EXPLORING THE RELATIONSHIP BETWEEN THE PROPERTIES OF DIFFERENT BRANDS OF CEMENT AND ENGINEERING PROPERTIES OF SANDCRETE BLOCKS

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Abstract

This study is aimed at determining the extent to which variation in properties of cement affects the compressive strength of sandcrete blocks. Laboratory tests were carried out to determine the standard consistency, initial and final setting time of six different brands of cement. The different brands are Dangote, Purechem, Elephant, Supermax, Superset and Nouvelle. Sandcerete blocks were moulded with the six different brands of cement and the compressive strength of the blocks were determined at 7, 14, 21 and 28days. Also, the water absorption and moisture content of the blocks were equally determined. The relationship between the standard consistency with both water absorption and moisture content were carried out. The relationship between the initial setting time and final setting time of cement and the compressive strength of blocks were equally determined.

Keywords: Relationship, Properties, brands of cement Engineering, Sandcrete Blocks

Introduction

The use of Sandcerete block in building construction is a global trend. The greater percentage of buildings in Nigeria and in many other countries in Africa are built with Sandcrete blocks. Sandcrete blocks has been described as comprising of natural sand, water and binder or blocks made or moulded with sand, water and cement which serve as a binder which is a major component material in the construction of buildings in Nigeria and many other countries in Africa Sholanke, Fagbenle, Aderonmu and Ajagbe 2015, Omopariola 2014a). Omopariola 2014b further refers to it as part of the structural components of a building which accounts for a significant part of the budget for putting up a building. However, there are recurrent cases of building collapse in Nigeria and other nations of the world. The use of poor – quality materials has often been cited as one of the reasons adduced for it. Furthermore, previous researches have proved that the quality of Sandcerete blocks supplied by commercial block producers are of low quality (Omopariola, 2014 c)

Properties of Cement

The properties of cement considered in this study are the standard consistency, initial and final setting time.

Consistency: The **consistency of cement test** is a test used in determining the amount of water content that is to be added in cement to attain Standard consistency or normal consistency of cement. It is Amount of water added in cement to penetrate the Vicat plunger up to a depth of 5-7mm from the bottom of the Vicat mould or 33-35mm from top of the Vicat Mould (Krishna, 2017, Shetty, 2010). It is a parameter that is used for determining the initial setting time, final setting time, soundness and strength of cement. The Standard or Normal consistency for Ordinary Portland cement varies between 25-35% Krishna 2017 and 26 to 33% (IS:4031-PART4-1988). However, Krishna 2017 adduced reasons for variation in the standard consistency as follows:

1.Weather conditions
2.The excessive composition of silica
3. The fineness of cement.
4. Cement produced by different companies doesn't have the same consistency.

$$P = \frac{w}{c} \times 100$$

……(1)

Where, W=Quantity of water added, C=Quantity of cement used

Setting Time: ASTM C125 defined setting time of cement as the time that elapsed from the time mixing water is added to a cementitous mixture until the mixture reaches a specified degree of rigidity as measured by a specific procedure which is a gradual and continuous process. Chemical reactions take place as a result of addition of water to cement which leads to the formation of cement paste that becomes stiffer with time and sets. The elapsed time to attain a specified level of resistance to penetration by a probe as a result of the rigidity of cement paste is measured and denoted as the setting time. This is regulated and retarded by the addition of gypsum thus ensuring that the concrete does not set too quickly before it can be placed or too slowly so as to hold up construction. BS12:1978: Specifies that the initial setting time for Ordinary and Rapid Hardening Portland must be a minimum of 60 minutes for grade 32.5 cement and 75 minutes for grade 42.5 cement while the final set must take place not later than 10 hours.

Properties of Sandcrete Blocks

The properties of sandcrete blocks examined in this study are water absorption, moisture content and compressive strength Hill and Rivzi !982 stated that building materials are generally hygroscopic that is they take up water and subsequently maintain a dynamic equilibrium of water content by either absorbing water from the environment or desorb it. The consequence of this phenomenon is the expansion and contraction of the material which in turn leads to damage through cracking". Hence the need to consider the two properties of block that relates it to water. These properties are moisture content and water absorption.

Moisture Content: Moisture content has to do with the amount of water present in a material. According to Thermal-survey.co.uk, "the main failure of buildings is the damage caused by water and its interactions on the building and local environment''. While Wikipedia stated that water/moisture content is the quantity of water contained in a material such as soil, rock, ceramics, fruit or wood. Keralli (2001), stated that increase in the moisture content of a material causes volume expansion to occur which is termed wetting expansion. In Omopariola 2015, it was stated that the deleterious effects of moisture on block properties is its vulnerable to repeated swelling and shrinkage due to variations in moisture and temperature.

