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Structural Assesment of Concrete Produced with Broken Bottles as a Partial Replacement of Coarse Aggregate

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ABSTRACT

In Nigeria, the rate at which waste is produced daily is very high, which leads to environmental pollution, global warming and high cost of disposal. The cost of disposal increases as the rate at which waste is produced increases, so researches derived a method of reducing the cost of disposal by reducing the amount of waste produced. Waste was used as a partial replacement in the production of concrete in civil engineering construction. In this study, industrial waste (waste glass) was used as partial replacements of coarse aggregate in the production of concrete. In this study, broken bottles replaced coarse aggregate for 2%, 4%, 8% and 10%. 45 cubes and 45 cylinders were casted for 0%, 2%, 4%, 8% and 10% replacement of coarse aggregate with broken bottles. The grade used was m15 (1:2:4). Slump test and compaction test was done to determine the workability and consistency of the mix. Compressive strength test and split tensile strength test was carried out for 0%, 2%, 4%, 8% and 10% to determine the strength of the cubes. The result from the analysis showed that the 0% (control) had the highest compressive strength of 20.01 N/mm2 at 28 days for the casted cubes. The highest compressive strength gotten from partial replacement of aggregates with percentages of broken bottles was at 2% having a compressive strength of 18.47 N/mm2 at 28 days and the lowest compressive strength was at 10% having a value of 13.24 N/mm2 at 28days. Also, for the split tensile strength, the highest tensile strength gotten was at 0% (control) with a value of 2.09 N/mm2 at 28days and lowest tensile strength was at 10% having a value of 1.29 N/mm2 at 28 days. The highest replacement was at 2% having a tensile strength of 1.80 N/mm2 at 28 days. The result for the slump test and compaction factor test showed that the slump value, which had the highest workability, was at 0% having a value of 74mm and compaction factor value was at 10% having a value of 0.94mm. The result proves that the use of broken bottles as partial replacement for the coarse aggregates is possible and acceptable at 2% to 4% since it has not exceeded the minimum compressive strength value at 28 days for m15 (mix ratio 1:2:4).

Keywords: Structural, Assessment, Concrete, Broken Bottles, Partial Replacement, Coarse Aggregate

INTRODUCTION

In the modern world the construction of buildings have played a very important role in the survival of humanity. Building construction works and civil engineers all over the world depends largely on "concrete" as a major material in construction. It was discovered that a close relationship between the construction material available and the type of structure we build. Obviously, certain types of structures can only be built after they have developed the appropriate material for construction (Schriftenreine Baustiffe and Massivball, 2004). Concrete in today's world is a very important construction material that is widely used because of its good properties such as its sustainability, durability, adaptability, versatility. Concrete is a composite construction material primarily made up of cement, aggregate and water. Cement is an essential in the production of concrete because it serves as a binder for the aggregates. The aggregates comprise of the coarse aggregate (this can be generally be gravel or crushed rocks or limestone or granite) and the fine aggregate (this are materials such as sand). Water is required for hydration of cement to produce chemical compounds that bind the other components together in producing concrete. In addition, various chemical admixtures and minerals are added to increase the concrete density. Concrete has a very high compressive strength but lower tensile strength (American concrete institute MI, 2004) that is why it is often combined with steel, which has very high tensile properties. Sustainability of concrete has become a point of interest to researchers and engineers due to the accelerated degradation of the present and future environment. Sustainability is a very important factor to consider because it will be wasteful and unreasonable to have to rebuild infrastructures before the expected design life has been reached.

