PRECAST STONE MASONRY BLOCK (STONECRETE) FOR WALLING - A PRELIMINARY INVESTIGATION

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ABSTRACT

The physical and strength characteristics of precast stone masonry block (stonecrete) were investigated with a view of assessing its suitability and economy as a walling material. Twenty (20) precast stone masonry blocks of 300mm x 200mm x 150mm of normal dimension were tested with varying mix proportions at 28 days curing period using ELG Budenberg compression machine with maximum capacity of 600 kN.

The results of the study show that the precast stone masonry block of 1:5:8 mix with compressive strength of 7.0 N/mm^2 is suitable for load bearing wall. The compressive strength increases with decrease in the water/cement ratio. The block from the mix also has advantage of cement reduction by 42% compared to the sandcrete block. The 2:3:6 mix with compressive strength of 27 N/mm^2 is good for water retaining wall and other civil engineering works that require very high strength.

Key Words: precast, stone, masonry, wall, and compressive strength.

INTRODUCTION

Urban housing has been provided economically in most parts of the world, especially in Europe with precast stone masonry, however, less attention is given to this building material in Nigeria. The occurrence and use of building stones have also been known for centuries especially in Europe (Khan at el, 1991). However, this construction method is not common in developing countries especially in the cities. Despite the extensive use of sandcrete blocks for walling, the studies performed on precast stone masonry are remarkably small or non existence. The reason for the scarcity of studies on precast stone masonry may be due to larger confidence placed on sandcrete blocks. Moreover,

the knowledge of its advantage over sandcrete block is still not sufficient in Nigeria.

However, lack of definite knowledge of the characteristics of the precast stone masonry (stonecrete) is also a possible reason for the lack of building stone resource development.

In the past, burnt bricks have been widely used for load bearing structures but the manufacture of these masonry materials is posing serious threat to the ecology as well as the environment. Venkatarama Reddy (2004) reported that the manufacture of burnt bricks was environmentally hazardous as it also requires enormous quantity of coal and bio-fuel. Thus, there was need for alternative new materials for load bearing masonry to replace the burnt bricks.

Stonecrete is incredibly affordable alternative to real stone and architectural facings, because stonecrete blocks are also more durable in strength, cost-effective, eco-friendly and structurally sound than conventional materials and requires less maintenance (Nordstrand et al, 2004). Stonecrete's cost effectiveness; through mass production techniques, and versatility or design make it for a variety of residential and commercial projects (Nordstrand et al, 2003). Stonecrete masonry aesthetic beauty, longevity and low maintenance make it ideal for nearly any building (Vasanthakuma, 2003).

Furthermore, the escalating cost of construction materials especially cement in developing countries has necessitated attempts made to reduce the amount of cement with other alternative materials. These attempts are aiming at reducing the cost of building construction in Nigeria. The use of precast stone masonry block has reduced the cost of building materials by about 40% (Sharma, 1978).

The paper therefore presents the characteristics of the precast stone masonry from experimental studies of different mix proportions

MATERIALS AND METHOD

Preparation of Precast Stone Masonry Block

The precast stone masonry blocks were prepared using a mould of 300mm x 200mm x 150mm dimension. One or two stones pieces of 120mm to 260mm dimension obtained from Abeokuta, Ogun State Nigeria were placed in the compartments of the mould. The stone spalls occupy 25% to 30% volume of the mould. The concretes were prepared using ordinary Portland cement (BS 12: 1978) obtained from Ewekoro cement factory, Ogun State and well graded sand with fine particles (15% to 20%) passing sieve No 300 micron and (5% to 15%) passing sieve No 150 micron. Crushed granite with density of 2150 kg/m^3 and maximum diameter of 10mm was also used as coarse aggregate in the concrete.

Concrete mixes of 2:3:6; 1:2:4; 1:3:6 and 1:5:8 with water/cement ratio of 0.55, 0.65, 0.75 and 1.0 respectively to obtain normal consistency (Reynolds and Steedman, 1990) were used for the study. The concrete was poured in layers into the mould with the stone pieces (120mm to 260mm), vibrated and inter-spreading of more stone pieces. This is followed by the final layer of concrete and final vibration of the block to give a smooth finish. Twenty block specimens were produced and cured for 28-day period for laboratory testing. The block specimens were cured by sprinkling water for 14 days and then air-dried for another 14 days under cover.

Laboratory Test

The laboratory tests were conducted on the precast stone masonry and the grading sand to conform to specification. The sand was graded using procedure specified by the British Standards (BS: 1377 – 1990). The values of the characteristics compressive strength of the precast stones were obtained experimentally by subjecting the twenty (20) test specimens to vertical compression load using ELG Budenberg compression machine with maximum capacity of 600 kN. Five (5) block specimens per water-cement ratio were produced for the test. The water absorption capacity, moisture content and slumping properties of the precast stone were also determined in the laboratory using procedures specified by the American Society for Testing and Materials (ASTM).