Water Absorption: According to Omopariola water absorption refers to the amount of water absorbed by a composite material when immersed in water for a stipulated period of time under specified conditions, it is the rate at which water is taken into, and morphed into another object or phase. It is obtained by determining the ratio of the weight of water absorbed by a material, to the weight of the dry materials. In Omopariola 2015, one of the ways of improving the quality of sandcrete blocks is to reduce its Total Water Absorption capacity. This is because of the deleterious effects of moisture on block properties. The vulnerability of blocks to repeated swelling and shrinkage as moisture and temperature variations take place progressively lead to the weakening of a block fabric (either directly or indirectly). BS 7543, (1992) also stated that the presence of absorbed water can also lead to the creation of conditions suitable for the resumption and acceleration of otherwise dormant chemical activity. Hence, blocks with higher water absorption capacity are not likely to be durable.

Laboratory Tests

Laboratory tests were carried out on both the properties of cement and sandcrete blocks. The tests carried out on properties of cement are normal consistency, initial and final setting time. While those on sandcrete blocks are moisture content, water absorption and compressive strength.

Laboratory tests on Cement: The laboratory tests carried out on cement are Normal Consistency Test, Initial and Final Setting Time of cement which were done in accordance with specifications in BS EN 196-3:2005 respectively.

Laboratory tests on Blocks: Moisture content test was carried out on the sandcrete blocks in accordance with and using equation 2 to obtain the values

$$Mc = \frac{Ww - Wd}{Vs}$$

……(2)

Where Mc = Moisture content (Kg/m3), Ww = Mass of wet sample, Wd = Mass of dry sample Mw = Mass of water and

Vs = Volume of block sample.

Similarly, the water absorption test was carried out in accordance with and obtaining the values using equation (3)

$$TWA = \frac{Ww - Wd}{Wd} \times 100\ \% \quad \text{.....(3)}$$

Where TWA = Total Water Absorption, Ww = Wet weight and Wd = Dry weight

The compressive strength test was carried out in accordance with BS 6073 Part 1, (1981) and BS 3921, (1974). The compressive strength was then calculated in each case from the ratio of the maximum load and the cross – sectional area of the block in N/mm2. Load was then obtained for each sample.

$$CS = \frac{Ml}{As}\ kN/mm^2 \quad \text{.....(4)}$$

Where CS = Wet compressive strength N/mm2, Ml = Maximum load and As = Cross sectional area

Regression Analysis: Regression analysis was carried out using SPSS to determine the relationship of the consistency of cement with Total Water Absorption and with moisture content. Similarly, the same tool was used to determine the relationship of both the initial and final setting time of cement with the compressive strength of blocks.

Results and Discussions

Consistency of Cement

The value of the results of the standard consistency of cement is presented in Figure 1

The results of the Standard or Normal consistency of all the cement samples tested as shown in figure 1 falls between 30.75 and 34.75%. It implies that the Standard or Normal consistency for all the samples are withing the range recommended in literature or specified in relevant codes for Ordinary Portland cement (25-35% Krishna, 2017 and 26 to 33%, IS:4031-PART4-1988). However, Krishna 2017 adduced reasons for variation in the standard consistency as follows:

1.Weather conditions
2.The excessive composition of silica
3. The fineness of cement.
4. Cement produced by different companies doesn't have the same consistency.

From the foregoing, further tests will be required to confirm (1 – 3) above but 4 is obvious.

