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Effect of Coarse Aggregate Sizes 25mm, 20mm, 15mm, 10mm and 5mm on the Strength of Concrete

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Abstract: This study concentrates basically on how granite of different sizes affect the strength and performance of concrete which for different structural components such as beams and columns. All the materials where locally soursed from Landmark University and the Omu-Aran locality. Two major kinds of test where conducted on the experimental samples, which are the physical and the mechanical test. The physical test comprises of the water absorption rate test, while the mechanical test comprises of flexural strength test and the compressive strength test. Another very important test that was done was to see how cost effective the different aggregate size could be and to be able to select the one which best suits the purpose. This study will help in terms of safety determination and also cost maximization.
Key word: Effect, Coarse aggregate, Sizes strength and Concrete.

Introduction

Concrete is a major part of our infrastructural facilities in this 21st century because of its versatility in use. It has been said that concrete is the most used man-made material in the world. In the year 2006, it was recorded that over seven (7) cubic kilometers of concrete was used per year that is more than a cubic meter for every person in the world. Therefore, the effect and importance of concrete in the modern society cannot be under estimated. Coarse aggregate can also be said to be structural filler; this is because the shape and size of coarse aggregate can create a form of void in the concrete when it finally sets. It also forms a large part of the volume of concrete. It is always bonded together with the cement. The workability, durability, weight and strength of any concrete are largely dependent on the shape and size of the coarse aggregate contained in it. Coarse aggregate can also affect the way a concrete will appear on the surface after it has been casted. Therefore, it is of outmost importance that the countertop mix of concrete be considered. Coarse aggregates serve several purposes in concrete. It makes up to about 60% to 75% of the total mix ratio of concrete. This in many ways signifies how important it is to get the right and proper material. If a concrete mixture does not contain clean and pour aggregate, then there will be a reduction in the strength and stability of the concrete is not made up of strong and clean aggregates, it can reduce the stability of the concrete. This can also make the proposed life span of the concrete to be reduced and it can also influence the shrinkage rate at the setting time of the concrete. There are two major types of aggregates: the fine and coarse aggregates. Fine aggregate can pass through the 3/8-inch sieve and it is usually made up of crushed stone or sand, while coarse aggregates can be primarily made of gravel. Since we will also be talking about the economic importance of aggregate in this project, we should not forget that aggregates in concrete provides some certain economic advantages depending on he size and amount of it. We should also note that aggregates typically make up about 60 to 75 percent of the volume of concrete mixture, and they are the least expensive

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of the materials used in concrete, therefore, the economic impact is measurable. Concrete is also used in constructing office buildings, dams, bridges, warehouses, pavements, bungalows, sky scrapers, school buildings, roads pavements, parking lots, fences/walls and poles. concrete is applied in parts of a building's foundations and also used make structural components like floor slabs, columns, beams, lintels, roof beam, staircases, walls, arches, etc. Concrete is an artificial stone-like material used for different kinds of constructional purposes and it is manufactured by mixing cement and which allows the mixture to harden by hydration. Concrete could also be referred to as a composite material that is made up of fillers and a binder (Falade, 2009; Lafe, 1986; Neville and Brooks, 2004; Gupta, 2004; Nawy, et al, 2008; Chuldley and Greeno, 2006).

Materials and Methodology

This study undertook some experiments investigation in order to promote a good understanding of the effect of coarse aggregate sizes on the strength of concrete; the tests where done on five samples of the coarse aggregate, the fine aggregate sample, the green concrete (in other words; Wet concrete), and the hardened concretes with respect to the different aggregate sizes in them. The topic drew most of its reference form some people who have worked on related topic or experiments in times past.

Materials

The materials which were used in the experimental investigation for this study where sourced within Landmark University and Omu-Aran locality and the materials are as follows:

Table 3.3 Materials and their sources.

MATERIAL	SOURCE
Water	Landmark university laboratory
Cement (binder/adhesive)	Ejiwu cement store, Omu-Aran
Sharp sand (fine aggregate)	Landmark University
Granite (Coarse aggregate)	Gbose quarries, along Oko town, Kwara state

Experiments

The following are the different tests that will be done and also the procedures intended to be followed in order to get an optimum result.

Water Absorption Rate (War)

This is a test method which is used to determine the rate of sorptivity (absorption) of water by concrete made out of hydraulic cement, this is done by measuring the increase in the mass of specimen or concrete resulting from the absorption of water as a function of time after the specimen has been immersed in water for a certain period of time.

