, small- scale firms typically practicing the later, using head-pans or wheelbarrows. Typically, blocks for load bearing walls should have a mix of one head pan of cement to six head pans of clean sand (1:6). Where a large number of blocks are to be manufactured, batching by weight is the norm, whereby the raw materials are discharged into a weigh batcher, which measures the correct proportion of dry materials for the mix and the mixing done by mechanical means (Ojo, 2016). A concrete mixer is often used, but a pan type mixer should be preferred where it is available as a better result is obtained. The mixing should continue until the cement contents are evenly mixed with the sand. It advisable to mix dry first then add water in sprays. Only sufficient water to enable the hydration of the cement should be added. The mixture should cake when is pressed in between the palm without bringing out water (Obande, 1996).

Figure 1: Batching and Moulding of Blocks

The nature of the mix for the blocks considerably affects the vibration time required for a good filling of the mould and very fine aggregates require a relatively longer vibration time. As shown in Figure 1, blocks are formed in machines with steel moulds, with the mix consolidated by vibrating and compacting. This provides accurately formed block. Thus, the moulds can be removed immediately after impact. Commercial production is by a power driven automated machine with gang moulds that produce thousands of units each day.

Figure 2: Air drying and Storage

The tendency of the block to crumble, shrink and crack is deferred by curing. During curing operation, the blocks are kept moist by wetting so that setting and hardening is gradual. During the drying operation, the moisture content is reduced to average humidity, preventing the moisture of the block from being reduced by the surrounding air at the time of laying. Curing and drying can be accomplished in the open air with protection from the weather as shown in Figure 2 or by blowing heated air through stacked block, by high temperature steam that is curing in sealed kilns, or by high pressure steam curing in a pressure vessel called an autoclave that is filled with saturated steam at a temperature of about 3700. The open-air procedure requires from 2-4 weeks, while the heated air process is more rapid, although steam curing is accomplished in about 12 hours. Ojo (2016) however reported that blocks produced in Nigeria were sometimes left uncured, particularly when they are produced on the site where they would be used.

Blocks should be stacked on a dry surface away from where they will be broken by other activities in the workshop on the site. If during the rains they are likely to be soiled by mud or buried in the wet ground; they must be stacked on a raised platform or old blocks (Baiden and Tuuli, 2004). Blocks are stacked as they will be used in the wall and on no account, should a stack be high as to damage the bottom layers of the blocks. All blocks should be handled with care to avoid chipping the edges and corners. This is especially important if the wall is to be left un-rendered, chipped block make unsightly joints so they will probably have to be discarded (Akanya, 2008).

Nigeria: Weather and Climate

Weather is the day to day changes in the conditions of the atmosphere, while climate is the weather condition of an area over a long period (Aisuebeogun, 2005). The characteristics of weather systems in Nigeria, similar to other West African countries, is driven by the combined effects of pressure and wind systems, whose dynamics is dependent on the surface pressure systems over North Africa and over the South Atlantic Ocean (Nigerian Meteorological Agency-NIMET, 2010). Two major climatic types according to Ojo (1977) can be discerned in Nigeria: the humid and arid climate, which can be further grouped weather conditions into the wet and dry seasons. The wet season lasts from April to September with a peak in June and July. It is during the wet season that we have the heaviest rainfall in Nigeria.

This is because the Tropical Maritime Air Mass carries a lot of moisture from over the Atlantic Ocean and on arriving West Africa, increases the moisture content or humidity of the air and therefore cloud cover evidenced by relative humidity can remain at over 90% for many days. This, moisture condenses on being forced to rise either by convection or over a barrier of high lands or an air mass and then falls back as rain. The moisture also tends to lower the temperature by making the atmosphere less transparent to the sun rays. The pressure distribution in turn has its effect on winds experienced in Nigeria during this season. An air mass (the tropical maritime air mass) is progressively drawn in from the south to west, which is a low-pressure area, as the sun moves northwards. In mid-July it prevails all over the region, becoming the dominant factor, which determines the weather and climate of Nigeria during this season (NIMET, 2010).