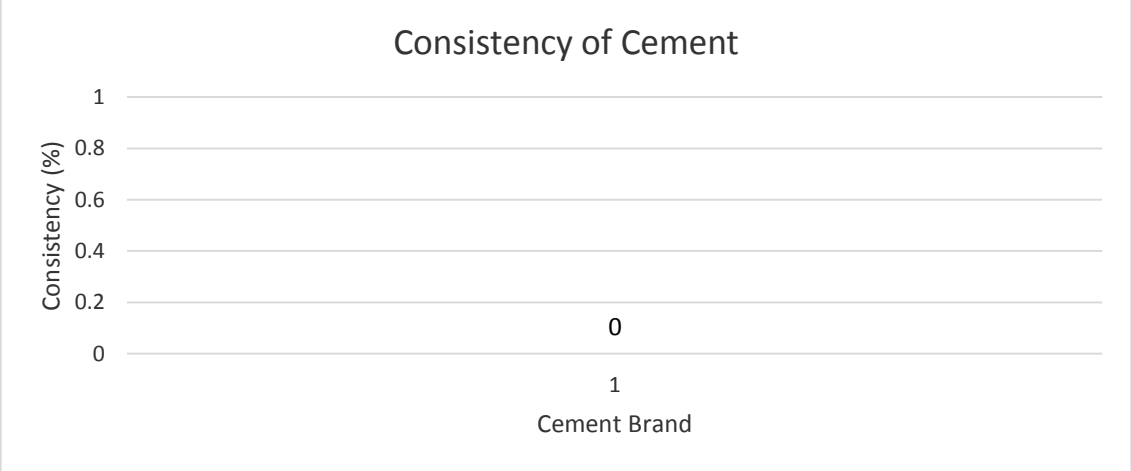


Figure 1 results of the standard consistency of cement

Figure 2 gives the result of the initial and final setting of cement. The result indicates that all the samples are in accordance with stipulated specifications in BS12:1978: which specifies that the initial setting time for Ordinary and Rapid Hardening Portland cement must be a minimum of 60 minutes for grade 32.5 cement and 75 minutes for grade 42.5 cement while the final set must take place not later than 10 hours. The initial setting time of Purechem and Elephant which are grades 32.5 are 150 and 158minutes respectively. These are more than the 45minutes stipulated in the code. The final setting times are 5hours and 3.17 hours respectively and are lower than the specified 10 hours. Similarly, the initial setting times of Dangote, Nouvelle, Powermax and Superset are 160, 130, 170 and 100minutes respectively. These are higher than the 60minutes specified in the code. While the corresponding values for the final setting time are 4.67, 4.5, 4 and 3.75 hours respectively and are lesser than the specified 10 hours.

Initial and Final Setting Time of Cement

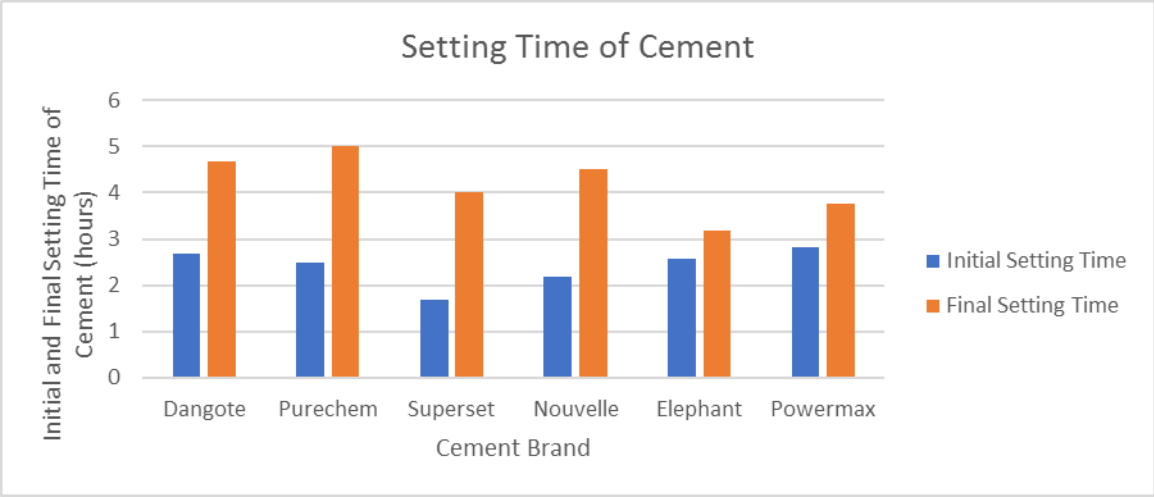


Figure 2 Results of the initial and final setting time of cement

Total Water Absorption of Sandcrete Blocks

From the results shown in Table 3, it can be deduced that the TWA values ranges between 6.3 and 11.9% for 150mm blocks while it is 7.7 to 11.8 for 225mm blocks are within the limits specified in literature and compare well with those of like materials. The recommended maximum value according to (ILO, 1987) is 15%. However, in BS 5628 Part 1, it was stated that TWA values below 7% are regarded as being low, while those above 12% are regarded as high. Jackson and Dhir (1996) puts the range of TWA of other materials such as clay bricks 0 to 30%; concrete blocks 4 to 25%; calcium silicate bricks 6 to 16%. Although this value is neither absolute nor widely adopted by other researchers, it still serves a useful purpose. This implies that only the TWA value for 150mm blocks made with Nouvelle block can be regarded as low while 150mm blocks made from all other brands as well as all the 225mm blocks made from all the brands have medium or moderate water absorption.

