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INFLUENCE OF MASONRY COMPONENT CHARACTERISTICS ON COMPRESSIVE STRENGTH OF LOW STRENGTH CONCRETE BLOCK MASONRY

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ABSTRACT

Purpose: This study evaluated comparatively, the influence of block units and mortar characteristics on the uniaxial compressive strength of low-strength concrete block masonry prisms, with a view to understanding their behaviour.

Design/methodology/approach: Half scaled specimens of 450 mm x 225 mm block units were produced with which 36 concrete block prisms were constructed. Block prisms were tested for their uniaxial compressive strength, considering block unit compressive strength, width, and area of hollow of block units, as independent variables. Secondary data from prior tests reported in literature on the effect of mortar strength and mortar joint thickness on prism compressive strengths were also adopted for the study.

Findings: Results showed that increases in uniaxial compressive strength of low-strength block prisms resulted from increases in block unit strength, mortar strength and width of block unit, as well as decreases in area of hollow and mortar joint thickness. Block unit strength was found to be the most block prism strength-influencing variable with a linear regression unstandardized coefficient of 1.497, within a standard error of 0.235. Influence of all block and mortar characteristics considered were found to be significant at a 0.05 level of significance.

Research limitations/Implications: The study emphasized on block prisms with block to mortar bed depth ratio of 8.65. The study concluded that block and mortar characteristics had similar effects on low-strength concrete block prisms as they did on medium and high strength prisms though to varying degrees.

Practical implications: Therefore, predictive models applicable to medium or high strength masonry systems may not be a perfect fit to low strength masonry systems.

Originality/value: Models for predicting the strength of concrete block walls developed on the basis on these findings would contribute to accurate assessment of structures incorporating low strength concrete block walls.

Keywords: Block units, Concrete block prisms, Low-strength, Mortar, Uniaxial compressive strength.

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1. INTRODUCTION

Masonry is one of the oldest methods of construction adopted by man for the provision of shelter. Advancements in the application of masonry in construction has seen a shift in the use of masonry in large load bearing walls for low rise structures, to slender infills for framed structures and structural load-bearing walls. In whatever modern applications masonry walls are required, their strength and stability under the condition of use is of utmost importance to the designers, constructors and other stakeholders.

A vast array of materials exists for use as masonry units. Clay bricks and stones have been established as masonry units since ancient times. However, developments since the ninth century, have seen the introduction of concrete blocks, autoclave aerated blocks and other new masonry unit types that have found significant usage in masonry structures. The EN 771-3: 2011 (CEN, 2011) defines aggregate concrete block units as masonry units manufactured from cementitious binder, aggregates and water with possible inclusion of admixtures and other materials. Concrete blocks provide the advantage of ease of production and sourcing of constituent materials. Constituent materials include cement, fine aggregate, water and admixtures. Units are jointed in components using mortar which consists of cement, fine aggregate, water, lime and admixtures in acceptable proportions.

Masonry is incorporated into buildings, primarily as walls which bear compressive loads (Chiama & Ulaeto, 2023; Ulaeto & Ugwoeri, 2023). Compressive loads emanate from the wall's self-weight and weight of building components borne by the wall. These make the compressive strength of walls an important property for consideration by designers and builders. Forte *et al.* (2017) noted that the compressive strength of concrete block masonry was influenced by masonry component characteristics, interaction between these characteristics and the quality of workmanship employed in construction.

Documentation of the influence of these characteristics on response of concrete block prisms is well established in literature for high and medium-strength concrete block units. High and medium-strength concrete block units possess compressive strengths ranging from 5 MPa to over 25 MPa (Fortes *et al*., 2017; Fonesca *et al*., 2019; Caldeira *et al*., 2020). They are used in load-bearing walls construction and are specified for use in masonry design codes such as the BS 5628-1 (1992), Eurocode 6 (CEN, 2005) and TMS 402/602-11 (TMS, 2011).