The dry season really sets in about October and last till March of the following year, with December/January being the driest months. Temperature then is low, because the sun is in the Southern hemisphere. Since the air mass originates from beyond the Sahara and blows over this desert en-route, it picks up the dry and dusty nature of this desert and so reduces the humidity to the barest minimum. There is complete reversal in the distribution of temperature over West Africa for it is now cooler in the north (below 21^0c) than in the south (over 27^0c). Late December, (the middle of dry season) on West Africa contains all the familiar dry season features. In the early morning, midnight mist still hangs over the ground, the middle of the morning is dry and crisps and the afternoon windy, dusty and hazy. The day ends with a cool, calm evening. Everything dries quickly (cloths, blocks, pond, skin and even leaves). However, it is much more comfortable in the south, where the harmattan lessens the oppressiveness of the heat than in the north where the dry can be very hot and the night very cold and relative humidity even as low as 10% (Aisuebeogun, 2005).

Nigeria's climate is strongly correlated with north-south location, with hot-dry weather conditions being found in the northern parts and progressively changes to warm humid conditions south-wards towards the coast. Ayoade (1988), classified Nigeria into three major climatic zones: the dry sub-humid climate covering states in the northern parts of the country; the moist sub humid climate in the middle belt, and the humid climate in the southern region of the country. Rainfall amounts of 300 – 1000mm are typically experienced in the northeast, northwest and in the central region, which are dry-sub humid. The southeast and southwest, have a moist sub-humid climate and experience about 2000 – 3000mm of rainfall annually. Rainfall amounts between 3000 – 4500mm are typical of the south-south region, with the highest cumulative rainfall amount of 4224.0mm recorded in Port Harcourt, the study area. Annual rainfall is thus least in northern parts of Nigeria, and maximum in southern, particularly towards the coast. Future precipitation projections by the United States Agency for International Development (USAID, 2012) and the Federal Ministry of Environment (2011) further indicate a potential incremental climate change in the south-south, which may experience a wetter climate with an additional 15 cm of rainfall annually compared to present day climate.

Method of Study

Data collection for this research was carried out with the use of structured questionnaires. The questionnaire was administered to Fifty (50) randomly selected block making industries within Port Harcourt city. The questionnaire was designed to solicit information on recorded production: number of sandcrete block on a weekly basis, for a period of 12 months. Data collected from the questionnaire were confirmed to be reliable and used for the research work. Similarly, data on the usage of blocks was collected from fifty randomly selected building construction sites in Port Harcourt for the 12-month period. The construction sites sampled were at various stages of block work progress: from substructure to before the roofing phase, which relayed the demand for blocks. Data on rainfall for Port Harcourt was also collected as obtained from the archives of the Nigerian Meteorological agency, Port Harcourt. The data collected is presented in tabular forms, graphs and analysed descriptively for trends using line graphs. Further to this, correlation analysis is used to infer statistically significant relationship.

At the next phase of analysis, the paired sample t-test, is used to investigate statistically significant differences between consumption and production means for dry and rainy season months. The t-test formula is given below

$$t = \frac{\overline{X}1 - \overline{X}2}{\sqrt{\frac{\left[\sum D_1^2 + \sum D_2^2\right]}{\left[N1 + N2 - 2\right]}\left[\frac{N1 + N2}{N1N2}\right]}} \quad \text{or} \quad \frac{\overline{X}1 - \overline{X}2}{\sqrt{\frac{\sum D_1^2 + \sum D_2^2}{N(N-1)}}}$$

.

Where X_1 = mean of first group

X_2 = mean of second group.

N1 = the number of cases in the first group.

N2 = the number of cases in the second group.

$\sum D_1^2$ = the sum of squared deviation scores of first group.