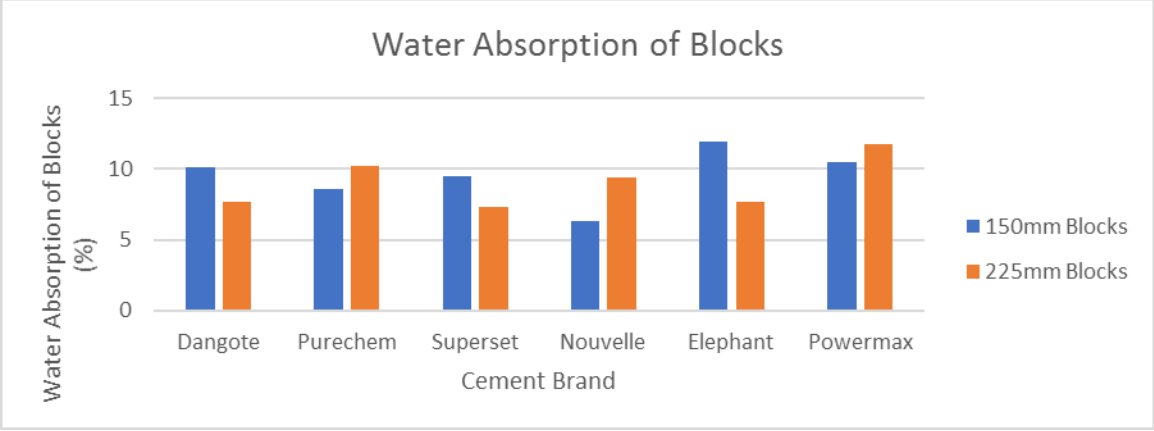


Figure 3 Results of Total Water absorption for Sandcrete Blocks

Moisture Content of Sandcrete Blocks

The obtained values of moisture content as presented in figure 4 ranges from 60 – 78kg/m3 for 150mm blocks made from all cement brands and 63 – 76kg/m3 for 225mm blocks made from all cement brands. This follows that the moisture content of all the block samples are within the recommended value of 80kg/m3 (Taylor, 1977)