Low strength concrete block units are classified as units that have a gross average compressive strength of about 3.48 MPa (Syiemiong and Marthong, 2019). Low-strength concrete block units are predominantly used in developing countries for infill walls in low to medium-rise buildings, parapet walls, boundary fence walls and structural walls in low-cost single and two storey buildings (Ulaeto *et al*., 2024). Nigeria, a developing country, adopts the Nigeria Industrial Standard (NIS) 87 (2007) for specifications on quality of sandcrete (concrete) blocks. The NIS 87 (2007) specifies compressive strengths of 3.45 Nmm^{-2} and 2.5 Nmm^{-2} as the minimum strengths of sandcrete blocks for structural and non-structural applications, respectively. However, several studies (Onwuka, *et al.*, 2013; Ewa and Ukpata, 2013; Ajagbe, *et al.*, 2013; Aiyewalehinmi and Tanimola, 2013; Odeyemi *et al.*, 2018; Ambrose, *et al.*, 2019) have shown that concrete block units used for construction purposes in Nigeria have compressive strength ranging between 0.19 and 2.02 Nmm^{-2}. Studies in literature which cover the behaviour of masonry constructed with low-strength concrete blocks are limited (Syiemiong and Marthong, 2019). This makes prediction of the behaviour of masonry wall systems incorporating low strength concrete block units difficult under normal and accidental loading conditions. Interaction between block units and mortar with varying characteristics is not clearly established for masonry systems with low concrete block units.

Therefore, this study aims to evaluate comparatively, the influence of block units and mortar characteristics on the uniaxial compressive strength of low-strength concrete block masonry prisms, with a view to understanding the behaviour of low-strength concrete block masonry walls. The study will improve understanding of the response of masonry structures constructed with low-strength concrete block units, where masonry components characteristics could be varied to improve masonry wall performance under specific loading conditions. The performance of masonry structures incorporating such block units can be enhanced with this knowledge.

2. LITERATURE REVIEW

The uniaxial compressive strength of concrete block masonry walls is an important property of this building element. This is such that it is a core property on which the design of masonry structures is based (CEN, 2005; TMS, 2016). Concrete block masonry strength in compression is dependent on masonry component characteristics. Factors which influence the compressive strength and response of hollow masonry prisms have been listed to include block geometry, block compressive strength, mortar type, mortar bedding area, mortar thickness, mortar compressive strength, prism height-to-thickness ratio, test set-up, bond pattern, and workmanship (Thamboo, *et al.*, 2013; Sarhat and Sherwood, 2014; Fortes *et al*., 2017; Fonseca *et al*., 2019).

Fortes (2012) as cited in Fortes *et al*. (2017) noted that increasing block strength did not bring about corresponding increases in the prism/block strength ratio after conducting a series of tests on block masonry walls. Analysis of results of tests on solid and hollow block prisms by Zahra, *et al.*, (2021) showed that an average difference in masonry prism strength of 42% existed between prisms made of solid blocks and those made of hollow blocks.

Mortar strength, mortar thickness and mortar type have been listed amongst mortar characteristics which influence the uniaxial compressive strength of concrete block walls (Hendry *et al*., 2004; Fortes, *et al*., 2017). The primary determinant of mortar strength is the cement (and lime) content adopted in the mix design. Masonry design codes specify mortar based on volume mix proportions (Thamboo, *et al.*, 2019).

Several studies have investigated the influence of mortar strength on the behaviour of masonry prisms (Drovgka *et al*., 2015; Zahra and Dhanaselar, 2016; Alvarenga *et al*., 2017; Fortes *et al*., 2017, Mohammad *et al*., 2017; Caldeira, *et al*., 2020; Zahra *et al*., 2021). Generally, slight increases in ungrouted masonry compressive strength were reported, with increases in the compressive strength of mortar. Changes in failure modes of masonry are also reported in the literature. Fortes *et al*. (2017), Caldeira *et al*. (2020) and Zahra *et al*. (2021) noted the influence of the ratio of mortar strength to block strength (based on net area) on the failure mode of concrete masonry walls. When mortar was much weaker than blocks, mortar crushing was the prevailing failure mode; while block splitting or block crushing was observed when mortar was much stronger than blocks. It has been established that reduction in mortar thicknesses increases masonry compressive strength and elastic modulus (Francis *et al*., 1972; Cassinello, 2006; Lima *et al.*, 2012; Thamboo, *et al.*, 2013; Reddy *et al*., 2009). Caldeira *et al*. (2020) observed that the influence of joint thickness on the compressive strength of masonry was more significant in masonry with mortar strength much lower than block unit strength. This was attributed to decrease in lateral confinement caused by the increase in mortar thickness. Standard mortar thicknesses of around 6 – 15 mm are recommended in major international codes (Australian Standard Association, 2001; Brazilian Association of Technical Standards, 2011; CEN, 2005; TMS, 2011; Canadian Standards Association, 2014).