$\sum D_2^2$= the sum of squared deviation scores of second group.

$$D^2 = \sum X2 - \left(\sum \frac{X}{N} \right)^2$$

If N1 =N2 then $t = \dfrac{\overline{X}1 - \overline{X}2}{\sqrt{\dfrac{\sum D_1^2 + \sum D_2^2}{N(N-1)}}}$

The value of t so obtained is compared to the t-value from statistical table to determine its significance. At this point it is not known which of the samples has a higher cost or by how much. Several procedures are available to answer this question. The approach deployed for this purpose is the use of confidence intervals, which is also based on the t distribution. The confidence interval which is the difference between two population means is found by

$(X_1 - X_2) \pm t\sqrt[2]{MSE(1/N1 + 1/N2)}$ …………………………

Decision Rule: If the confidence interval is positive, X_1 is significantly higher than X_2. If the confidence interval is negative, X_2 is significantly higher than X_1.

Results and Discussion

Figure 3 and 4 shows the amount of rainfall and average block production during the 12 months. Figure 3 shows a steady increase in rainfall amount from 32.2mm in January, reaching a peak of 487.1mm in September, with a steady decline from October to December.

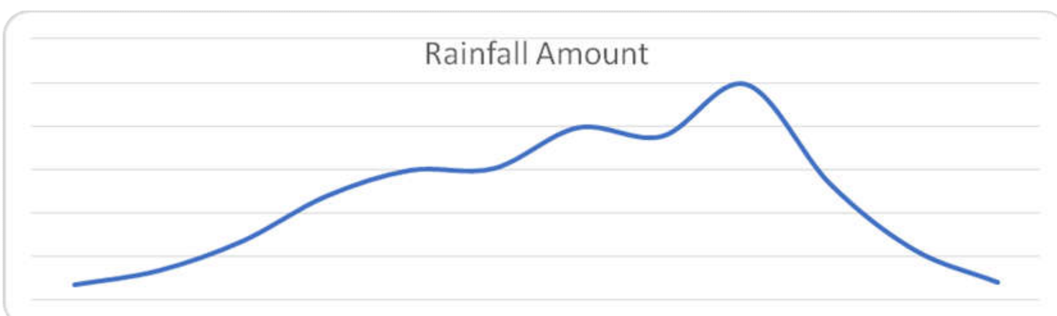

Figure 3: Chart of Rainfall Amount

Monthly consumption among the construction sites as showed in figure 4 depicts the maximum of 233336 blocks and minimum of 143559 blocks utilised in the months of January which experienced the minimum of rainfall of about 36.2mm and September which experienced about 496.1mm of rainfall respectively. It was observed that from the months of April to August/September there was a drastic decline in consumption. There was also a sharp increase in the consumption from October when the dry season started to set in, from about 164137 blocks were consumed, eventually reaching a peak demand peak in January, which had the least amount of rainfall.

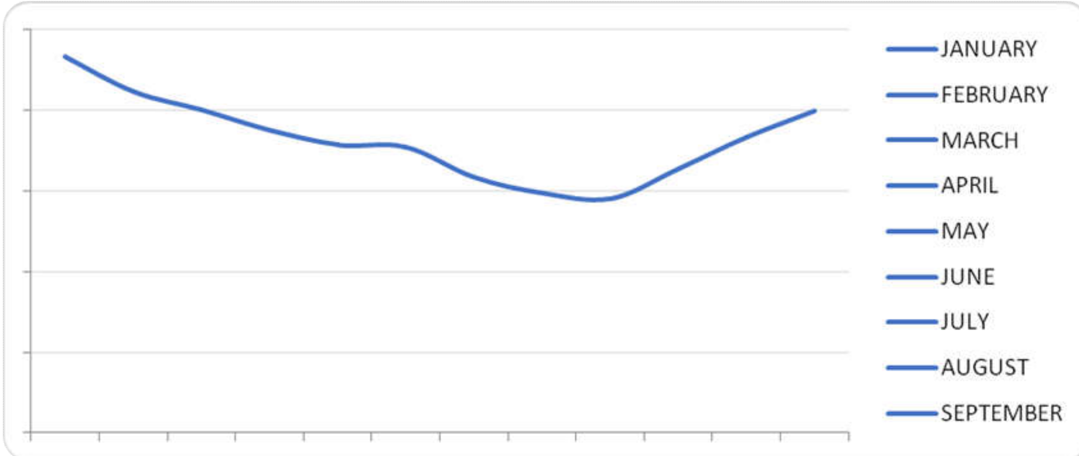

Figure 4: Monthly Consumption of Blocks

Comparative analysis of both charts implies that the demand for sandcrete blocks is in the opposite direction of the rainfall pattern, highest in the dry season when rainfall is minimal and lowest during the wet season. However, the interpretation is only descriptive and fundamentally implies an inverse relationship between the rainfall amount and the consumption of sandcrete blocks. Further inferential statistics using correlation analysis is carried out to determine the strength of the observed association at specified level of significance.