Materials

Fine aggregate (sand), Coarse aggregate (Granite), Cement and Water

Apparatus:

Mold (for concrete beams, cube and cylinder), curing tank and Weighing balance

Procedure

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The procedure below was used to determine the water absorption rate for the concrete in this research.

1. The concrete constituents where mixed and placed in their different mold.
2. They were left for a certain period to get dry.
3. They were than measured and placed in the curing tank.
4. After the first seven days, I took the weight of the concrete again and subtracted it from its weight before curing (W2-W1).
5. I repeated step four for 14, 21 and 28 days respectively.
6. Then I was able to determine my water adsorption rate (WAR)

Table 2 water adsorption rate

Age (days)	Grade	Weight 1 (kg)	Weight 2 (kg)	WAR (W2-W1)
7				
14				
21				
28				

Compressive Strength Test

This test will be used to determine the mechanical property of the different hardened concrete which will contain each coarse aggregate size. Out of many tests that can be applied to concrete, this one is of utmost important because it gives an idea about all the characteristics of concrete. By this test one can judge whether concrete is properly done or not.

Materials

Concrete cube, Concrete beam and Concrete cylinder.

Apparatus

Compressive strength test apparatus. Weights of different masses.

Procedure

1. Remove the specimen from water after specified curing time and wipe out excess water from the surface after taking its weight.
2. I cleaned and set the bearing surface of the machine.
3. I Aligned the specimen centrally on the base plate of the machine I then rotated the movable portion gently by hand so that it touches the top surface of the specimen.
4. I then applied the load gradually without shock and continuously at the rate of $140kg/cm^2$/minute till the specimen failed.
5. Finally, I recorded the maximum load and noted any form of unusual feature in the type of failure.
6. Procedure 1 to 6 was repeated for days 14, 21 and 28.

Table 2 water adsorption rate

Age (days)	Grade	Weight	Maximum (KN)	Load
7				
14				
21				

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28				

Sieve Analysis

This test is most commonly called the gradation test; it is a basic test for all aggregate types. It is used to determine the distribution of aggregate particles, by size, within a given sample. This is in order to ensure data can also be used to determine the relationships between different aggregate blends, to determine the compliance with such blends, and to also predict trends during the production prosecco through plotting of gradation curve graphically, to name. The sieve analysis has proven to be a very good quality control and tool as it could also be used in conjunction with some other experiments too.

Materials,

Fine aggregate (sand), Coarse aggregate (granite)

Apparatus

Sieves of different sizes. Sieve shaker.

Procedure

1. I took a representative oven dried sample of soil that weighs about 500g.
2. I then determine the mass of the soil sample accurately. W_t(g)
3. I then prepare a stack of sieves having larger opening sizes (i.e lower numbers) and placed them above the ones having smaller opening sizes (i.e higher numbers).
4. I made sure that the sieves are clean, to enable free movement of sample through the sieve opening.
5. I then weighed all the sieves and the pen separately
6. I poured the soil from step 3 into the stack of sieves from the top and placed the cover, and put the stack in the sieve shaker and fixed the clamps, adjusted the time on 10 to 15 minutes and got the shaker going.
7. Finally, I stopped the sieve shaker and measured the mass of each sieve + retained soil.

Table 4; Sieve analysis.

Sieve number	Sieve opening (mm)	Mass of soil retained on each sieve Wn (g)	Percentage of mass retained on each sieve size Rn	Cumulative percentage retained ∑Rn	Percent fine 100-∑Rn

Aggregate impact test

This test is meant to determine aggregate toughness i.e resistance of the stone to future loading. According to Rajesh scientific industries, "Impact test may either be carried out on cylindrical stone specimens as in page impact test or on stone aggregates as in aggregate impact test". The British Standard Institution and the Indian Standard Institution has standardized the aggregate impact test. The aggregate impact value indicates a relative measure of the resistance aggregate to a sudden shock or an impact, which in some aggregates differs from its resistance to a slow compressive load. The method of test covers the procedure for determining the aggregate impact value of coarse aggregates.

Materials

Coarse aggregate (granite)

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Apparatus

Aggregate impact value testing machine, Weighing balance and Sieves of different sizes.