A comparative analysis on the amount of cement and other constituent materials used in the production of conventional sandcrete and precast stone masonry (1:5:8 mix) was conducted.

Results and Discussion

The results of the water absorption capacity and moisture content are presented in Table 1. The mean values are 4.90% and 0.04% respectively. These values fall within the acceptable standards with permissible values of 10% and 0.09% for water absorption capacity and moisture content respectively.

Table 2 shows the slump values of the fresh concrete at different mix proportions. 2:3:6 mix with water/cement ratio of 0.55 recorded the highest slump values varying from 95mm to 97mm. Similarly, the 1:5:8 mix with water/cement ratio of 1.0 recorded the least slump values of 24mm to 28mm. The high slump value of the 2:3:6 mix can be attributed to the high specific surface of 2:3:6 mix and the water/cement ratio of 0.55 as more free mixing water produce more workable mix.

The density and compressive strength of the stonecrete of the various mix proportions are presented in Table 3. The average value of

compressive strength of 2:3:6 mix with water/cement ratio of 0.55 at 28-day curing age is 27.72N/mm^2. The 1:2:4 and 1:3:6 mix proportions with water/cement ratio of 0.65 and 0.75 recorded average compressive strength of 22.58 N/mm^2 and 14.58 N/mm^2 respectively. The 1:5:8 mix with water/cement ratio of 1.0 recorded the least compressive strength of 7.06 N/mm^2, which can be used for loading wall. The 2:3:6, 1:2:4 mixes are excellent for use in large engineering projects where the superimposed pressure is generally high while 1:3:6 mix is suitable for small project.

The compressive strength of the precast stone masonry varies directly with the mix proportion and water/cement ratio as shown in Figure 1. The strength of the stonecrete increases with decrease in water/cement ratio i.e. increase in cement content gives rise to increase in compressive strength of the stonecrete. The densities of the stonecrete at different mix proportions and water/cement ratio show no significant difference in values. The little difference can be due to slight variation in compactive effort during compaction of the concrete. The density values range from 2300 to 2450 kg/m^3. This indicates appreciable dense material when compared to the normal concrete with a design density of 2400 kg/m^3 (BS 8100 – 1995).

The comparative analysis of cement consumption and other aggregates for 10m^2 of wall area using sandcrete block and 1:5:8 precast stonecrete blocks is presented in Table 4. The results present the materials for the production, setting, plastering and pointing operations for 225mm sandcrete block and 200mm thickness precast stonecrete block for 10m^2 wall area. The study revealed that the amount of cement used for the precast stonecrete wall is 42.37% less than the quantity of cement required for the same area of sandcrete block wall. Similarly, the quantity of sand used for the precast stonecrete wall is 48.78% less than the amount of sand required for sandcrete block wall of the same area.

CONCLUSION

The results of the study show that 1:5:8 mix with an average compressive strength of 7.06 N/mm^2 is more economical for use as walling material. The study also revealed that the strength of 1:5:8 mix is suitable and adequate for load bearing walls. 2:3:6 and 1:2:4 mixes have very high strength with more cement consumption and therefore can only be considered for water retaining walls and other structures that require high compressive strength.

Consequently, the utilization of stonecrete as walling material will significantly reduce the cost of building construction drastically, thereby achieving economy. The use of stonecrete as walling material

will also boost self-sufficiency in building construction industry especially in areas where there are abundant stone and rock materials. Moreover, the texture of stonecrete gives a good aesthetics to the building.

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Table 1: Results of water absorption capacity tests on stonecrete blocks

S/No	Water absorption capacity (%)	Moisture content (%)	Permissible value (%) British Standard, 1994	
			Water absorption capacity (%)	Moisture content (%)
1.	4.8	0.02		
2.	5.1	0.04	10.0	0.09
3.	4.9	0.05		
4.	4.7	0.03		
5.	5.0	0.06		

The water-cement ratio of 0.55 of the mix proportion 2:3:6.

Table 2: Values of concrete slump with varied mix proportion

S/No	Slump (mm) with mix proportions			
	2:3:6	1:2:4	1:3:6	1:5:8
1.	96	53	44	28
2.	97	54	44	25
3.	96	55	45	27
4.	95	55	44	24
5.	95	53	45	25

The water-cement ratios of the mix proportions of 2:3:6; 1:2:4; 1:3:6 and 1:5:8 are 0.55, 0.65, 0.75 and 1.0 respectively

