Determining Productivity of Masons for both Stretcher and Header Bonding on Building Sites

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ABSTRACT
This paper presents the findings of a study to determine the daily productivity of masons on building sites in Kampala taking into consideration header and stretcher bonds, and working below and above window levels. The study involved field observations over a period of three months. Findings show that for stretcher bond working up to window level, the mean built area per day was 3.17 m^2 and 4.82 m^2 for brick work in header bonding. Whereas working above window level the mean built area was 2.77 m^2 and 2.90 m^2 for stretcher and header bonds respectively. Working above window level, height is the main determinant of productivity as it is yields nearly equal masonry areas irrespective of the bond type. The height affects equally the time delivery of masonry materials. The study also established that productivity was lower for stretcher than header bond for masonry works up to window level. The reason according to interviews with masons at several sites is the time spent levelling the brick work in stretcher than in header bond takes time and significantly reduces masonry work output.

Key Words: Bond, header bond, productivity, masons, stretcher, masonry

1.0 INTRODUCTION

Productivity of masons on building projects is important in construction project management as it affects key planning decisions involving time and resource allocation. Therefore understanding the productivity of masons is important for management of building projects that involve masonry works. A mason is a skilled casual worker who builds with stone or similar material such as brick, concrete or artificial stone. The masonry process is perceived to be one of the labour intensive aspects of construction from time immemorial as in Chudley and Greeno (2005). This is because blocks/bricks must be handled and placed one at a time with expected work output referred to as productivity. Productivity of masons is measured in terms of area in square metres of brick work built by a single mason per unit of time preferably a day normally 8 hours of work. The size and bonding type of bricks/blocks primary influences the speed, workmanship and output of the masons.

A brick is defined as a walling unit with co-ordinating or format size of 225mm length, 112.5 mm width and 75mm height according to British Standards Institution BS [3921] (1985). A block is a walling unit exceeding the BS dimensions specified for bricks and its height shall not exceed either its length or 6 times its thickness. Header bond has all the headers in every course and it is used for structural or external brick walls. A Stretcher bond on the other hand has the length of the brick running parallel to the wall usually resulting in thin and non-structural walls. Stretcher bonds are used for partitions in building and for external walls for buildings roofed with light material such as iron sheets. This paper presents the results of field observations on productivity of masons on thirty one building projects in Kampala with window level as reference datum.

2.0 PROBLEM STATEMENT

Daily productivity of masons building projects in Kampala is not documented in the literature for common bonding types of header and stretcher leaving managers to base on their past experience. This makes it difficult for new construction managers to plan for project duration and resource requirements. There is need therefore to observe and document productivity of masons on building projects in Kampala.

3.0 RESEARCH OBJECTIVE

The objective of the study was to determine the daily productivity of masons in both stretcher and header bonding at selected building construction sites in Kampala with the window level as the reference datum. Realization of the above objective was through; determination of normal daily working hours of masons, observing and measuring the wall area built per day by individual masons, and using statistical methods to make statements on productivity of masons in respective categories.

4.0 LITERATURE REVIEW

4.1 Productivity

Productivity is defined as the output per person, machine or organization per given time and can be measured in units of product, number of customers, or any other measure that a business might prefer to use (Chitkara, 1998). Productivity defines the success of construction projects and therefore good managers strive to devise methods that boost productivity, reduce project duration, cost and improve profitability. Low or uncertain productivity of construction workers is one of the causes of cost and time overruns in construction projects as noted by Alinaitwe *et al,* (2007). Chitkara (1998) defined the computation for average economic productivity as dividing by output (measurable outcomes) by input units (time or physical). If the production process uses only one factor such as labour, then this yields labour productivity. In the case of masonry works, productivity is a function of square metres of walling built per payable unit time; day or hour depending on the laws. However, most commonly, the time unit is a day. The productivity of masons is influenced by experience, level of education, motivation and input process such as delivery of working materials.

4.2 Brick Work

The use of brickwork flourished during the third and fourth centuries, after which the craft suffered a rapid decline until its re-introduction from Flanders towards the end of fourteenth century. Since then it has been firmly established and remains as one of the major building materials Chundley and Greeno (2005). Brickwork is used primarily in the construction of walls by bedding and jointing of bricks into established bonding arrangement. A standard work size should be of 215 x 102.5 x 65 mm British Standards Institution (1985). However, variable brick dimensions exist on the market in Kampala. The bricks are laid in mortar in either stretcher or header.

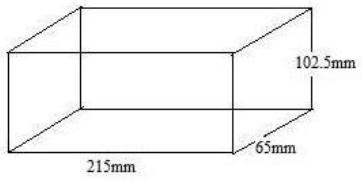

Figure 1: Brick dimensions

4.3 Block Work

They can be made with either clay blocks or pre-cast concrete blocks. Standard block size is 300×225×150 mm. However, block works are less popular as masonry materials on building

projects compared to burnt clay bricks. The blocks are laid in mortar and usually in stretcher bond.