Procedure:

1. I took the coarse aggregate into the cylindrical cup or the machine.
2. Then I weighed (W1) it accurately to 300g (minus weight of cup)
3. I then set the sample carefully to the base of the machine.
4. Then I dropped twenty-five blows of the 13.5kg hammer on the sample.
5. I then finally sieved the aggregate and measured the mass (W2) of the aggregate retained on the sieve.
6. Steps 1 to 5 was repeated for the other coarse aggregate grades.

Table 3.5: Aggregate impact value.

Coarse Aggregate grade (MM)	Net weight of aggregate measured in grams (A)	Percentage passing through 2.5mm sieve in grams (B)	Percentage retained on sieve 2.5mm in grams (C)	Aggregate impact value B/A x100%
5	300			
10	300			
15	300			
20	300			
25	300			

FLEXURAL STRENGTH TEST

This method is similar to AASHTO 177 and it covers the procedure for determining the flexural strength of concrete by the use of a simple beam with center point loading. This test method covers the determination of the flexural strength of concrete by the use of a simple beam with third-point loading. We will be using this test to determine the flexural strength and rigidity of each hardened concrete bar made from the different aggregate sizes.

Materials:

Concrete beam

Apparatus:

Weighing balance, Compressive strength test machine, Weights of various masses and Curing tank

Procedure

1. I remove the concrete beam from the curing tank after specified curing time and wipe out excess water from the surface after taking its weight.
2. I then cleaned and set the bearing surface of the test machine.
3. I Aligned the beam centrally (horizontally for beam and vertically for column mode) on the base plate of the machine I then rotated the movable portion gently by hand so that it touches the top surface of the specimen.
4. I then applied the load gradually without shock and continuously at the rate of 140kg/cm^2/minute till the specimen failed.
5. Finally, I recorded the maximum load and noted any form of unusual features in the type of failure.
6. Procedure 1 to 6 was repeated for days 14, 21, and 28.

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Table 3.5: Flexural strength

Coarse Aggregate grade (MM)	Net weight of aggregate measured in grams (A)	Percentage passing through 2.5mm sieve in grams (B)	Percentage retained on sieve 2.5mm in grams (C)	Aggregate impact value B/A x100%
7				
14				
21				
28				

Result and Analysis

In this chapter, results will be tabulated, observations and recommendations will be made based on the final results gotten from the experimental exercise which has initially been carried out in the laboratory, graphs will also be plotted to efficiently prove the real relevance and effect of experimental exercise.

Flexural Strength (ft), Compressive Strength (Fcu) and Water Absorption rate (WAR)

Below are the tables showing the results gotten from the flexural tensile strength (Ft) test, water abortion rate (WAR) and compressive strength (Fcu) test carried out on both the concrete cube and beam samples for the curing ages ranging from seven (7) to twenty-eight (28) days. The graphs of all the results are plotted against each aggregate size in order to note the strength progress for each structural component modeled from each aggregate size by the curing days.

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Table 4.1; Compressive Strength (Fcu) and Flexural Tensile Strength (Ft) test Result for Seven days.

Aggregate Size	Age (days)	Weight (kg)	Weight 2(kg)	Density (Kg/m3)	Crushed Load (kN)	Fcu (N/mm2)	Ft (N/mm2)	WAR
5mm	7	7.7	8.3	2281.481	174.7	7.764	2.407	0.6
5mm	7	7.6	8.4	2251.852	109.7	4.876	1.511	0.8
5mm	7	7.2	7.8	2133.333	166.1	7.382	2.288	0.6
5mm	7	7.5	8.17	2222.222	150.167	6.674	2.069	0.67
10mm	7	7.5	7.8	2222.222	203.2	9.031	2.800	0.3
10mm	7	7.7	8.1	2281.481	243.6	10.827	3.356	0.4
10mm	7	7.7	8	2281.481	329.6	14.649	4.541	0.3
10mm	7	7.633	7.97	2261.728	258.800	11.502	3.566	0.333
15mm	7	7.7	8.2	2281.481	333	14.800	4.588	0.5
15mm	7	7.75	7.95	2296.296	380.5	16.911	5.242	0.2
15mm	7	8.05	8.4	2385.185	341.1	15.160	4.700	0.35
15mm	7	7.83	8.18	2320.988	351.5	15.624	4.843	0.35
20mm	7	7.65	7.9	2266.667	244	10.844	3.362	0.25
20mm	7	7.55	7.85	2237.037	344.5	15.311	4.746	0.3
20mm	7	8.3	8.7	2459.259	333.9	14.840	4.600	0.4
20mm	7	7.833	8.15	2320.988	307.467	13.665	4.236	0.32
25mm	7	7.45	7.8	2207.407	447	19.867	6.159	0.35
25mm	7	7.45	7.85	2207.407	388.6	17.271	5.354	0.4
25mm	7	7.55	7.9	2237.037	392.8	17.458	5.412	0.35
25mm	7	7.483	7.85	2217.284	409.467	18.199	5.642	0.37