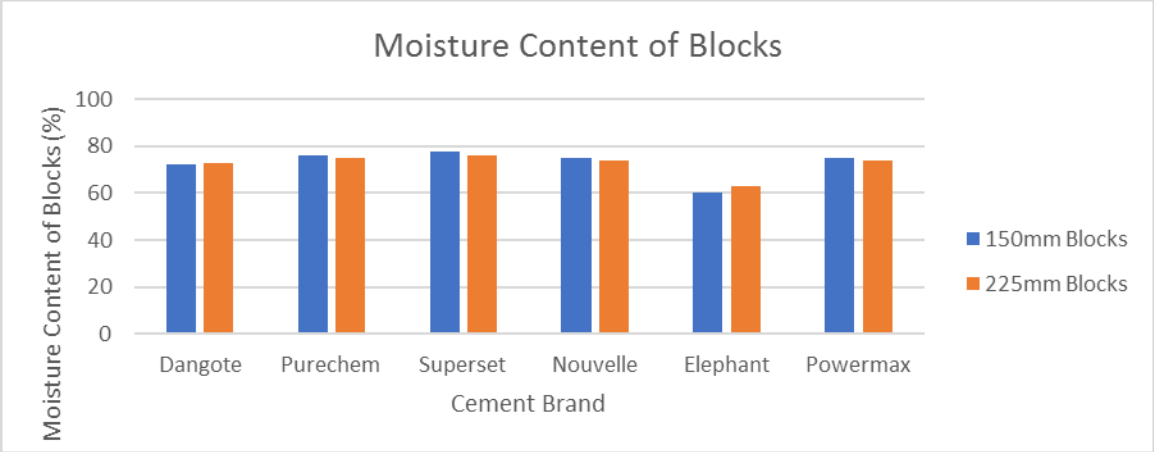


Figure 4 Results of Moisture Content for Sandcrete Blocks

Compressive Strength for Sandcrete Blocks

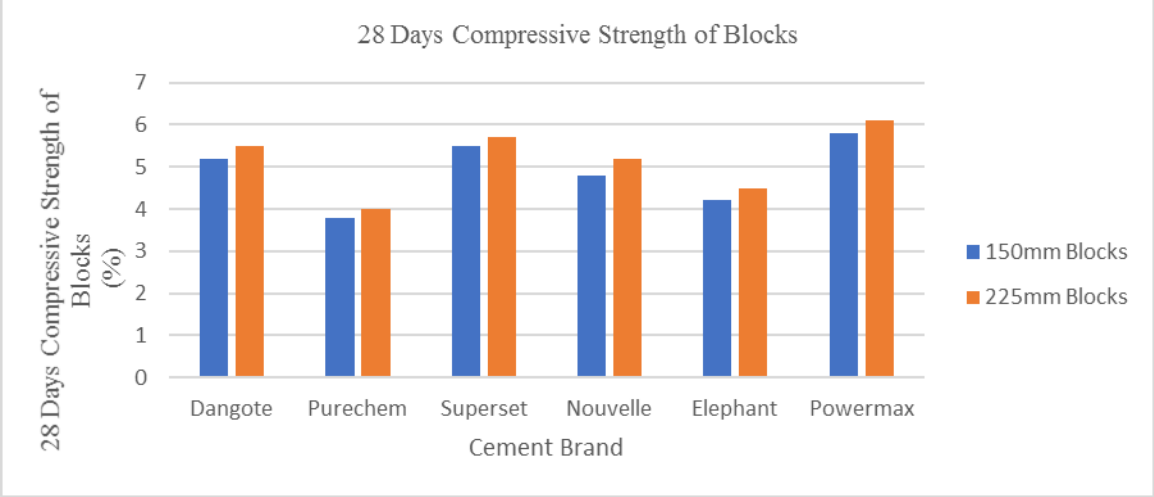


Figure 5 Results of Compressive Strength for Sandcrete Blocks

The result of the compressive strength of the blocks are presented in figure 5. The results indicated that the blocks made with grade 32.5 has lower values of compressive strength than that made with grade 42.5 cements for both 150mm and 225mm sizes. Purechem and Elephant cements (both of grade 32.5) has CS values of 3.8, 4 and 4.2 4.5N/mm2 respectively. On the other hand, the 150mm blocks made with 42.5 grades of cement have higher values of 5.2, 5.5 4.8 and 5.8, for Dangote, Superset, Nouvelle and Powermax respectively. As for 225mm blocks made with 42.5 grades of cement the values are 5.5, 5.7, 5.2 and 6.1 respectively. All these values fall are above the specified minimum compressive strength of 2.5N/mm2 and 3.45N/mm2 for sandcrete blocks prescribed by NIS 87: 2000 for load bearing and non-load bearing walls for the 28days result.

Regression Analysis of the relationship of Properties of Cement with the Properties of Sandcrete Blocks

The results of the regression analysis are presented in Tables 1 and 2. While the scatter diagram of the regression curve are presented in figures 6 – 13. From Table 1, the correlation of normal consistency of cement with the moisture content of both 150mm and 225mm blocks are 0.735, 0.772 respectively with r2 value of 0.540 and 0.595 respectively. The regression equations are Y = 21.82 + 0.15x and Y = 17.03 + 0.22x respectively. It implies that there is a positive high correlation between normal consistency of cement with the moisture content of both types of blocks. The regression equation gives the relationship that exists between the two variables.

In the same vein, in Table 1, the values of correlation coefficients (r) of normal consistency of cement with the water absorption of both 150mm and 225mm blocks are – 0.719 and 0.400 respectively, while r2 value are 0.517 and 0.160 respectively. The regression equations are Y = 37.87 – 0.51x and Y = 30.23 + 0.31x respectively. It implies that while there is a negative high correlation between normal consistency of cement and water absorption of 150mm blocks, the correlation between normal consistency of cement and water absorption of 225mm blocks positive medium correlation. The regression equation gives the relationship that exists between the two variables.

Table 1. Relations between Consistency of Cement and Moisture Content with Water Absorption of Blocks

Types of Variables	Correlation Coefficient (r)	R2	Regression Equation
Consistency of Cement and Moisture Content of 150mm Blocks	0.735	0.540	Y = 21.82 + 0.15x
Consistency of Cement & Moisture Content of 225mm Blocks	0.772	0.595	Y = 17.03 + 0.22x
Consistency of Cement & Water Absorption of 150mm Blocks	- 0.719	0.517	Y = 37.87 – 0.51x
Consistency of Cement & Water Absorption of 225mm Blocks	0.400	0.160	Y = 30.23 + 0.31x

Table 2 gives the relations between the Initial and Final setting time of cement and the compressive strength of Blocks. From the table, the Correlation Coefficient (r) of all the values are low and have negative values except the relationship between Final Setting Time of Cement and the Compressive Strength of 225mm Blocks which gives medium negative correlation. It implies that there is no significant relationship between these values.