It must be emphasised that all studies reviewed in the paragraphs above cover masonry prism and walls constructed with medium to high strength concrete block units. However, Ulaeto *et al*. (2024) studied the effects of varying mortar characteristics on the compressive strength of masonry prisms made with low-strength concrete blocks. The study revealed that when mortar and block units were of similar strengths, crack development during failure was more pronounced and failure of prisms was less sudden. It also showed that like masonry prisms constructed with medium and high-strength concrete blocks, those constructed with low-strength concrete block units experienced significant increases in uniaxial compressive strength with increases in mortar compressive strength and decreases in mortar joint thicknesses. The results of tests obtained from the study are as summarised in Table 1.

Table 1: Uniaxial compressive strength of concrete block prisms with varying mortar strength and joint thickness

Compressive strength of mortar (MPa)	Average compressive strength (MPa)	Joint thickness (mm)	Average compressive strength (MPa)
3.979	1.212	6	1.421
2.975	1.112	9	1.200
1.975	1.000	13	1.000
1.508	0.935	19	0.779
0.706	0.907	25	0.580

Source: Ulaeto, *et al.*, (2024)

Some design codes do not have provisions for design of walls with low strength concrete block units. Prediction of the characteristic strength of block masonry constructed with hollow and solid blocks having a ratio of height to least horizontal dimension of between 2.0 and 4.0 in the BS 5628-1 (1992), considers a minimum concrete block unit strength of 2.8 MPa. This is as shown in Figures 1 and 2. This implies that characteristic strength of masonry walls built with concrete block units produced in some Nigerian block factories cannot be predicted using the BS 5628-1 (1992) model. As the strength of many of these block units fall below the range of values considered (Onwuka, *et al.*, 2013; Odeyemi *et al.*, 2018; Ewa and Ukpata, 2013; Ajagbe, *et al.*, 2013; Aiyewalehinmi and Tanimola, 2013; Ambrose, *et al.*, 2019). It is therefore necessary that the influence of masonry component characteristics on prisms made of low-strength concrete blocks units be assessed. This understanding will be of great importance to the safety of buildings in regions of the world where such masonry units are used.

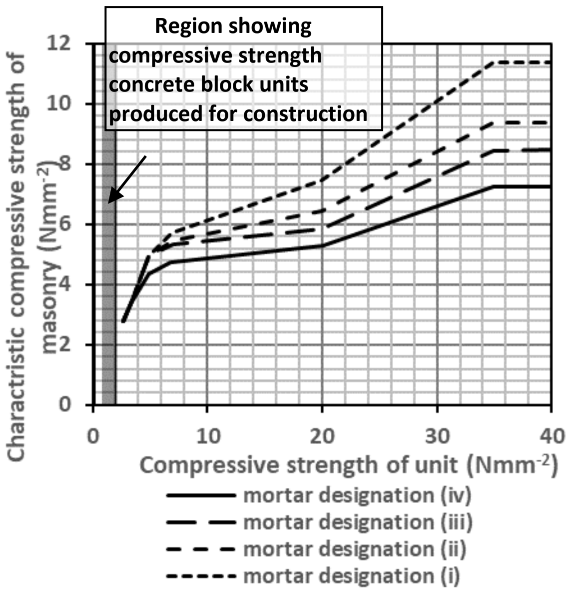

Figure 1: BS 5628-1 (1992) prediction of characteristic compressive strength of masonry based on compressive strength of hollow block units.