In recent times, different researches have been conducted to improve concrete in ways it can be safe and perform more purposes that are specific. This research conducted were discovered to help in increasing the flaws of normal concrete such as high permeability, cracks in concrete and low density. The compressive strength of concrete cement paste is affected by several parameters such as water cementitious materials ratio, the use of admixtures, curing, cement type and the materials used in the production of concrete. Several means of producing concrete were discovered by partially combining the aggregates or cement with other materials especially waste. The increase in solid waste led to the use of industrial waste in the production of concrete. In recent time, the use of waste glass in the production of concrete has increased drastically because of the level of consumption of drinks, waste window glass and containers. Glass is a very harmful waste to the environment and the rate at which waste glass are produced is higher at which they are recycled. If waste glasses can be used in the production of concrete, there would be a decrease in the disposal of waste glass and environmental problems. Also the use of waste glass in the production of concrete as a partial replacement reduces the cost of waste glass disposal and concrete production because there would be a lesser amount of materials such as the aggregates needed. Has expected there would be an obvious difference between the glass concrete and the conventional concrete. This includes a reduction in the strength between the aggregates and the cement paste. The interlocking shear strength between the cement paste and the aggregates of that of a glass concrete will be lesser than that of concrete produced with natural aggregates. Glass can be defined as an inert material, which could be recycled and reused many times without changing its chemical properties. Additionally, the friability of glass particles may weaken the concrete. The effect of using waste glass was discovered by other researcher to reduce the strength of the concrete.(Nahhab, 2009)

It was discovered that all concrete requires "CURING" so that cement hydration can proceed in order to allow the development of strength and durability. To have a good concrete the placement of an appropriate mix is done before curing in applied in a suitable environment. CURING is a procedure to endorse hydration of cement and consist of a control of temperature and moisture movement from and into the concrete(Neville, 1996)). The primarily reason for curing is to keep the concrete moist by preventing loss of moisture from it during the period in which it is gaining strength. Curing can be achieved by keeping the concrete element completely saturated or as much saturated as possible until the water-filled spaces are substantially reduced by hydration products (Gowripalan et al., 1992). The hydration of cement is a chemical reaction which curing aims at, it virtually ceases when the relative humidity within capillaries drops below 80% (Neville, 1996). This implies that if the humidity of the ambient air (completely enveloped air) is at least that high, then there will be no need for active curing to ensure continuing hydration because there will be little movement of water between the concrete and ambient air. In Nigeria, the relative humidity falls below 80% at a certain time in a day, which would require active curing rather than allow curing to occur on its own. If concrete were cured for only three (3) days, it would reach about 60% of the strength of continuously cured concrete; if it is cured for seven (7) days, it will reach 80% of the strength of continuously cured concrete. If a concrete is not well cured, especially at the early stage, it will not gain the required properties at desired level due to a lower degree of hydration, and would suffer from irreparable loss. Improper curing would imply insufficient moisture and this has been discovered to produce cracks, compromise strength, and reduce long-term durability.(James, Malachi, Gadzama, & Anametemfiok, 2011)

MATERIALS AND METHOD

Materials

The materials used in the production of concrete cubes are:

1. Portland cement (Dangote)
2. Aggregate (fine aggregates and coarse aggregate)
3. Water
4. Concrete molds
5. Engine oil
6. Broken bottles

Cement

The cement to use was Dangote Portland cement of grade 42.5, which was available in the local market of Omu-Aran, Kwara state. The cement was used as a binder in the production of the concrete.

Aggregates

Sharp sand was gotten from the premises of Landmark University, Omu-Aran, and Kwara state was sieved through 300mm micron sieve and was used for all experiments. In addition, coarse aggregates obtained from a local quarry in Omu-Aran, Kwara state was sieved through 10mm sieve to obtain the coarse aggregate, which was used for the casting

Water

Water used for mixing was potable water, suitable for domestic consumption gotten from the Civil engineering laboratory, Landmark University, Omu-Aran, Kwara state.

Concrete Moulds

Concrete molds are the equipment used in the construction of the cubes and cylinders. They help in providing assistance. The concrete takes the shape of the concrete molds and cylindrical molds depending on how compacted they are by the tamping rods. The plate 3.1-3.2 shows the concrete mold used in the project.