Table 2. Relations between the Initial and Final setting time of cement and the compressive strength of Blocks.

Types of Variables	Correlation Coefficient (r)	R2	Regression Equation
Initial Setting Time of Cement & Compressive Strength of Blocks(150mm)	– 0.016	0.003	Y = 2.54 – 0.03x
Initial Setting Time of Cement & Compressive Strength of Blocks(225mm)	– 0.053	$2.67x10^{-4}$	$Y = 2.45 – 9.9 X 10^{-3x}$
Final Setting Time of Cement & Compressive Strength of Blocks(150mm)	– 0.263	0.069	Y = 5.25 – 0.22x
Final Setting Time of Cement & Compressive Strength of Blocks(225mm)	– 0.460	0.211	Y = 6.26 – 0.41x

Figures 6 – 13 presents the scatter graph of the relationship between the various parameters.

Regression Graph of Relationship Between Normal Consistency of Cement and Moisture Content of Sandcrete Blocks

Figures 6 and 7 shows the regression graph of the Relationship between Consistency of Cement and Moisture Content of 150mm Blocks and 225mm blocks respectively. Both graphs give indications of a positive high relationship with regression equations of Y = 21.82 + 0.15x and Y = 17.03 + 0.22x respectively.

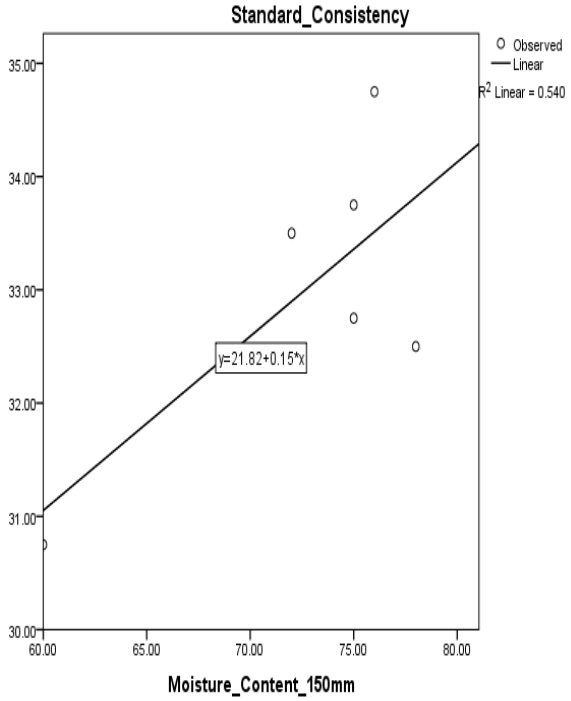


Figure 6 Relationship between Consistency of Cement and Moisture Content of 150mm Blocks

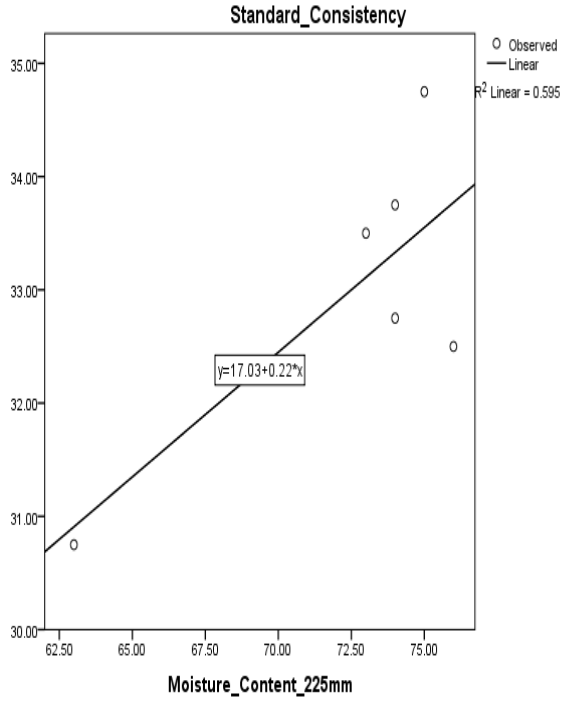


Figure 7 Relationship between Consistency of Cement and Moisture Content of 225mm Blocks

Regression Graph of Relationship Between Normal Consistency of Cement and Water Absorption of Sandcrete Blocks

