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Assessment of Compressive Strength of Concrete Produced from Different Brands of Portland Cement

Gideon Olukunle Bamigboye[1], Anthony Nkem Ede[1], Chioma Egwuatu[1], Joshua Jolayemi[1], Oluwaleke Olowu[2] and Tajudeen Odewumi[3]

1. Department of Civil Engineering, Covenant University, Ota, Ogun State, Nigeria.
2. Department of Building Technology, Yaba College, P.M.B 2011 Sabo, Lagos, Nigeria.
3. Department of Civil Engineering, The Polytechnic Ibadan, P.M.B 22, Nigeria.

Abstract

Concrete is basically a mixture of two components: aggregates and paste. The paste, comprised of Portland cement and water, binds the aggregates (usually sand and gravel or crushed stone) into a rocklike mass as the paste hardens because of the chemical reaction of the cement and water. In our society today some of the cement brands that are being sold are not up to standard and this may be traced to negligence on the part of the manufacturers by paying very little attention to the quality and also the regulatory body does not put strict measures to enforce the required standard. This problem has led to the production of poor quality concrete that increases the risk of collapse of building structures. This research determined the cement brands that have the highest compressive strength to enhance the quality and durability of the structures being built in the country. Different brands of Portland cement were used to produce concrete varying with1:2:4 and 1:3:6 mix ratio respectively with a curing date of 3, 7, 14, 21, and 28 days respectively. No additive was used in any of the mix. The tests carried out include slump test at its fresh state while compressive strength was carried out for the hardened concrete, also the vicat test was carried out on the cement brands to determine the setting time. Compressive strength at 28 days showed that Dangote 3X cement produced 25.27N/mm^2, Ibeto cement 38.89 N/mm^2, Purechem cement 24.58 N/mm^2, Unichem cement 21.16 N/mm^2 and Elephant cement 27.9 N/mm^2 for 1:2:4 mix ratio respectively. For 1:3:6 mix ratio at 28 days Dangote cement produced 18.89 N/mm^2, Ibeto cement 22.07 N/mm^2, Purechem cement 11.63 N/mm^2,Unichem cement 15.86 N/mm^2 and Elephant cement 16.71 N/mm^2 respectively. The study concluded that Ibeto cement has the highest strength at 28 days for 1:2:4 and 1:3:6 mix ratios respectively.

Keywords: Cement, Compressive strength, Concrete, Fresh Property, Portland Cement