Plate 3. 1: Cylindrical molds used in casting

Plate 3. 2: cube molds used in casting

Engine Oil

Engine oil was used as a lubricant for the easy removal of the casted cubes form the molds. The engine oil was rubbed inside the cubes and cylinder with a foam for easy removal when the casted cubes were removed from the molds.

Broken Bottles

Broken bottles were gotten from Mark wood hotel and Bigs gate hotel, omu-aran and Kwara state. A milling machine in the geotechnical laboratory was used in crushing the broken bottles, before it is sieved.

Sample Preparation

After sourcing of materials, which includes 2 bags of cement (150kg), 45 concrete cubes molds and 45 cylindrical concrete molds, the inner surface of the molds were lubricated with engine oil. After coating the molds with engine oil, a mixture of cement, aggregates, water for the control were poured into each molds in very little quantity using a hand trowel as support in order to produce a well-shaped concrete after molding. The same procedure was applied for the 0%, 2%, 4%, 8%, 10% of broken bottles with the cement, water and aggregates mixture. The mixing of materials was done manually using shovels, head pans and hand trowel and tampering rods.

The proportion below was used in calculating the amount of materials used:

Calculation for cubes
Mix ratio = 1:2:4
1 cement bag = 50kg
$1m^3$ = 316.8kg
1 volume of mold = 150mm × 150mm ×150mm
Converting to m^3 = 0.15 × 0.15 × 0.15
= 3.375× 10^{-3}
$1m^3$ = 316.8kg
3.375× 10^{-3} m^3= x
x = 3.375× 10^{-3} m^3 × 316.8kg
x = 1.07kg
For 9 cubes = 9 x 1.07
= 9.63kg