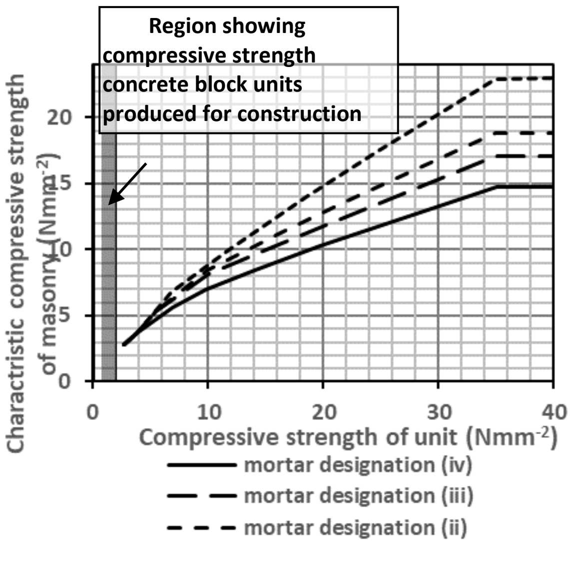

Figure 2: BS 5628-1 (1992) prediction of characteristic compressive strength of masonry based on compressive strength of solid block units.

3. METHODOLOGY

An experimental research approach was adopted for the study. This consisted of preliminary tests, to determine particle size distribution of fine aggregates used for mortar and blocks; mortar compressive strength and block compressive strength tests; and uniaxial compressive strength tests carried out on low-strength concrete block masonry prisms. Results of experiments and secondary data covering the effects of mortar characteristics on block prism behaviour obtained from Ulaeto, *et al.*, (2024), formed the basis of comparison.

Fine aggregate (sand) used for the study was river sand. Particle size distribution for the fine aggregate was carried out in accordance with the BS EN 933-1: 2012a. Cement used was bought from a reputable dealer and assessed to ensure that it was in good condition. It was manufactured to the requirements of the NIS 444-1 (2014), with a compressive strength of 42.5 Nmm^{-2}, as specified by the manufacturer. Portable water from the laboratory water supply system was used for hydration of block and mortar mixes. Water/cement ratios for mortar and blocks were 1.20 and 0.45 respectively.

Concrete block units used were moulded using fabricated steel moulds. Block units were half scaled specimens (length x depth: 225 mm x 112.5 mm) of blocks with length by depth dimensions, 450 mm x 225 mm, used in most developing countries of Sub-Saharan region of Africa (Oyekan and Kamiyo, 2011; Ambrose, *et al*., 2019). Concrete blocks units produced in the regions are of mixes ranging between 1:5 to 1:12 (Oyekan and Kamiyo, 2011). Block units were cured by covering them with polythene bags and daily spraying with water from 2 days after moulding. Mortar uniaxial compressive strength test and concrete block unit uniaxial compressive strength tests were carried out in accordance with, BS EN 1015-11:2019 and BS EN 772-1:2000, respectively.

Concrete block masonry prisms were constructed in the University of Uyo Concrete Laboratory. Masonry prisms consisted of two blocks along their length and three courses along their height as shown in Figure 3.

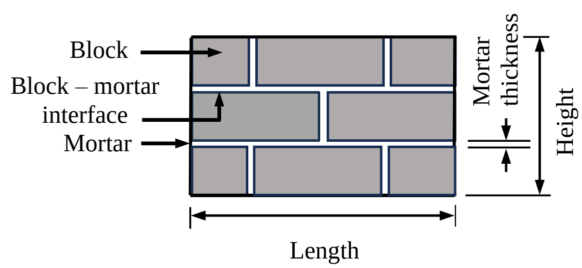

Figure 3: Masonry prism specimen

Variables considered during testing were as highlighted in Table 2. Concrete block masonry prisms were sprayed with water daily and covered with polythene bags up till a day before testing. Testing of concrete block masonry prisms was carried out to the requirements of BS EN 1052-1 (1999).