1. Introduction

Concrete is composed of aggregates embedded in a cement matrix which fill the space between the aggregates and bind them together. Concrete is a very strong building material and the use of concrete predates back before the Roman Empire. It was widely used in the Middle East, Greece and Egypt for building before the Romans made wide use of it for road construction. In each of these usages the components of concrete varied and from the mid-eighteen century till date concrete has been the most common building materials. After the patent of Portland cement in the 1824 by Joseph Aspdin, concrete became the most adopted material for the construction of infrastructure and buildings in the advanced world. Concrete has very good compressive strength and resistance to fire (Oyenuga, 2001; Ede and Aina, 2015), but the tensile strength is just about 10% of the compressive strength and have been responsible for many recent researches aimed at improving the general strengths of concrete (Zongjin, 2011; Ede and Abgede, 2015). As there has not been a better alternative over the years modern structures in developed and developing nations are mostly built in concrete. Concrete is an artificial stone-like material used for various constructional purposes and manufactured by mixing cement and various aggregates. Better still, concrete could be a composite material, which is made up of filler and a binder. Concrete as the most widely used man-made construction materials is second only to water as the most utilized substance on the planet (Gambhir, 2005). It is obtained by mixing cementitous materials, water and aggregate (and sometimes admixtures) in required proportion. Joseph and Raymond (2014) found that concrete develops an average of 26 % of the 28 days strength in 1 day and 85 % in 21 days and concluded that concrete develop strength rapidly at early age compared to later ages. Quality of concrete material can have positive or negative impact on a society. For instance, in Nigeria the most dominant construction material is concrete and the most collapse structures are concrete structures. Various researches (Ayininuola and Olalusi 2004, Ede, 2010 and 2011) have all identified the use of substandard materials, particularly concrete as the leading causes of building collapse in Nigeria. Deodhar (2009) reported that, the strength of concrete is mainly affected by the water cement ratio; the workability is affected by aggregate to water ratio and the cost by the aggregate cement ratio. The evolution of concrete has pass through plain concrete, reinforced concrete, precast concrete, pre-stressed concrete to the contemporary concrete. Plain concrete made of Portland cement, coarse and fine aggregate and water is usually called the first generation of concrete while the steel bar–reinforced concrete is the second generation concrete (Ede et, al., 2015[a]). As the versatility of concrete continues to increase, the quality can hardly be certified because of many other factors such as aggregates, cement, mixing procedures and skill of operators, placement and consolidation. It varies according to so many variables such as quality of constituent materials (cement aggregates, water and admixtures), skill of the manufactures, management placement procedures and environmental issues (Zongjin, 2011; Ede et al., 2015[b]). Shetty (2006) reported that in concrete, aggregates and paste are the major factors that affect the strength of concrete. Abdullah, (2012) stated that the strength of the concrete at the interfacial zone essentially depends on the integrity of the cement paste and the nature of the coarse aggregate. The binding quality of Portland cement paste is due to the chemical reaction between the cement and water (Raheem and Bamigboye, 2013). Portland cement is not a simple chemical compound, it is a mixture of many compounds. Four of these make up 90 % or more of the weight of Portland cement, tricalcium silicate, dicalcium silicate, tricalcium aluminate and tetracalcium alumnoferrite (Kosmatka et, al., 2002). The less porous the cement paste, the stronger the concrete. Therefore, no more water than is absolutely necessary to make the concrete plastic and workable should be used. Even then, the water used is usually more than is required for complete hydration of the cement. About 0.4 grams of water per gram of cement are needed to completely hydrate cement (Raheem and Bamigboye, 2013). The degree of cement hydration which is a function of water to cement ratio has a direct impact on the porosity and consequently on the strength. The richness of the mix is one of the factors that affect the rate of strength development in concrete mix and is a direct function of the quality and quantity of the cementitus material. Knowledge of the rate of reaction between cement and water is important because it determines the rate of hardening. The initial reaction must be slow enough to allow time for the concrete to be transported and placed. Once the concrete has been placed and finished, rapid hardening is desirable. Gypsum added at the cement mill when clinker is ground, acts as a regular of the initial rate of setting of Portland cement. Other factors that influence the rate of hydration include cement fineness, admixture, amount of water added and temperature of the material at the time of mixing. Yahaya, et, al., (2014) Compared compressive strength of four brands of cement, Ordinary Dangote, Eagle cement, Unicem and Ibeto cement. Concluded that Eagle cement has the highest compressive strength at 28 days. This study focus on five brands of cement, Dangote 3X cement, Ibeto cement, Purechem cement, Unichem cement and Elephant cement (super set).

2. Materials and Methods

The cements used for this research were Dangote (3X) cement, Purechem cement, Unichem cement, Elephant (super set) cement and Ibeto cement. They were supplied in 50 kg bags for each of the brands. The fine aggregate was obtained from Ogun River with 95% passing through the 4.75mm test sieve. The aggregate size was 20 mm maximum with 91.32% passing through the 25mm test sieve. Potable water was used for mixing in accordance with BS 3148: Part 3, 1993. The materials were batched by weight; 150 mm x 150 mm x 150 mm metallic moulds with oil smeared on the inside of the moulds to avoid sticking were used for casting of concrete specimen using 1:2:4 and 1:3:6 mix ratio respectively.