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Table 4.1.1; Average value of Fcu, Ft and WAR for curing day seven

Aggregate size(mm)	Fcu(N/mm²)	Ft(N/mm²)	WATER ABSORPTION
5	6.67	2.07	0.67
10	11.50	3.57	0.33
15	15.62	4.84	0.35
20	13.67	4.24	0.32
25	18.20	5.64	0.37

Discussion: The graph above shows that the strength level of the beam concrete and the cube concrete is very low especially for the 5mm, 10mm and 20mm granite grade. The water adsorption rate is higher for the 5mm granite size, this might be due to the amount of void in the cube and beam. It is absolutely unadvisable to engage any structural element at this age and strength level.

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Table 4.2; Compressive Strength (Fcu) and Flexural Tensile Strength (Ft) Test Result for fourteen days.

Aggregate Size	Age (days)	Weight (kg)	Weight 2(kg)	Density (Kg/m3)	Crushed Load (kN)	Fcu (N/mm2)	Ft (N/mm2)	WAR
5mm	14	8.3	8.92	2459.259	148	6.578	2.039	0.62
5mm	14	8.4	9.2	2488.889	159	7.067	2.191	0.8
5mm	14	7.8	8.3	2311.111	180.1	8.004	2.481	0.5
5mm	14	8.167	8.81	2419.753	162.367	162.367	2.237	0.64
10mm	14	7.35	7.95	2177.778	258.5	11.489	3.562	0.6
10mm	14	7.35	8.3	2177.778	317	14.089	4.368	0.95
10mm	14	7.35	8.6	2177.778	240.8	10.702	3.318	1.25
10mm	14	7.350	8.28	2177.778	272.100	12.093	3.749	0.93
15mm	14	7.6	8.2	2251.852	318	14.133	4.256	0.6
15mm	14	7.65	7.95	2266.667	402.3	17.880	5.543	0.3
15mm	14	7.9	8.6	2340.741	400.5	17.800	5.518	0.7
15mm	14	7.72	8.25	2286.420	373.6	16.604	5.147	0.53
20mm	14	7.6	8.1	2251.852	308.9	13.729	4.256	0.5
20mm	14	7.5	8	2222.222	323.5	14.378	4.457	0.5
20mm	14	8.2	8.9	2429.630	403.9	17.951	5.565	0.7
20mm	14	7.767	8.33	2301.235	345.433	15.353	4.759	0.57
25mm	14	7.35	7.95	2177.778	455	20.22	6.269	0.6
25mm	14	7.4	8.2	2192.593	422	18.756	5.814	0.8
25mm	14	7.5	8.4	2222.222	407.5	18.111	5.614	0.9
25mm	14	7.417	8.18	2197.531	428.167	19.030	5.899	0.77

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Table 4.2.1; Average value of Fcu, Ft and WAR for curing day fourteen.

Aggregate size(mm)	Fcu(N/mm²)	Ft(N/mm²)	WATER ABSORPTION
5	7.22	2.24	0.64
10	12.09	3.75	0.93
15	16.60	5.15	0.53
20	15.35	4.76	0.57
25	19.03	5.90	0.77

Discussion: The strength level for the samples is still considerably low although the WAR for the 10mm coarse aggregate (granite) grade has increased, the compressive strength and flexural strength of the 15mm coarse aggregate grade has increase but it is still highly unadvised to engage any structural component at this age.

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Table 4.3; Compressive Strength (Fcu) and Flexural Tensile Strength (Ft) Test Result for twenty one days.