Table 1: Correlation of Monthly Rainfall Amount and Consumption

Months	Season	Rainfall Amount (Mm)	Consumption (No of Blocks)
January	Dry	36.2	233336
February	Dry	68.5	211532
March	Dry	136.3	200395
April	Rainy	239.6	188065
May	Rainy	298.9	178619
June	Rainy	303.3	177429
July	Rainy	396.9	158723
August	Rainy	376.8	149163
September	Rainy	496.1	145414
October	Rainy	268.1	164137
November	Dry	116.9	183559
December	Dry	41.8	199502

The correlation analysis shown in Table 2 returned a value of 0.892 confirming that a strong negative relationship exists between the amount of rainfall and the demand for sandcrete blocks in Port Harcourt at a .05 level of significance.

Table 2: Correlation Analysis Rainfall Amount Vs Number of Blocks

		Rainfall Amount	Number of Blocks
Rainfall Amount	Pearson Correlation	1.000	.892
	Sig. (2-tailed)		.002**
	N	12	12
Number of Blocks	Pearson Correlation	.892	1.000
	Sig. (2-tailed)	.002**	.
	N	12	12

** Correlation is significant at .05 level

This statistically reaffirms the literature, that weather is a key determinant of productivity on construction sites.

T-Test for significant differences in Production and Consumption means

The following hypotheses were structured to test for statistically significant differences in production relative to consumption during the dry season and rainy season months.

1. Ho-The rate of production in dry season is equal to the rate of consumption in dry season

   Ho: $U_1 = U_2$ ………………………(1)

   H_1: The rate of production in dry season is not equal to the rate of consumption in dry season

   H_1: $U_1>U_2$ ………………………….(2)

   H_1: $U_1<U_2$ ………………………….(3)

2. Ho: The rate of production in rainy season is equal to the rate of consumption in rainy season

   Ho: $U_1 = U_2$ ………………………..(4)

   H_1:The rate of production in rainy season not equal to the rate of consumption in rainy season

   H_1: $U_1>U_2$ ………………………….(5)

   H_1: $U_1<U_2$ ………………………….(6)

Where U_1 and U_2 are production and consumption means. Table 3 contains data on number of blocks produced relative to consumption, dichotomised into rainy season and dry season months.

Table 3: Total Weekly and Monthly Production

DRY SEASON				**WET SEASON**			
MONTH		**Production**	**Consumption**	**MONTH**		**Production**	**Consumption**
NOV	1	39732	37321	APR	1	41363	24417

	2	44131	43047		2	39762	41548
	3	44218	39110		3	39899	38378
	4	42008	20081		4	47747	43722
DEC	1	52657	50987	MAY	1	41551	40534
	2	48186	34171		2	44278	51539
	3	43991	38436		3	47513	47319
	4	52063	55908		4	36350	39427
JAN	1	46036	47260	JUN	1	52082	43168
	2	52726	53441		2	44695	33349
	3	60960	56727		3	39251	36978
	4	60244	55908		4	34578	43934
FEB	1	53405	47984	JUL	1	47371	45578
	2	51446	48513		2	39405	52169
	3	50841	43748		3	42309	37042
	4	53912	41287		4	34578	43934
MAR	1	45866	39190	AUG	1	31519	35698
	2	56416	56618		2	39467	39298
	3	56767	56054		3	35501	31094
	4	54782	48533		4	32984	43073
				SEPT	1	44452	45091
					2	39338	39931
					3	31074	29931
					4	32604	41461
				OCT	1	36765	42832
					2	45325	43503
					3	42756	38580
					4	42898	39222

Hypothesis 1

Table 4 shows the results of the t-test for paired samples, carried on the number of blocks produced and consumed during the dry season months.