The test carried out includes: Sieve analysis which was used to determine the grading of aggregates in accordance with BS 812: Part 103, 1985. Slump and compaction factor test on fresh concrete in accordance with BS 1881: Part 102,1983 and BS 1881: Part 103, 1993 respectively, initial and final setting time of the cement was also tested in accordance with BS 4450 Part 3, 1978 on cement and compressive strength test on hardened concrete in accordance with BS 1881:Part 116:1983. Three concrete cubes were tested for each testing days namely: 3 days, 7 days, 14 days, 21 days and 28 days. Curing of the samples was done by ponding method and the water in the curing pond was kept at an average laboratory temperature of 28 0C to prevent the thermal stresses that could result in cracking just as James et al., 2011 suggested. At the testing days, the concrete were removed from the curing bath, allowed to drain for about an hour, weighed and the compressive strength determined using an automatic Controls Compressive strength testing machine available at structural laboratory, Department of Civil Engineering, Covenant University, Ota.

3. Results and Discussion

The results of sieve analysis for sand and granite used are presented in Table 1 and 2 likewise in figures 1 and 2. The particle size distribution curves of sand and granite showed that aggregates used for this study complied with the standard, were well graded and are therefore suitable for making good concrete. Table 3 and 4 summarized the 1:2:4 and 1:3:6 mix ratios slump test for five brands of cement.

Table 1: Sieve Analysis of Sharp Sand

Sieve Size	Weight Retained	% retained	cumulative % retained	% finer
9.30	14.40	2.59	2.59	97.41
6.30	5.80	1.04	3.63	96.37
4.75	9.30	1.67	5.31	94.69
2.36	4.90	0.88	6.19	93.81
1.00	222.30	39.98	46.17	53.83
0.60	180.90	32.54	78.71	21.29
0.30	86.40	15.54	94.24	5.76
0.21	11.50	2.07	96.31	3.69
0.08	14.80	2.66	98.97	1.03
Pan	5.70	1.03	100.00	0
	556.00	100.00		

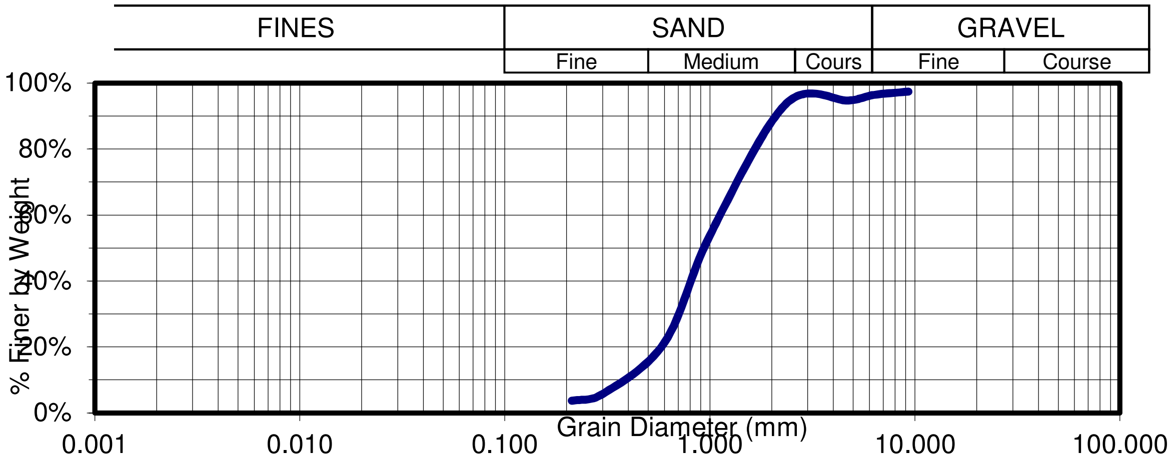

Figure 1: Grading curve distribution for sharp sand

Table 2: Sieve analysis result for coarse aggregates

Sieve Size	Weight Retained	% retained	cumulative % retained	% finer
31.50	0.00	0.00	0.00	100.00
25.00	88.50	8.68	8.68	91.32
19.00	362.10	35.53	44.21	55.79
12.50	504.00	49.45	93.66	6.34
9.50	14.60	1.43	95.09	4.91
6.30	29.00	2.85	97.94	2.06
4.75	0.00	0.00	97.94	2.06
0.00	21.00	2.06	100.00	0.00
	1019.2			