Table 2: Variables considered in testing

Variable	Method of determination	
Block strength (BS)	Mix ratio by volume:	1:6 1:7 1:8 1:9 1:10
Block thickness (BT)	Linear measurement of thickness:	112.5 mm 87.5 mm 62.5 mm
Area of hollow of blocks, AHB	Linear measurement of length and width of hollow. AHB = L x W	0 mm^2 2531.3 mm^2 5062.5 mm^2 7593.8 mm^2

Masonry prisms were constructed three courses high (Figure 3) since the scope of study was only limited to assessment of the relationship between block prism characteristics and prisms uniaxial compressive strength.

4. PRESENTATION AND DISCUSSION OF RESULTS

Masonry prisms were mounted on a Wincom digital display hydraulic universal testing machine, model WA-300B as shown in Figure 4. Uniform compressive forces were applied to the top face of each prism at a loading rate of 0.05 (N mm^{-2}) s^{-1}.

Figure 4: Test setup adopted for uniaxial compressive strength test of concrete block prisms.

4.1. Results

4.1.1 Particle size distribution for fine aggregate

Sieve analyses were carried out on fine aggregate samples extracted from a batch, supplied for preparation of mortar and block units. Results of sieve analyses were plotted as particle size distribution curves which are presented in Figure 5. The particle size distribution of the fine aggregate used in mortar fell within the fine and coarse grading limits for mortar, specified in the BS EN 13139 (2002).

4.1.2 Block unit and mortar compressive strength

The 28-day average compressive strength of mortar used for assessment of block unit characteristics on masonry prisms gave a value of 1.4 MPa. This was based on a mortar mix ratio of 1:0:8 (cement: lime: fine aggregate). Varying block characteristics led to variations in the compressive strength of block units. Table 3 shows that for solid block units, units with higher cement content showed higher compressive strength, increases in the width and decreases in percentage area of hollows of units led to slight increases in unit compressive strength.

4.1.3 Effect of block characteristics on average uniaxial compressive strength of low-strength concrete block prisms

Results showing the influence of block unit characteristics on the uniaxial compressive strength of low-strength concrete block prisms are as shown in Tables 4, 5 and 6 for block unit compressive strength, block unit width and area of hollow respectively. Increases in block unit compressive strength led to increases in the prism compressive strength. Table 4 showed that the SA6 block unit which was of a 1:6 mix and compressive strength of 1.46 MPa gave a masonry prism, PSA6, with uniaxial compressive strength of 1.14 MPa. The block unit with the least cement content, SA10, gave a masonry prism with uniaxial compressive strength of 0.93 MPa.

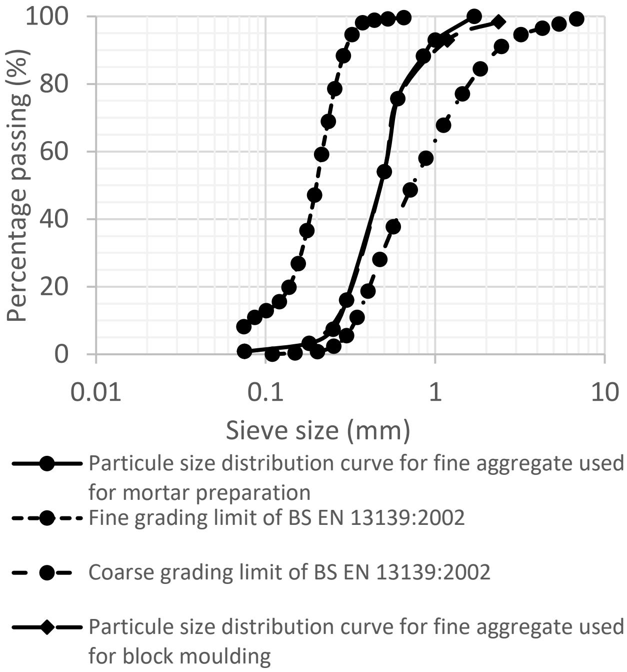

Figure 5: Particle size distribution curve of fine aggregates used for mortar and block units