Table 3: Density and Compressive strength of Stonecrete at 28-day curing age

Concrete mix proportion	Specimen tested No	Density with mix proportion (Kg/m^3)	Compressive strength with mix proportion (N/mm^2)	Average compressive strength with mix proportion (N/mm^2)
2:3:6	1	2333	28.2	27.72
	2	2400	27.6	
	3	2362	28.0	
	4	2403	27.5	
	5	2336	27.3	
1:2:4	1	2340	22.6	22.56
	2	2377	23.1	
	3	2390	22.5	
	4	2425	21.9	
	5	2342	22.7	
1:3:6	1	2401	14.3	14.58
	2	2370	14.5	
	3	2383	14.4	
	4	2338	15.0	
	5	2430	14.7	
1:5:8	1	2398	7.6	7.06
	2	2400	7.0	
	3	2391	6.9	
	4	2362	6.8	
	5	2440	7.0	

The water-cement ratios of the mix proportions of 2:3:6; 1:2:4; 1:3:6 and 1:5:8 are 0.55, 0.65, 0.75 and 1.0 respectively.

Table 4: Comparison of consumption of cement and other aggregates for 10m^2 of wall area

		Cement consumption (50Kg) bag		**Other constituent materials**					
		225mm Sandcrete Block wall	200mm Precast stone masonry Block wall	225mm Sandcrete Block wall. Unit in m^3			200mm Precast stone masonry Block wall. Unit in m^3		
No	Item			sand	Coarse aggregate	Stone pieces	sand	Coarse aggregate	Stone pieces
1.	Blocks	7.02	3.42	1.22	-	-	0.48	0.77	0.073
2.	Mortar	0.72	0.95	0.14	-	-	0.15	-	-
3.	Plaster (internal)	0.72	0.72	0.14	-	-	0.10	-	-
4.	Plaster (external)	0.72	-	0.14	-	-	0.10	-	-
5.	Pointing (external)	-	0.20	-	-	-	0.01	-	-
	Total	9.18	5.29	1.64	-	-	0.84	0.77	0.73
	Saving Percent		42.4%						

Comparison is based on precast stone masonry block of mix proportion 1:5:8 with water-cement ratio of 1.0

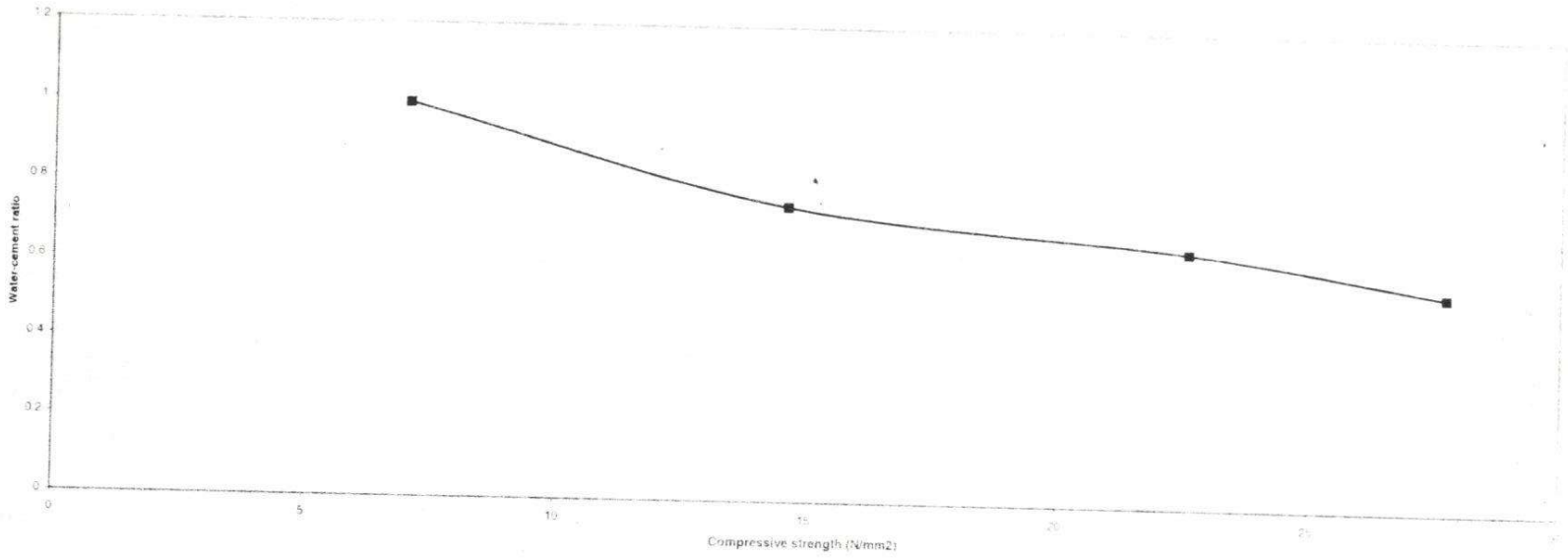

Fig. 1: Relationship between compressive strength and water-cement ratio of the precast stone masonry