Aggregate Size	Age (days)	Weight (kg)	Weight 2(kg)	Density (Kg/m3)	Crushed Load (kN)	Fcu (N/mm2)	Ft (N/mm2)	WAR
5mm	21	8.35	8.92	2474.074	221.6	9.849	3.053	0.57
5mm	21	8.5	9.2	2518.519	209.9	9.329	2.892	0.7
5mm	21	7.85	8.6	2325.926	177.5	7.889	2.446	0.75
5mm	21	8.233	8.91	2439.506	203.000	9.022	2.797	0.67
10mm	21	7.5	7.95	2222.222	246.2	10.942	3.392	0.45
10mm	21	7.7	8.3	2281.481	296.3	13.169	4.082	0.6
10mm	21	7.7	8.6	2281.481	332.8	143791	4.585	0.9
10mm	21	7.633	8.28	2261.728	291.767	12.967	4.020	0.65
15mm	21	7.7	8.2	2281.481	353	15.689	4.864	0.5
15mm	21	7.75	8.3	2296.296	398.5	17.711	5.490	0.55
15mm	21	8.05	9.2	2385.185	402	17.687	5.539	1.15
15mm	21	7.83	8.57	2320.988	384.5	17.089	5.298	0.73
20mm	21	7.65	8.55	2266.667	406.3	18.058	5.598	0.9
20mm	21	7.55	8.4	2237.037	418.8	18.613	5.770	0.85
20mm	21	8.3	9.2	2459.259	394.6	17.538	5.437	0.9
20mm	21	7.833	8.72	2320.988	406.567	18.070	5.602	0.88
25mm	21	7.45	8.3	2207.407	466.4	20.729	6.426	0.85
25mm	21	7.45	8.2	2207.407	406.5	18.067	5.601	0.75
25mm	21	7.55	8.4	2237.037	425.7	18.920	5.865	0.85
25mm	21	7.483	8.30	2217.284	432.867	19.239	5.964	0.82

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Table 4.3.1 Average value of Fcu, Ft and WAR for curing day twenty-one

Aggregate size(mm)	Fcu(N/mm²)	Ft(N/mm²)	WATER ABSORPTION
5	9.02	2.80	0.67
10	12.97	4.02	0.65
15	17.09	5.30	0.73
20	18.07	5.60	0.88
25	19.24	5.96	0.82

Discussion: Considering the result displayed by the graph above, structural elements such as beams might attain their maximum strength level at this age, but this kind of strength will only be attained engaging water-curing method. The water-curing method has proven to be highly efficient for curing.

Compressive Strength (Fcu) and Flexural Strength (Ft) Test Result for twenty eight days.

Aggregate Size	Age (days)	Weight (kg)	Weight 2(kg)	Density (Kg/m3)	Crushed Load (kN)	Fcu (N/mm2)	Ft (N/mm2)	WAR
5mm	28	8.1	8.92	2400.000	294.5	13.089	4.058	0.82
5mm	28	8.45	9.2	2503.704	204.4	9.084	2.816	0.75
5mm	28	7.6	8.6	2251.852	237.6	10.560	3.274	1
5mm	28	8.050	8.91	2385.185	245.500	10.911	3.382	0.86
10mm	28	7.45	7.95	2207.407	341.5	15.178	4.705	0.5
10mm	28	7.3	8.3	2162.963	303.1	13.471	4.176	1
10mm	28	8.4	8.6	2488.889	334.6	14.871	4.610	0.2
10mm	28	7.717	8.28	2286.420	326.400	14.507	4.497	0.57
15mm	28	7.7	8.35	2281.481	420.3	18.680	5.791	0.65
15mm	28	7.75	8.45	2296.296	428.8	19.058	5.908	0.7
15mm	28	8.05	9.02	2385.185	412.3	18.324	5.681	1
15mm	28	7.83	8.62	2320.988	420.5	18.687	5.793	0.78
20mm	28	8.05	8.8	2385.185	450	20.000	6.200	0.75
20mm	28	7.4	8.4	2192.593	487.6	21.671	6.718	1
20mm	28	7.4	9.2	2192.593	364.6	16.204	5.023	1.8
20mm	28	7.617	8.80	2256.790	434.067	19.292	5.980	1.18
25mm	28	7.55	8.3	2237.037	444.4	19.751	6.123	0.75
25mm	28	7.65	8.2	2266.667	432.5	19.222	5.959	0.55
25mm	28	7.4	8.7	2192.593	476	21.156	6.558	1.3
25mm	28	7.533	8.40	2232.099	450.967	20.043	6.213	0.87