Figures 8 and 9 presents the relationship between the normal consistency of cement with the water absorption for both 150mm and 225mm blocks. While there is a negative relationship between normal consistency of cement and water absorption of 150mm blocks, the relationship between normal consistency of cement and water absorption of 225mm

blocks is positive. The regression equations are Y = 37.87 – 0.51x and Y = 30.23 + 0.31x respectively

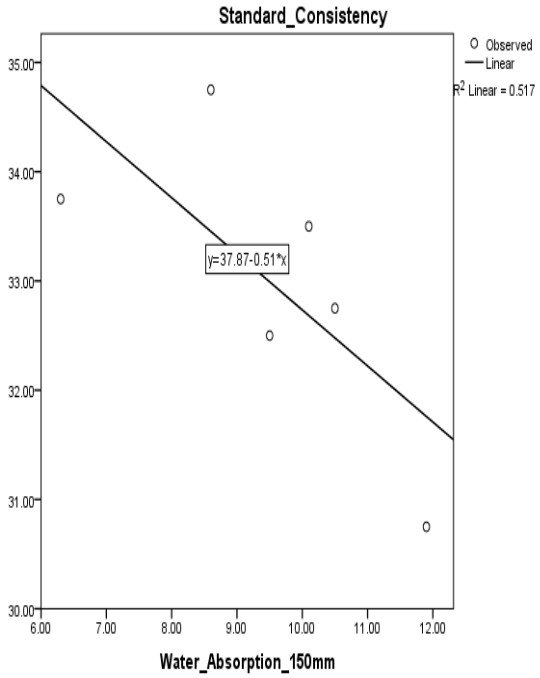


Figure 8 Relations between Consistency of Cement and Water Absorption of 150mm Blocks

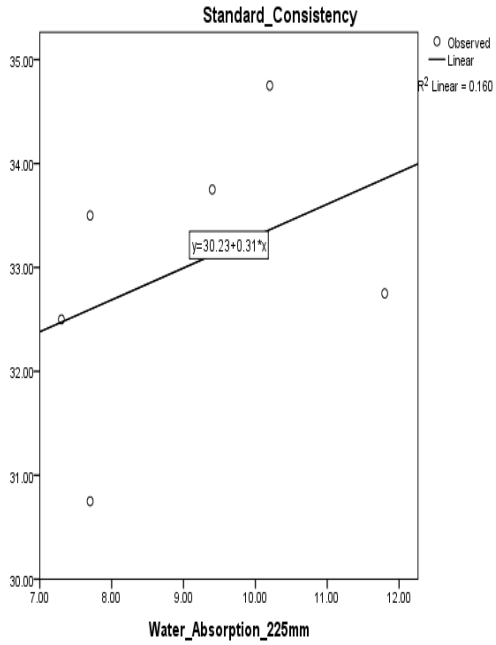
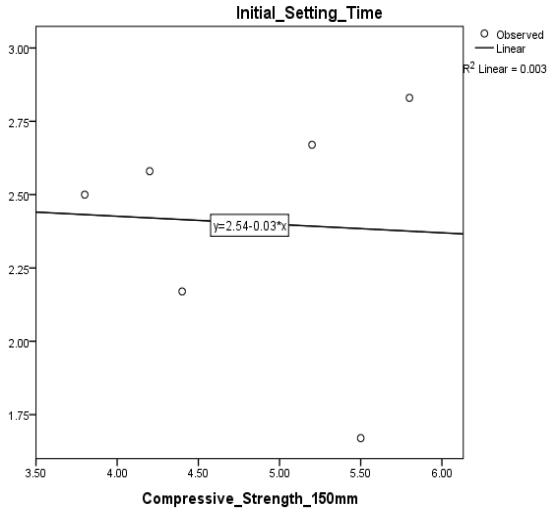


Figure 9 Relations between Consistency of Cement and Water Absorption of 225mm Blocks

Regression Graph of Relationship Between of Initial Setting Time Cement and the Compressive Strength of Sandcrete Blocks

In figure 10 and 11 representing the regression graph of relationship between initial setting time of cement and the compressive strength of sandcrete blocks, all the values low and in the negative direction. The regression equations are given as Y = 2.54 – 0.03x, Y = 2.45 – 9.9 X 10^{-3x} for both the 150mm and 225mm blocks respectively. It implies that there is no significant relationship between these values. Y = 6.26 – 0.41x