Table 4: T-Test for Blocks Production and Consumption During Dry Season

	Variable 1	*Variable 2*
Mean	50519.35	50066.2
Variance	36174562.03	42437559.64
Observations	20	20
Pearson Correlation	0.984461353	
Hypothesized Mean Difference	0	
Df	19	
t Stat	2.75385363	
P(T<=t) one-tail	0.05536861	
t Critical one-tail	1.729132812	
P(T<=t) two-tail	0.11073722	
t Critical two-tail	4.655024054	

Inference: The T-calculated value (2.754) is lesser than t-tabulated value (4.655) at 19 degrees of freedom. The p-value of 0.11073722 returned for the two-tail test, is also higher than the specified alpha level: $p > .05$, hence, the null hypothesis (Ho) is retained because the result is not significant, implying that there is no statistically significant difference between the mean of production and mean consumption of sandcrete blocks in Port Harcourt during the dry season. It can thus be inferred that the supply and demand for sandcrete blocks in dry season, closely match each other.

Hypothesis 2

Table 5 shows the results of the t-test for paired samples, carried on the number of blocks produced and consumed during the rainy season months.

Table 5: T-Test For Blocks Production And Consumption During The Rainy Season.

t-Test: Paired Two Sample for Means		
	Variable 1	*Variable 2*
Mean	50519.35	47116.2
Variance	36174562.03	43535117.54
Observations	28	28
Pearson Correlation	0.954941756	
Hypothesized Mean Difference	0	
Df	27	
t Stat	4.531385363	
P(T<=t) one-tail	0.002517065	
t Critical one-tail	1.729132812	
P(T<=t) two-tail	0.00503413	
t Critical two-tail	3.144024054	

Inference: The t-calculated value (4.531) is greater than t-tabulated value (3.144) returned at 27 degrees of freedom. The p value of 0.00503413 is also lesser than the designated 5% alpha level for 2-tailed test. Hence, the Null hypothesis (Ho) of no difference in means between production and consumption is rejected. while the alternate hypothesis (H1) is accepted, upholding that there is a statistically significant difference between the rate of production of sandcrete blocks and the rate of consumption during the rainy season. Block production is thus significantly higher than its consumption in rainy season. It can thus be inferred that the supply of sandcrete blocks during the rainy season in Port Harcourt is in excess of its demand.

Conclusion

The study has provided statistical evidence backing up literature assertions that weather is key to determining the consumption of sandcrete blocks on construction sites, which in-turn defines demand. The study outcome has however shown that this variability in demand is not directly reflected in production patterns. Significant difference between the supply and demand for sandcrete blocks during the rainy season was noted. This is relative to dry season, whereby the difference between the supply and demand for sandcrete blocks was found statistically insignificant. A logical implication of the study outcome is that supply more closely matched demand during the dry season. This emphasizes the need to synchronise the production and consumption patterns, particularly during the rainy season months in Port Harcourt. Establishing productivity goals in line with the seasonal climatic sequence is thus a fundamental requirement for the lean production of sandcrete blocks in Port Harcourt, necessary to reduce waste streams due to the impact of adverse weather conditions.

In this vain, productivity can be significantly increased by improved organizational and supervisory arrangements centered on weather patterns. This could be achieved by proper acquaintance with weather reports obtainable from meteorological services. In this vain, the greater use of specialization, planning and programming techniques would often result in higher productivity and reduced project duration. However, it was noted during the field work that most of the block production industries in Port Harcourt are run and owned by illiterates or semi-literates, who have not acquired formal technical training. Such entrepreneurial structure is not sustainable and would deter innovations in the production of sandcrete blocks. Formal training in construction is thus necessary to enhance profitability through efficient management of the production process geared towards maintaining a just-in-time supply of sandcrete blocks without maintaining intermediate stocks.

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