Table 4.4.1 Average value of Fcu, Ft and WAR for curing day twenty-eight

Aggregate size(mm)	Fcu(N/mm^2)	Ft(N/mm^2)	WATER ABSORPTION
5	10.19	3.38	0.86
10	14.51	4.50	0.57
15	18.69	5.79	0.78
20	19.29	5.98	1.18
25	20.04	6.21	0.87

Discussion: At this curing age, all the concrete samples have archived their maximum curing strength. It is clearly observed that the graph indicated that all the coarse aggregate grades have gotten to their best curing strength level given that they have be left for twenty-eight days under water-curing system, it is thereby advised that it should be considered based on their experimental strength level after twenty-eight days of curing before being put to use in any structural element. Nevertheless, all the coarse aggregate grades which have been tested are all very useful considering the sample strength, they can be recommended for different structural components depending on their sizes and the purpose for which they will serve. The following tables and graphical statistics father indicates the strength level/progress and effect of the curing days on the WAR, flexural strength and compressive strength of the samples made from the various coarse aggregate grades.

Table 4.5; comparative strength progress between curing days for 5mm grade.

FOR 5mm AGGREGATE				
CURING AGE (DAYS)	7	14	21	28
Fcu (N/mm^2)	6.67	7.22	9.02	10.91
Ft(N/mm^2)	2.07	2.24	2.8	3.38
WATER ABSORPTION	0.67	0.64	0.67	0.86

Table 4.6 Comparative strength progress between curing days for 10mm grade.

FOR 5mm AGGREGATE				
CURING AGE (DAYS)	7	14	21	28
Fcu (N/mm^2)	11.5	12.09	12.97	14.51
Ft(N/mm^2)	3.57	3.75	4.02	4.2
WATER ABSORPTION	0.33	0.93	0.65	0.57

FOR 5mm AGGREGATE				
CURING AGE (DAYS)	7	14	21	28
Fcu (N/mm^2)	15.62	16.6	17.09	18.69
Ft(N/mm^2)	4.84	5.15	5.3	5.8
WATER ABSORPTION	0.35	0.53	0.73	0.78

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Table 4.8 Comparative strength progress between curing days for 20mm grade.

FOR 5mm AGGREGATE				
CURING AGE (DAYS)	7	14	21	28
Fcu (N/mm^2)	13.67	15.35	18.07	19.3
Ft(N/mm^2)	4.24	4.76	5.6	5.98
WATER ABSORPTION	0.32	0.57	0.88	1.18

Table 4.9 Comparative strength progress between curing days for 25mm grade.

FOR 5mm AGGREGATE				
CURING AGE (DAYS)	7	14	21	28
Fcu (N/mm^2)	18.12	19.03	19.24	20.64
Ft(N/mm^2)	5.64	5.9	5.96	6.21
WATER ABSORPTION	0.37	0.77	0.82	0.87

Discussion: The graphical illustrations above further clarifies the fact that all the coarse aggregate size are useful, a close observation of the graphs show if the 15mm aggregate grade should be properly cured in water for more days, it might attain the flexural strength of even the 25mm grade, the WAR increased until day-14 for all the samples, there after it remained constant, this indicates that the sorptivity of concretes made from hydraulic cements gets to the maximum at fourteen days, the compressive strength of all the grades increased considerably with respect to their sizes; generally, the 5mm grace appears to be the weakest aggregate size, nevertheless it is still very useful and it could be considered for less load-bearing part of a structure such as ground floor pavements, foundation blinding for bungalow houses and walk ways. Observations from the graphical results has proven that the 15mm aggregate size has been able to the expected standard for flexural strength and compressive strength of concrete; it can therefore be said that grade 13mm aggregate is considerably strong and more cost effective compared to the other aggregate sizes.

Aggregate Impact Test

The table below shows the

Coarse aggregate grade (mm)	Net weight of aggregate measured in grams (a)	Percentage passing through 2.5mm sieve in grams (B)	Percentage retained on sieve 2.5mm in grams (C)	Aggregate impact value B/A x100%
5	300	30.74	69.26	10.24
10	300	33.0	67.0	11.0
15	300	31.57	68.43	10.52
20	300	31.07	68.93	10.35
25	300	26.77	73.23	8.92