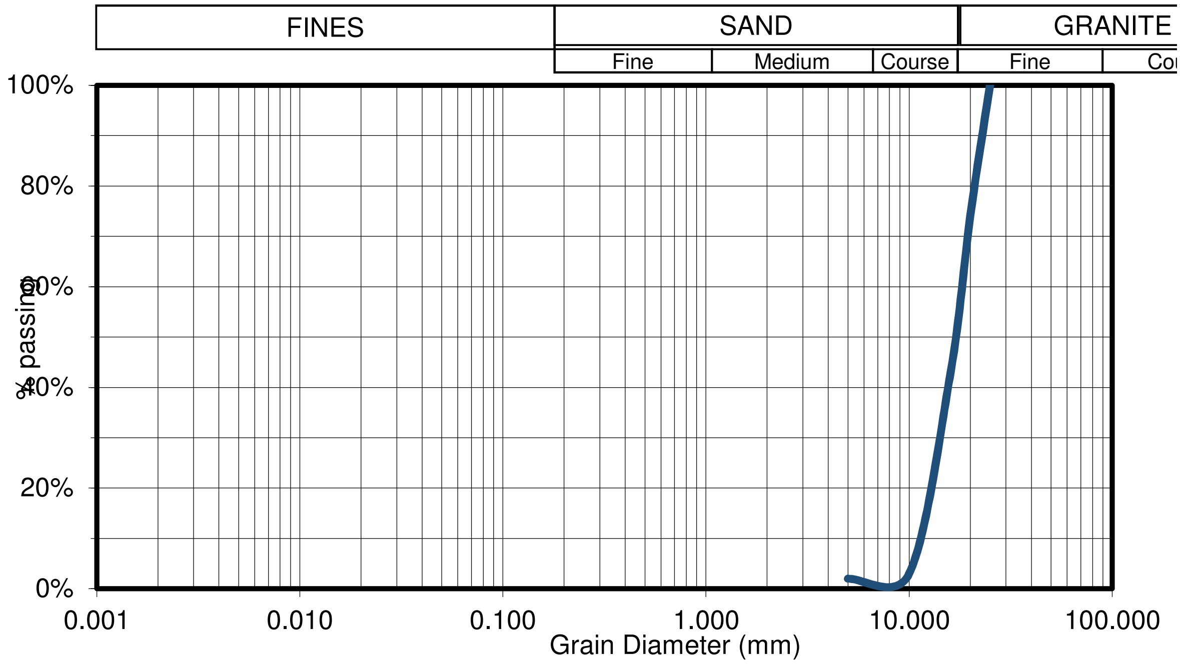

Figure 2: Grain size analysis for granite

Table 3. 1:2:4 mix ratio Slump test results of the various brand of cement

Cement brand	Height of slump cone (mm)	Height of collapse (mm)	Slump (mm)
Dangote 3X	300.00	260.00	40.00
Ibeto	300.00	255.00	45.00
Purechem	300.00	248.00	52.00
Unichem	300.00	258.00	42.00
Elephant (Super set)	300.00	260.00	40.00

Table 4. 1:3:6 mix ratio Slump test results of the various brand of cement

Cement brand	Height of slump cone (mm)	Height of collapse (mm)	Slump (mm)
Dangote 3X	300.00	240.00	60.00
Ibeto	300.00	235.00	65.00
Purechem	300.00	232.00	68.00
Unichem	300.00	241.00	59.00
Elephant (Super set)	300.00	240.00	60.00

From the table of values showing the slump heights, it can be deduced that the slump height for all cement brands with the mix ratio of 1.2.4 are much lower than the slump height with mix ratio of 1.3.6 indicating that the 1.2.4 mix ratio was more workable than the 1.3.6 mix ratio. This was traceable to the presence of more coarse aggregate in the 1.3.6 mix ratio as compared to the 1.2.4 mix, while the workability of mix ratio 1.2.4 could be traced to the presence of more cement as batched by weight, creating a more binding property for the particle in the mix. Thereby requiring more water to be added during the mix causing a shear slump while the mix ratio 1.2.4 retained its shape resulting to a true slump.