Table 3: Result of block unit compressive strength test

Block unit label	Block size (mm)	BU area of hollow (mm^2)	Block mix ratio	Crushing force value (kN)		Average crushing force value (kN)	Average compressive strength (MPa) *
SA6	225 x 112.5	0	1:6	36.94	36.89	36.92	1.46
SA7	225 x 112.5	0	1:7	35.90	35.92	35.91	1.42
SA8	225 x 112.5	0	1:8	34.97	35.01	34.99	1.38
SA9	225 x 112.5	0	1:9	34.11	34.03	34.07	1.35
SA10	225 x 112.5	0	1:10	33.45	33.52	33.49	1.32
SB8	225 x 87.5	0	1:8	25.64	25.71	25.68	1.30
SC8	225 x 62.5	0	1:8	17.92	17.88	17.90	1.27
H10A8	225 x 112.5	2531.3	1:8	27.68	27.62	27.65	1.09
H20A8	225 x 112.5	5062.5	1:8	26.70	26.69	26.70	1.05
H30A8	225 x 112.5	7593.8	1:8	25.97	25.89	25.93	1.02

**Gross area strength was considered for hollow block units*

Decreases in block unit width led to decreases in the uniaxial compressive strength of concrete block prisms specimens built. Table 5 shows that three specimens with widths 112.5 mm, 87.5 mm and 62.5 mm gave block prisms with average compressive strength of 1.00 MPa, 0.91 MPa and 0.86 MPa respectively.

Increases in block unit area of hollow, led to decreases in the uniaxial compressive strength of concrete block prism specimens built. Table 6 shows that prism specimen PSA8 made with block units with no hollow gave a uniaxial compressive strength of 1.00 MPa while specimen PH30A8 made of block units with area of hollow 7593.8 mm^2 (30% of the block unit top surface area) gave a uniaxial compressive strength of 0.40 MPa.

Table 4: Effect of block unit compressive strength on prism uniaxial compressive strength

Prism specimen label	Block mix ratio	Block unit compressive strength (MPa)	Crushing force value (kN)			Average crushing force value (kN)	Average compressive strength (MPa)
PSA6	1:6	1.46	59.12	59.33	59.21	59.22	1.14
PSA7	1:7	1.42	55.57	55.32	55.43	55.45	1.07
PSA8	1:8	1.38	51.85	51.92	51.87	51.89	1.00
PSA9	1:9	1.35	50.25	50.18	50.2	50.22	0.97
PSA10	1:10	1.32	48.47	48.39	48.46	48.43	0.93

Prism dimension: 462.5 mm x 112.5 mm
Percentage hollow of blocks used: 0 %
Mortar compressive strength: 1.4 MPa

Table 5: Effect of block unit width on prism uniaxial compressive strength

Prism specimen label	Prism dimensions (mm)	Crushing force value (kN)			Average crushing force value (kN)	Average compressive strength (Mpa)
PSA8	462.5 x 112.5	51.85	51.92	51.87	51.89	1.00
PSB8	462.5 x 87.5	36.87	36.50	36.71	36.69	0.91
PSC8	462.5 x 62.5	24.52	24.81	24.8	24.81	0.86

Block compressive strength: 1.38 MPa
Percentage hollow of blocks used: 0 %
Mortar compressive strength: 1.4 MPa

Table 6: Effect of block unit area of hollow on prism uniaxial compressive strength

Prism specimen label	BU area of hollow (mm^2)	Crushing force value (kN)			Average crushing force value (kN)	Average compressive strength (MPa) *
PSA8	0	51.85	51.92	51.92	51.89	1.00
PH10A8	2531.3	36.95	36.75	36.75	36.85	0.71
PH20A8	5062.5	34.19	34.26	34.26	34.23	0.66
PH30A8	7593.8	20.61	20.65	20.65	20.63	0.40

Prism dimension: 462.5 mm x 112.5 mm
Percentage hollow of blocks used: 0 %
Mortar compressive strength: 1.4 MPa
**Gross area compressive strength*