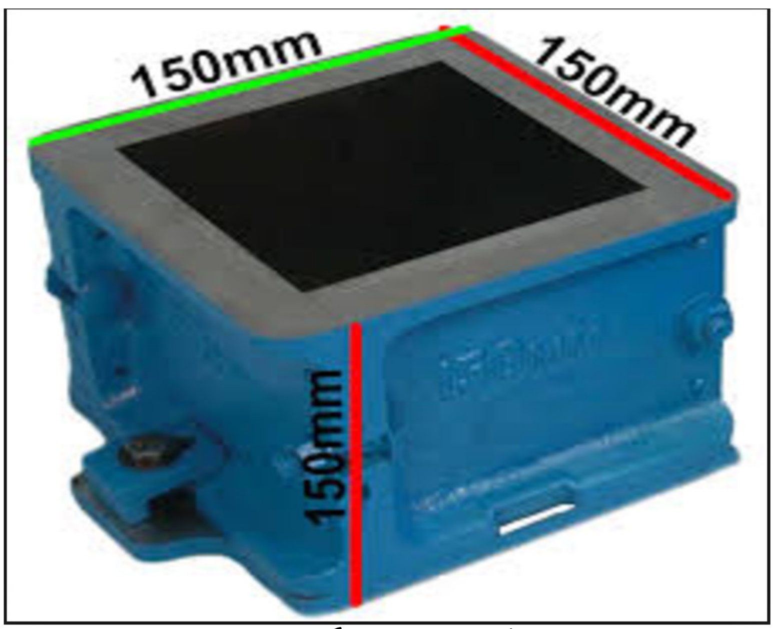

Figure 3. 1: Diagram of a cubic mold

Calculations for Cylinders

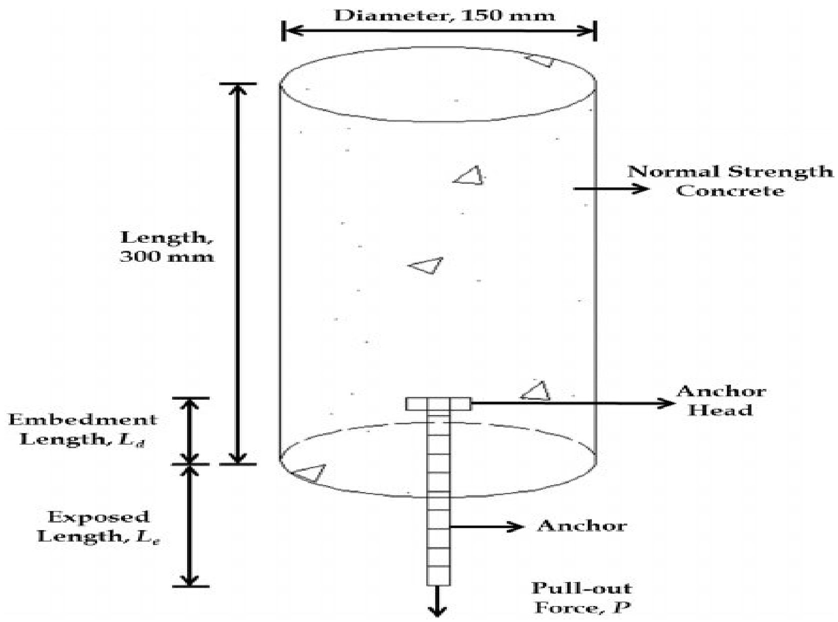

Figure 3. 2: Schematic diagram of a cylindrical mold

MIX RATIO = 1:2:4

1 cement bag = 50kg

$1m^3$ = 316.8kg

1 volume of cylinder = $\pi r^2 h$

Where r = 150/2

r = 75mm, converting to m = 75/ 1000

r = 0.075

h = 200mm, converting to m

h = 0.2m

$\pi r^2 h$ = π x 0.075^2 x 0.2

$\pi r^2 h$ = 3.53 x $10^{-3} m^3$

$1m^3$ = 316.8kg

3.53 x $10^{-3} m^3$ = x

x = 316.8kg x 3.53 x $10^{-3} m^3$

x = 1.12kg

Therefore 9 cylinders = 9 x 1.12

= 10.08kg

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Table 3. 1: Calculation of Cylinder

Batch (%)	Cement (kg)	Fine aggregate (kg)	Waste glass (kg)	Coarse aggregate (kg)
0%	10.08	20.16	-	40.32
2%	10.08	20.16	0.80	39.52
4%	10.08	20.16	1.61	38.71
8%	10.08	20.16	3.23	37.09
10%	10.08	20.16	4.03	36.29
TOTAL	50.4 kg	100.80 kg	9.67 kg	191.93 kg

In summary

- 50.4 kg of cement
- 100.80 kg of fine aggregate
- 9.67 kg of waste glass
- 191.93 kg of coarse aggregate

The table 3.2 shows the calculation for cubes.

Table 3. 2: Calculation of cubes

Batch (%)	Cement (kg)	Fine aggregate (kg)	Waste glass (kg)	Coarse aggregate (kg)
0%	9.63	26.88	-	53.76
2%	9.63	25.54	1.34	51.07
4%	9.63	24.19	2.69	48.38
8%	9.63	22.85	4.03	45.70
10%	9.63	21.50	5.38	43.01
TOTAL	48.15 kg	120.96 kg	13.44 kg	279.54 kg

In summary

- 48.15 kg of cement
- 120.96 kg of fine aggregate
- 13.44 kg of waste glass
- 279.54 kg of coarse aggregate

PLACEMENT, DEMOULDING AND CURING

After the mixing was done properly, the molds were lubricated for easy removal of the cubes and cylinders, the concrete was then vibrated into 9 cubic molds and 9 cylindrical molds for the first set of concrete to be made which was for the 28days (0%, 2%, 4%, 8% and 10%). After the cubes and cylinders were left to cure for a day, I then demolded the cubes and cylinders from the molds and placed them in a tank filled with water for curing to occur. The same procedure was done for the 14days and 7days. The first set of cubes placed in the tank were left to cure for 28days, then the second set was left to cure for 14days, the third set was left to cure for 7days.