3.1 Cement Test:

From Table 5, the minimum initial setting times of all the brands of cement was 30 min, while the final setting time varied from 540 min to 600 min. This is in accordance with BS 4550 Part 3: 1978. Therefore, since the initial setting time of cement does not exceed 30 minutes, the cement is within the range of setting time. Also since the final setting times of cement are not more than 10 hours, the cement has satisfied the specified setting time.

Table 5. Setting time of cement

Brand of Cement	Initial Setting Time (minutes)	Final Setting Time (minutes)
Dangote 3X	30	540
Elephant (super set)	30	580
Ibeto	30	600
PureChem	30	600
UniChem	30	600

3.2 Compressive Strength Test

The compressive strength for 1:2:4 and 1:3:6 mix ratios for different brands of cement are presented in Table 6-15 showing the results of cube crushing at 3, 7, 14, 21and 28 days respectively. Table 6 and 7 shows the compressive strength result for Dangote 3X cement at 1.2.4 mix ratio and 1.3.6 mix ratio respectively at the different curing days of 3, 7, 14, 21, and 28 days respectively.

Table 6: Compressive Strength test of Dangote 3X cement using 1:2:4 mix ratio

Age (Days)	Average Weight of Cubes (kg)	Average compressive strength (N/mm^2)
3	9.00	16.89
7	8.83	18.14
14	8.30	21.78
21	8.20	22.06
28	8.50	25.27

It can be seen that the compressive strength increased progressively as the number of days of curing was increased having the least curing day at day 3 with a compressive strength of 16.89N/mm^2 to the highest day strength at 28 days with an average strength of 25.27 N/mm^2 for the 1.2.4 mix ratio. For the 1.3.6 mix ratio, a compressive strength of 7.11 N/mm^2 for the least day and 18.9 N/mm^2 as the average strength for 28 days were verified.

Table 7: Compressive Strength test of Dangote 3X cement using 1:3:6 mix ratio

Age (Days)	Average Weight of Cubes (kg)	Average compressive strength (N/mm^2)
3	8.17	7.11
7	8.50	12.15
14	8.50	15.76
21	8.33	17.19
28	8.67	18.89

From table 8, it was observed that the strength attainment at day 3, 7 and 14 was gradual and then became very rapid at 21 and 28 days for the 1.2.4 mix ratio of the Purechem cement brand. This may be linked to the type of additive added to the cement. There was a progressive increase in the day strength as the days increased for Purechem cement brand at mix ratio 1.3.6 but an overall reduction in the strength for this particular mix ratio was verified as in table 9.

Table 8: Compressive Strength test of Purechem cement using 1:2:4 mix ratio

Age (Days)	Average Weight of Cubes (kg)	Average compressive strength (N/mm^2)
3	8.83	12.81
7	9.00	13.85
14	9.17	14.67
21	8.83	22.98
28	9.00	24.58

Table 9: Compressive Strength test of Purechem cement using 1:3:6 mix ratio

Age (Days)	Average Weight of Cubes (kg)	Average compressive strength (N/mm^2)
3	8.50	5.63
7	8.50	8.19
14	8.50	9.78
21	8.50	11.39
28	8.50	11.63

Table 10: Compressive Strength test of Unichem cement using 1:2:4 mix ratio

Age (Days)	Average Weight of Cubes (kg)	Average compressive strength (N/mm^2)
3	8.50	15.21
7	8.67	17.18
14	8.50	19.25
21	8.67	20.39
28	8.83	22.16

From tables 10 and 11, it was concluded that the compressive strength of the Unichem cement increased progressively as the number of days of curing was increased having the least curing day at day 3 with a compressive strength of 15.21 N/mm² to the highest day strength at 28 days with an average strength of 22.16 N/mm² for the 1:2:4 mix ratio while the 1:3:6 mix ratio had a min of 11.11 N/mm² and a maximum 5.8 N/mm², respectively.