4.1.4 Regression models for prediction of effect of block and mortar characteristics on uniaxial compressive strength of low-strength concrete block prisms

To model the effects of block and mortar characteristics on the strength of low-strength concrete block prisms, a multiple linear regression analysis was carried out. Results of this analysis is as shown in Table 7, where the multiple correlation coefficient, R, has a value of 0.977. The coefficient of determination, R^2, shows that the independent variables explain 95.5% of the variability of the dependent variable. Closeness of the R^2 and Adjusted R^2 values showed the adequacy of the regression model containing the five predictors. The standard error of the Estimate gave a value of 0.04539 MPa. This means that on average, the uniaxial compressive strength of masonry prisms deviates only by 0.04539 MPa from the regression model based on the independent variables. Results from the Analysis of Variance (ANOVA) table, shown in Table 8, showed that the independent variables statistically significantly predicted the dependent variable, with $F(5, 60) = 257.424$ and p-value $(0.000) < 0.05$.

Table 7: Regression model summary on prediction of low strength masonry prism compressive strength

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate (MPa)
1	.977[a]	.955	.952	.04539

[a] Predictors: (Constant), Mortar Joint Thickness, Block Unit Strength, Block Unit Width, Block Unit Area of Hollow, Mortar Joint Strength

Table 8: Analysis of Variance results from regression analysis

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.651	5	.530	257.424	.000[b]
	Residual	.124	60	.002		
	Total	2.775	65			

4.1.5 Comparison of influence of block and mortar characteristics on uniaxial compressive strength of low-strength concrete block prisms

Linear regression model coefficients, from the multiple linear regression analysis were used to compare the effect of block and mortar characteristics on uniaxial compressive strength of low-strength concrete block prisms. Table 9 shows the regression model coefficients corresponding to the five independent variables. Positive unstandardized coefficients, B, were observed for the independent variables: block unit compressive strength, block unit width and mortar compressive strength. Negative coefficients were observed for block unit area of hollow and mortar joint thickness. Negative coefficients showed the inverse relationship between the variables, block unit area of hollow and mortar joint thickness, and the masonry prism compressive strength. All independent variables were found to have a statistically significant effect on the compressive strength of masonry prisms, with p-values (0.000) less than 0.05. Table 9 showed that block unit compressive strength had the highest influence (B = 1.497), then mortar compressive strength (B = 0.076), mortar joint thickness (-0.041), block unit width (0.003) and finally block unit area of hollow (-6.872×10^{-5}).

Table 9: Linear regression model coefficients for block and mortar characteristics influence on masonry prism compressive strength

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.996	.329		-3.026	.004
	Block unit compressive strength	1.497	.235	.174	6.372	.000
	Block unit width	.003	.000	.178	6.446	.000
	Block unit area of hollow	-6.872E-5	.000	-.636	-23.016	.000
	Mortar compressive strength	.076	.009	.241	8.738	.000
	Mortar joint thickness	-.041	.002	-.661	-24.233	.000

4.2. Discussion of results

Increases in cement content of block units from mix ratios 1:10 to 1:6, led to increases in block unit strength from 1.32 MPa to 1.46 MPa, which was a 10.6% increase. It had been established by Thamboo, *et al.*, (2019) that the key strength determinant in mortar and blocks was the quantity of binder contained in their mixes. However, results also indicted that block unit widths and percentage of hollow of block units also influenced block unit strength.

Increases in block unit compressive strength and block unit width led to increases in the compressive strength of block masonry prisms. This is in agreement with studies on medium and high strength concrete blocks by Thamboo, Dhanasekar and Yan (2013), Sarhat and Sherwood (2014), Fortes *et al.* (2017) and Fonseca *et al.* (2019). Analysis of Table 4, showed a prism strength to block unit strength ratio between 0.7808 and 0.7045 (Figure 10) for low strength concrete block specimens. These are close to the values of 0.7 and 0.8 reported in Drysdale and Hamid (1979) and Kingsley and Atkinson (1985) for normal strength concrete blocks, but higher than the average value of 0.53 reported by Fosenca *et al.*, (2019) for high strength concrete blocks. Fortes (2012) as cited in Fortes *et al.* (2017), noted that for high strength blocks, increasing block strength did not bring about corresponding increases to the prism/block ratio.