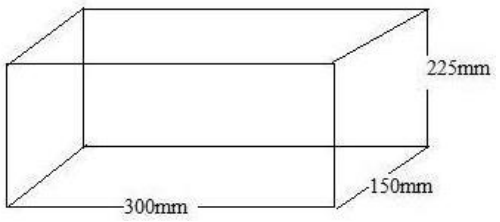

Figure 2: Block dimensions

5.0 METHODOLOGY

The methodology employed for the study involved identification of building project sites, obtaining access permission and carrying out field observations on masonry works by different masons. Photographs were taken at the several sites using a camera to keep record of the difference in heights of construction. A tape measure was used to measure the actual work done in a given time and recorded in a note book. Statistical methods were used to organize and aggregate data for further analysis involving computation of the mean and standard deviation.

5.1 Data collection and analysis

Data for the research was collected by observation of on-going masonry works at different sites in Kampala shown in Table 1, 2 & 3 for block and brick works. Time for commencement and stoppage of work were recorded as well. Basic statistical methods were used to compute statistics for analysis of the mean, standard deviation and coefficient of variation shown in Equation 1, 2 & 3. However, the sample size was smaller, and therefore more data shall be required for in-depth analysis.

$$\overline{X} = \frac{\sum_{i=1}^{n} x_i}{n} \tag{1}$$

$$s = \sqrt{\frac{\sum (X_i - \overline{X})^2}{(n-1)}} \tag{2}$$

$$CV = 100\left(\frac{s}{\overline{x}}\right) \tag{3}$$

Where x_i is built area per day per masonry and bonding type, and n is number of entries recorded in respective categories, x-bar is the mean built area per day per category, s is the standard deviation, and CV is the coefficient of variation expressed as a percentage. Confidence interval of the mean was carried out using a t-test at 95-percent confidence level and results are presented in Table 4.

6.0 FINDINGS

Data was collected at 14 site building sites for block work, 8 for brick work in stretcher and 9 in header bonding around Kampala shown in Table 1, 2 & 3. The sample size should have been larger for improved data reliability. However, the lead researcher was constrained in time and resources to increase the sample size. Nevertheless, the data collected provides a benchmark and documentation for the daily productivity of masons in Kampala.

6.1 Working Duration

The research established variable working duration per day, ranging from 6.5 hours to 10 hours. The modal working duration was 8.0 hours per day although 8.50 hours was also common according to records. Therefore the working duration is variable between sites. All sites had one hour dedicated for lunch between 1300 and 1400 hours. The observed work commencement time was 0800 hours and completion time variable at 1700, 1730 and 1800 hours a day.

6.2 Built area per day

Table 1, 2 & 3 show the observed built areas per day for block works in stretcher, brick works in stretcher and brick work in header respectively considering works below and above window level. Block work was mainly done in stretcher bonding.

Table 1: Built area in block work per day under stretcher bonding

Site Location	Built Area per Day (m^2)		
	Below Window Level	**Above Window Level**	**Working Period (Excluding one Hour Lunch Time)**
Proposed office block, plot 1, Lourdel Rd.	5	-	8am – 5:30pm (8hrs 30 min)
Golf course towers, Yusuf Lule Rd.	-	3	8:30am – 5:00pm (8hrs 30 min)
Perimeter wall, Kirinya Bweyogerere	-	4	8am – 5pm (8hrs)
Regency apartments extension, Naguru	-	4	8am – 5pm (8hrs)
Church building, Mbalwa Wakiso	3.5	-	8am – 5pm (8hrs)
Store house extension, UMA Nakawa	4	-	9am – 5:30pm (7hrs 30 min)
Tirupati Mazima mall, Kabalagala	5	-	8am – 5pm (8hrs)
Proposed petrol station, Kayunga road, Kamwokya	-	2.8	8am – 5pm (8hrs)
Workshop and offices, 7th St. industrial area	3	-	8am – 5:30pm (8hrs 30min)
Perimeter wall, Mbuya	-	3.2	8am – 5:30pm (8hrs 30min)
Residential house, Banda	3	-	9am – 5:00pm (7hrs)
Perimeter wall, Nalya	3.5	-	8am – 5:00pm (8hrs)
SDA Church extension, Kireka	-	2.8	8am – 5:00pm (8hrs)
Office dev't, Yusuf lule Road	-	2	8am – 5:30pm (8hrs 30min)
Mean (m^2)	3.86	3.11	
Standard Deviation (m^2)	0.84	0.71	
Coefficient of Variation (%)	22	23	