Table 11: Compressive Strength test of Unichem cement using 1:3:6 mix ratio

Age (Days)	Average Weight of Cubes (kg)	Average compressive strength (N/mm^2)
3	8.50	11.11
7	8.67	14.00
14	8.50	14.22
21	8.67	14.43
28	8.67	15.86

Table 12: Compressive Strength test of Elephant (Super set) cement using 1:2:4 mix ratio

Age (Days)	Average Weight of Cubes (kg)	Average compressive strength (N/mm^2)
3	8.17	10.96
7	8.17	15.33
14	8.50	24.45
21	8.67	26.33
28	8.50	27.93

For the Elephant cement brand, at 1.2.4 mix ratio there was a progressive increase in the compressive strength from the least age at day 3 with a strength of 10.96 N/mm² to the maximum strength of 27.93 N/mm². This particular cement brand and mix had the highest strength attained after the Ibeto cement brand. The strength gained with mix ratio 1.3.6 for Elephant cement was 6.07 N/mm², while the strength gained at the maximum 28 days which was 16.71 N/mm² and this was more than double the earliest day strength. This shows that there was a progressive increase in the strength, but an overall strength reduction as compared to using 1.2.4 mix ratio for the same cement brand.

Table 13: Compressive Strength test of Elephant (Super set) cement using 1:3:6 mix ratio

Age (Days)	Average Weight of Cubes (kg)	Average compressive strength (N/mm^2)
3	8.33	6.07
7	8.50	8.29
14	8.50	12.14
21	8.67	15.85
28	8.50	16.71

Table 14: Compressive Strength test of Ibeto cement using 1:2:4 mix ratio

Age (Days)	Average Weight of Cubes (kg)	Average compressive strength (N/mm^2)
3	9.00	24.44
7	8.70	26.67
14	8.83	30.99
21	8.50	31.83
28	9.00	38.80

From the table of values for Ibeto cement, it was observed that a high compressive strength was attained at the least age which was at day 3 with an average strength of 24.44 N/mm² and increased progressively to the highest age at 28 days with an average strength of 38.8 N/mm² for the 1:2:4 mix ratio. This particular brand of cement produced the highest compressive strength both at the least and highest age than all the other brands of cement. From this result it was concluded that there may be presence of high early strength additive added to the cement. From the compressive strength values, it was clearly deduced that the 1:3:6 mix ratio altered the compressive strength from the least to the highest age and produced an average of 14.84 N/mm² at day 3 to about 22.06

N/mm² at day 28.

Table 15: Compressive Strength test of Ibeto cement using 1:3:6 mix ratio

Age (Days)	Average Weight of Cubes (kg)	Average compressive strength (N/mm^2)
3	8.67	14.44
7	8.50	16.89
14	8.50	20.10
21	8.50	21.39
28	8.67	22.07

4. Conclusion

The minimum requirement of 25 N/mm^2 cube strength for reinforced concrete according to BS 8110: Part 1 (1997) was achieved by all except Unicem cement for the 1:2:4 mix ratio. It was concluded that the Ibeto cement brand with mix ratio 1:2:4 attained progressively increased compressive strength at the earliest age with an average strength of 24.4 N/mm^2 and 38.8 N/mm^2 at the 28 days, making it the cement brand with the highest compressive strength to be attained at the earliest and latest curing age. This high strength can be attributed to the addition of a high gaining strength additive in the cement brand. Then followed the Elephant (Super set), Dangote 3X, Purechem and Unichem. The research results showed clearly the dynamics of strength gain for common Nigerian Portland cements.

References

Abdullahi, M., (2012) "Effect of Aggregate Type on Compressive Strength of Concrete", *International Journal of Civil and Structural Engineering,* Vol. 2, No 3, pp. 791-800.

Ayininuola, G.M. and Olalusi, O.O. (2004) "Assessment of building failures in Nigeria: Lagos and Ibadan case study", *Africa Journal of Science and Technology (AJST)* 5 (1): 73-78.

BS 12 (1991), "Specifications for Portland cement", London, British Standards Institution.

BS 1881: Part 116 (1983), "Method for determination of Compressive strength of concrete cubes", London, British Standard Institution.