Table 10. Ratio of prism compressive strength to block unit compressive strength

Block specimen notation	Block unit compressive strength (MPa)	Prism specimen notation	Prism specimen compressive strength (MPa)	Ratio of prism compressive strength to unit compressive strength
SA7	1.42	PSA7	1.07	0.7535
SA8	1.38	PSA8	1	0.7246
SA9	1.35	PSA9	0.97	0.7185
SA10	321.	PSA10	0.93	0.7045

For the block unit width variable, increases in block unit width resulted in increases in block prism's carrying capacity due to an increased sectional area. These increases in the block prism compressive strength can be attributed to increased area of confinement of prisms by loading plates and by mortar at bedding joints; as well as decreasing slenderness of the block prism.

A 60% difference in the compressive strength of masonry block prism resulted between change in the area of hollow of block unit used in masonry prism from 0 mm^2 to 7593.8 mm^2. Zahra, Thamboo and Mohammad (2021) established that an average difference of 42% in masonry prism strength existed between prisms built with solid blocks and those built with hollow blocks. Lower tensile strengths of low strength concrete blocks would contribute to observed decreases in compressive strength of prisms made with hollow blocks, due to tensile splitting of block unit shells and webs.

Results from the linear regression analysis showed that the independent variables (block unit strength, block unit area of hollow, block unit width, mortar joint strength and mortar joint thickness) provide a good level prediction of the dependent variable (masonry prism compressive strength) with R and R^2 values of 0.977 and 0.955 respectively. This was as expected and similar to observations on medium and high strength concrete blocks (Caldeira et al., 2020; Zahra, Thamboo and Asad, 2021). However, results from Table 9 showed that concrete block unit strength had the most influencing effect on the compressive strength of low strength masonry prisms. It was deduced from results that a 1 MPa increase in block unit compressive strength, of a low strength masonry unit, would lead to a 1.497 MPa increase in the compressive strength of prisms made with the unit, within a 23.5% standard error. Though mortar compressive strength was the second most influence characteristic, it was observed not to have an influence as significant as that of concrete block unit compressive strength. Therefore, block unit compressive strength could be used as the primary variable for predicting compressive strength of low strength concrete prisms, as is the case for medium and high strength prisms and walls.

5. CONCLUSION AND RECOMMENDATIONS

The study aimed to evaluate comparatively, the influence of block units and mortar characteristics on the uniaxial compressive strength of low-strength concrete block prism, with a view to understanding the behaviour of low-strength concrete block walls. The effect of concrete block strength, block unit width and block unit area of hollow on uniaxial compressive strength of low-strength concrete block prisms were investigated. A comparative evaluation of block unit and mortar characteristics was also carried out to determine how much influence each variable had on uniaxial compressive strength of low-strength concrete block prisms. Results obtained from analyses of experimental results were elaborately discussed and based on the findings, the following conclusions were made.

i. Increases in the uniaxial compressive strength of low strength concrete block prisms can be effected through increases in the strength of block units and mortar used; increases in the width of block units; by decreasing the area of hollow of blocks units; and also by decreasing the thickness of mortar joints.

ii. Of the block and mortar characteristics considered, block unit strength has the most influencing effect on the uniaxial compressive strength of block prisms. Its influence is much higher than those of other characteristics.

iii. Block units and mortar characteristics have similar effects on low strength concrete block prisms as they do on medium and high strength concrete block prisms, though to a varying degree. Particular attention has to be given to the combination of block and mortar characteristics to achieve optimum strength and acceptable failure modes.

The study recommends that government and stakeholders in the construction industry should tighten regulations on implementation of minimum strength of block units used in construction, as they are the primary determinant of strength of masonry elements. However, due to the vast application of low strength concrete blocks in construction, relationships among block unit, prism and wall strengths should be established to aid structural integrity assessment of existing structures incorporating masonry elements made with these masonry units, when and where required.

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