Table 2.3: Cost Analysis of Mix Ratio

	Mix Ratio	Item	Unit Price (Naira)	Quality	Amount (Naira)
1	1: 1 $\frac{1}{2}$:3 (M_{20})	Cement	2000 per bag	6 bags	12,000.00
		Fine Aggregates	2000 per tone	0.52 tones	1,040.00
		Coarse Aggregates	4000 per tone	1.06 tones	4,240.00
		Total amount for M_{20}			17,280.00
2	1: 2 :4 (M_{15})	Item	Unit Price (Naira)	Quality	Amount (Naira)
		Cement	2000 per bag	5 bags	10,000.00
		Fine Aggregates	2000 per tone	0.54tones	1,080.00
		Coarse Aggregates	4000 per tone	1.11 tones	4,440.00
		Total amount for M_{15}			15,520.00
3	1: 3 :6 (M_{10})	Item	Unit Price (Naira)	Quality	Amount (Naira)
		Cement	2000 per bag	3 bags	6,000.00
		Fine Aggregates	2000 per tone	0.57 tones	1,140.00
		Coarse Aggregates	4000 per tone	1.16 tones	4,640.00
		Total amount for M_{10}			11,780.00

Fig 2.1: Slope of cost for concrete grade

Discussion: from the table, there is a clear indication that the mix ratio of 1:2:4 has a more reasonable price although it is more expensive than ratio 1:3:6, it is more advisable and safer to adopt ratio 1:2:4 in concrete production given that is is the more generally acceptable mix ration in the country.

RECOMMENDATION

The following recommendations will aid in reducing the occurrence of building collapse in Nigeria due to wrong use of coarse aggregate size and bad concrete practice:

1. All clients or building developers should be obligated to comply with approved building regulations before the construction of their buildings and all building construction works should be well designed and supervised by a registered member of Council for the Regulation of Engineering in Nigeria (COREN). Only competent registered contractors should be employed to carry out construction works or projects.
2. All Government functionaries and building developers should be properly trained and encourage to always give construction of large scale buildings to competent and registered contractor who will also be supervised by a registered Structural Engineering consultant and Architect who preferably have designed such projects in the past.
3. There should be a law in every state in the country, providing heavy penalties for contractors that fail to have registered professionals in supervisory capacity in major building projects.
4. All building construction materials like sand, cement, aggregates, reinforcement bars and particularly the coarse aggregate grade to be used for structural components such as beams, columns, and slabs should be properly tested before commencement of any construction.

5. Government should quickly promulgate a National Building Regulation for the elimination or considerable reduction of the incessant collapse of buildings in Nigeria and quick response committee for investigating incidents of building collapse should be formed.
6. Government should exercise leadership in protecting and enhancing the quality of all the buildings by encouraging and enforcing maintenance so as to protect human life and properties.
7. The law governing all approved structural details of buildings, materials and effective supervision by the local Town Planning Authorities should be enforced and not compromised. Section 30 (1) of the Nigerian Urban and Regional Planning Decree 88 of 1992, which demands that no building or structure or any part thereof should be erected, converted, altered or enlarged unless a development permit has been obtained by the owner or his agent from the ministry should be enforced. The Government should found this board established through the decree so as to ensure adequate monitoring of the building approval and construction in our society.
8. The professional bodies should hold regular workshops and Continuous Professional Development Programmes in order to expand the professional competence of members.
9. The mineralogy and alkalinity tests of coarse aggregates should be done to know whether the material contains some percentage of impurities, which deleterious and harmful to cement and reinforcement rods.

CONCLUSION

The following conclusions were drawn from the study:

This study has been able to identify that curing age, mode of curing and coarse aggregate size and quality is one of the major causes of building failure in Nigeria. Several case studies of building failure in Nigeria including casualties of those incidents have been highlighted. This phenomenon dates back to just over a decade after the country's independence. The losses always experienced as a result of building failure are enormous; ranging from loss of lives, several forms and degrees of injuries, loss of properties, etc. The National Building Code is a very important document which will greatly reduce the occurrence of building failure in Nigeria. It is always better to prevent building collapse than to try and salvage an already problematic situation. Concrete is likely to fail when it loses the required strength to support the load which it is designed to carry. Sometimes, concrete failure can be noticed with little cracks, deflections or severe which can lead to either partial or total deformation of the structure. Collapse can happen either during or after the construction has been done. Incidence of failures of structures linked to poor concrete practice in Nigeria is somehow particular to our major cities such as Lagos, Port-Harcourt, and Abuja, among others. The study has been able to establish that a concrete will only attain a good quality and standard when the aggregate size contained in its production is put into consideration at the time of its preparation.

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