BS 3148 (1993), "Method of test for water for making concrete (including note on the suitability of water)", London, British Standards Institution.

BS 4550: Part 3 (1978), "Method of testing Cement: Physical Test", London. British Standards Institution.

BS 8110: Part 1 (1997), "Structural use of concrete: code of practice for design and construction". London, British Standards Institution.

BS 812: Part 103 (1985), "Grading of aggregates", London, British Standard Institution.

BS1881: Part 102 (1983), "Methods for determination of slump", London, British Standards Institution.

BS1881: Part 103 (1983), "Methods for determination of Compaction factor", London, British Standards Institution.

Deodhar, S. V., (2009), "Civil Engineering Materials", 6th Edition, Khanna Publishers, 2-B, Nath Market, Nai Sarak, Delhi India. ISBN 81-7409-163-7.

Ede, A.N. (2010), "Building Collapse in Nigeria: the Trend of Casualties in the Last Decade (2000 -2010)", *International Journal of Civil & Environmental Engineering*, Vol. 10 No: 06, pp 32-42.

Ede, A.N. (2011), "Measures to Reduce the High Incidence of Structural Failures in Nigeria", *Journal of Sustainable Development in Africa,* Volume 13, No.1, pp 153-161.

Ede, A.N., Adebayo, S.O., Bamigboye, G.O. and Ogundeji, J. (2015b). "Structural, Economic and Environmental Study of Concrete and Timber as Structural Members for Residential Buildings in Nigeria", *The* International Journal of Engineering and Science (IJES), Volume 2, issue 3, pp. 76-84.

Ede, A.N., Agbede, J.O. (2015), "Use of Coconut Husk Fibre for Improved Compressive and Flexural Strength of Concrete", *International Journal of Scientific and Engineering Research;* 6(1): 968-974.

Ede, A.N., Aina, A.O. (2015), "Effects of Coconut Husk Fibre and Polypropylene Fibre on Fire Resistance of Concrete", *International Journal of Engineering Sciences & Management*; 5(2): 171-179.

Ede, A.N., Egunjobi. E.O., Bamigboye, G.O. and Ogundeji. J. (2015a) "Assessment of Quality of Steel Reinforcing Bars Used in Lagos, Nigeria". *International Research Journal of Innovative Engineering.* Vol. 1(3) pp. 1-8.

Gambhir, M .L. "Concrete technology", Third edition Tata McGraw- Hill Publishing Company Limited, New Delhi, 2005.

James T, Malachi A, Gagzama EW, Anametemfok V. (2011) "Effects of Curing Methods on the Compressive Strength of Concrete. Nigeria Journal of Technology. 2011; 3(3): 14-20.

Joseph, A.A and Raymond, M.D (2014) "Rate of Strength Development of Concrete Made Using Selected Nigeria Cement Brands". *International Journal of Technology Emerging Engineering Research.* Vol. 2 (12) pp. 48-51.

Kosmatka S.H., Kerkhoff B. and Panarese W.C., (2002), "Design and Control of Mixtures", Portland cement Association, Skokie, IL. 14th Edition.

Oyenuga, V.O. (2001), "Simplified Reinforced Concrete Design", 2nd Ed. Lagos: Asros Publishers.

Raheem, A.A. and Bamigboye, G.O. (2013) "Establishing Threshold Level for Gravel Inclusion in Concrete Production", *Innovative System Design and Engineering*. Vol.4 (9) pp. 25-30.

Shetty, M. S. (2005), Concrete Technology: Theory and Practice, Multi-Color illustration Edition, New Delhi, S. Chand.

Yahaya, B.S., Egbuna, I.C., Apeh. E.S. Ogwu, E., Achema. F., and Fabiyi. M. O. (2014), "Comparism of the compressive strength of concrete made with different brands of cement" *International Journal of Engineering and Innovative Technology (IJEIT).* Vol. 4(3) pp. 36-39.

Zongjin, L. (2011), Advanced Concrete Technology, 1st Ed. New Jersey: John Wiley & Sons, Inc.; 2011.