Table 2: Built area in brick work per day under stretcher bonding

Site Location	Built Area per Day (m^2)		
	Below Window Level	**Above Window Level**	**Working Period (Excluding one Hour Lunch Time)**
Egyptian Embassy Renovation, Kololo hill lane	-	3	8am – 5:00pm (8hrs)
Building extension, Kireka	3	-	9am – 4:30pm (6hrs 30min)
Company office building, along K'la-Mukono road	-	2.32	8am – 5:30pm (8hrs 30min)
Perimeter wall, Kirinya Bweyogerere	3.5	-	8am – 5:00pm (8hrs)
Commercial flat, Kakajjo Bweyogerere	-	3.41	7am – 5:00pm (9hrs)
Proposed warehouse, Haree Construction Co. Bweyogerere	-	3	8am – 5:00pm (7hrs), with 2 hour lunch
Residential house, Bugolobi Nakawa	-	2.1	8am – 6:00pm (9hrs)
Residential flat, Mbuya	3	-	8am – 5pm (8hrs)
Mean (m^2)	3.17	2.77	
Standard Deviation (m^2)	0.29	0.54	
Coefficient of Variation (%)	9	20	

Table 3: Built area in brick work per day under header bonding

Site Location	Built Area per Day (m^2)		
	Below Window Level	**Above Window Level**	**Working Period (Excluding one Hour Lunch Time)**
Commercial flat, Ntinda	4.2	-	8am – 5:00pm (8hrs)
Perimeter wall, Namugongo, Jjanda	-	3	9am – 5:00pm (7hrs)
Bungalow, Namugongo	-	4	8am – 5:30pm (8hrs 30min)
Proposed residential house, Kireka	5.85	-	8am – 6:00pm (9hrs)
Commercial flat, Kiwatule	5.4	-	8am – 5:00pm (8hrs)
Residential flat, Bunga Ggaba	-	1.4	8:30am – 5:00pm (8hrs 30min)
Proposed shopping arcade, Kireka opp. Shell	6	-	7am – 6:00pm (10hrs)
Bungalow, Bweyogerere	-	3.2	8:15am – 5:30pm (8hrs 15min)
Residential flat, Mbalwa Wakiso	2.65	-	8am – 5:00pm (8hrs)
Mean (m^2)	4.82	2.90	
Standard Deviation (m^2)	1.40	1.09	
Coefficient of Variation (%)	29	38	

With block work, the mean built area working below window level was 3.86 m^2 and 3.11 m^2 working above window level a difference of 0.75 m^2. Therefore, working at height above window level reduces productivity of masons as expected in practice. With brick work in stretcher bonding, the mean built area was 3.17 m^2 and 2.77 m^2 below and above window level respectively. The reduction is not significant if compared with the confidence bound at 95-percent level in Table 4. The mean built brick work area in header bonding was 4.82 m^2 and 2.90 m^2 for below and above window levels respectively. Height has significant influence on productivity of masonry works under header bonding. This is attributed to material haulage intensity required at heights that may not much the supply from porters. Built area per day in brick work for header bonding exhibited significant variations explained by the large coefficient of variation. The least variable measurements were built area of brick work under stretcher bonding below window level. Productivity of brick work is greatest under header bonding. This attributed to the fact that masons do less work levelling and plumbing the brick. In fact, starting bricks are plumbed and levelled as a start for the wall alignment. It is therefore possible to have unlevelled or plumbed wall if the mason is not experienced although productivity will be significantly higher compared to stretcher bonding.

Table 4: Limits of mean built area for block and brick works

DESCRIPTION	CONFIDENCE INTERVALS (95% confidence Level)					
	Stretcher Bonding			Header Bonding		
	Mean (m^2)	Lower Bound (m^2)	Upper Bound (m^2)	Mean (m^2)	Lower Bound (m^2)	Upper Bound (m^2)
Below Window Level						
Block Work	**3.86**	3.22	4.50	-	-	-
Brick Work	**3.17**	2.31	4.03	**4.82**	3.06	6.58
Above Window Level						
Block Work	**3.11**	2.61	3.61	**-**	-	-
Brick Work	**2.77**	1.89	3.65	**2.90**	1.52	4.28

7.0 CONCLUSION

The study established that daily working duration varies between sites from 6.0 to 10.0 hours with the modal duration of 8.0 hours. Masonry works below window level for block and brick work results in higher built area per day than above window level. For brick work, header bonding results in higher productivity than stretcher bonding but may result in unplumbed wall finishes if due care and supervision is not taken. The productivity of masons is governed by; weather patterns, availability and access of materials, commencement time and experience of the mason and porters. It is recommended that further research is carried out with large samples to establish significance of experience and level of education on productivity as well as large samples to predict productivity more reliably.

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