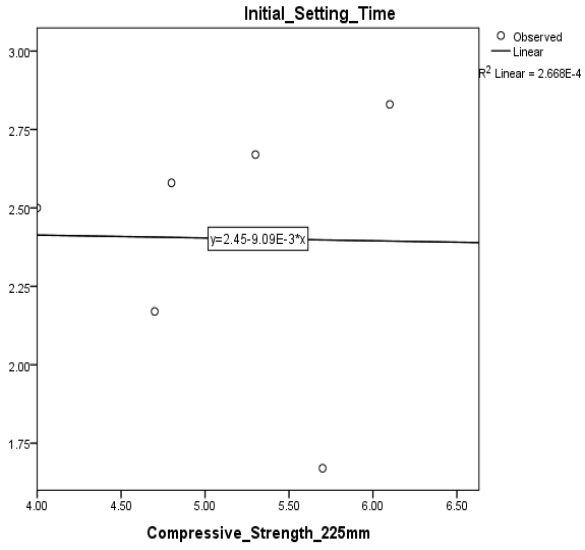
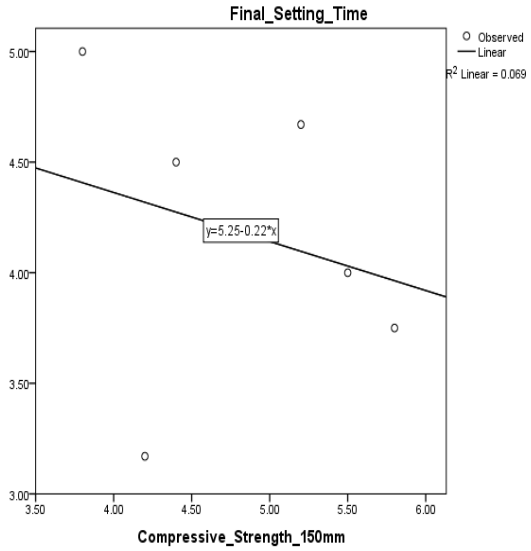


Figure 10 Relations between Initial Setting Time of Cement and Compressive Strength of 150mm Blocks Blocks

Figure 11 Relations between Initial Setting Time of Cement and Compressive Strength of 225mm

Regression Graph of Relationship Between of Final Setting Time Cement and the Compressive Strength of Sandcrete Blocks

Figures 12 and 13 are the regression graph of relationship between initial setting time of cement and the compressive strength of sandcrete blocks. From the both graphs, there are indications of low and negative relationship for 150mm blocks. While the relationship is negative but medium in the case of 225mm blocks. The equation of the relationships are given by Y = 5.25 – 0.22x, Y = 6.26 – 0.41x respectively.



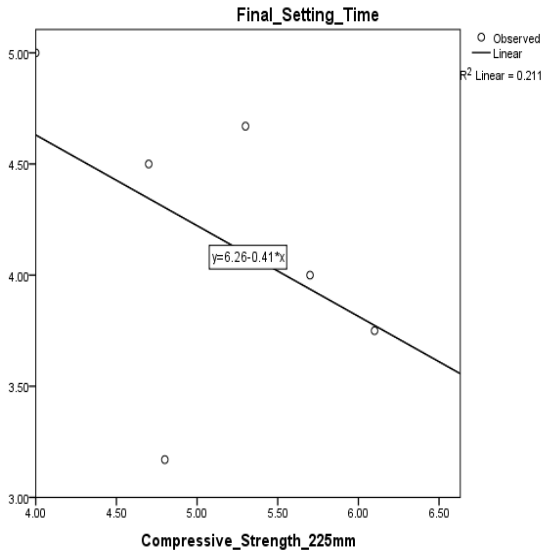


Figure 12 Relations between Initial Setting Time of Cement and Compressive Strength of 150mm Blocks

Figure 13 Relations between Initial Setting Time of Cement and Compressive Strength of 225mm Blocks

Conclusion

From the study, it can be deduced that all the properties of cement (normal consistency, initial and final setting time) of all the brands of cement tested in the study are in accordance with specifications in the relevant codes and standards. Similarly, all the properties of sandcrete blocks made from all the cement brands are in accordance with specifications in relevant literature, codes and standards. In carrying out the regression analysis, it can be concluded that while there are high positive correlation between the normal consistency of cement and the moisture content of both 150mm and 225mm blocks, the correlation between normal consistency of cement and water absorption of 150mm blocks is high and negative but for 225mm blocks it is medium and positive. The initial setting time of cement exhibit a very low negative correlation with the compressive strength of both 150mm and 225mm blocks, while the correlation of the final setting time of cement and the compressive strength of 225mm blocks is low and negative for 150mm blocks but moderate and negative for 225mm blocks.

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