Plate 3. 3: picture of casted cube

Plate 3. 4: cubes in water tank

EXPERIMENTAL TEST CARRIED OUT ON THE PROJECT

In the course of the project the tests carried out were;

1. Compression strength test
2. Split tensile test
3. Slump test

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4. Compaction factor test
5. Sieve analysis test

COMPRESSION STRENGTH TEST

The compressive strength of a material is the ability of the material to withstand any load applied on it or acting on it. The compressive strength test was carried out on the casted concrete cubes and after each curing days of 7, 14, and 28 were complete so as to determine the strength of the casted concrete cubes. The machine used was the compression machine. After the machine is turned on, the Area (22500mm^2) is set, and then the casted concrete cubes are placed in the compression machine. When the conditions of the machines were checked and confirmed working then the crushing begins. This is repeated for all the curing days on at least three (3) cubes. The volume of the cubic mold is 150mm by 150mm by 150mm. after each cube has been crushed the machine displays the strength of the cube. The plate 3.5 shows the compression machine used in carrying out compressive strength test.

Plate 3. 5: compression machine used in carrying out compressive strength test

SPLIT TENSILE STRENGTH TEST

The tensile strength of a material is the ability of a material to withstand any tensile stresses developed due to application of the compressive load at which the concrete specimen may crack. The determination of the split tensile strength of a concrete is carried out by casting cylinders. A diametric compressive load will be applied along the length of the cylinders at a continuous rate until failure occur. The split tensile strength of the concrete is determined by the time a crack has occurred along the length of the cylinder. The split tensile test was carried out on the cylinders according to their curing days 7, 14, 28days. A compression machine was used in performing this experiment with rods. Three specimen were used for each days. (Kisan, Sangathan, Nehru, & Pitroda, 1999).

The formula used in calculating the split tensile is; $f = \frac{2p}{\pi l d}$

Where p= the compressive force

L= length of cylindrical mold

D = diameter of cylindrical mold

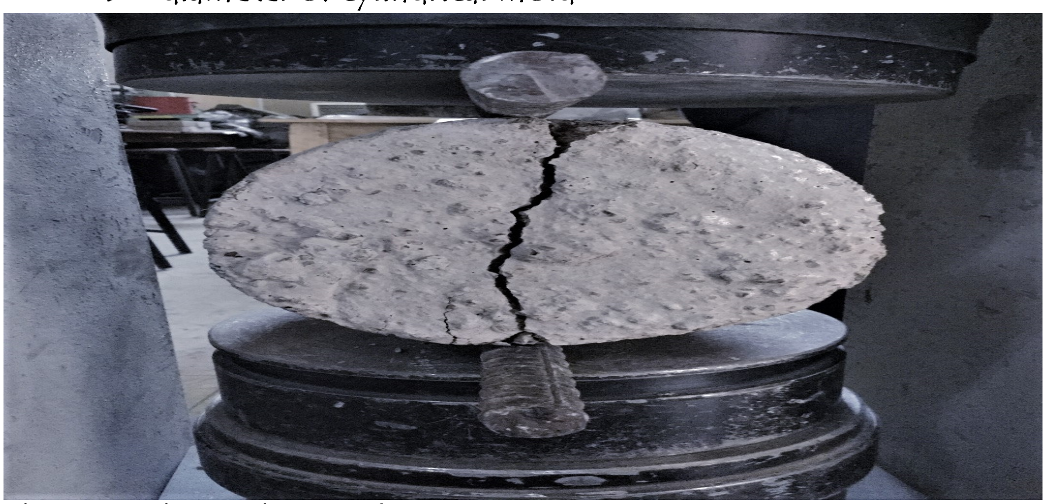

Plate 3. 6: Split Tensile strength

SLUMP TEST

Slump test is done to determine and know the consistency of fresh concrete. A slump test is indirectly used as a means of checking if, the correct amount of water has been added to the mix. The slump test was done for the control 0% and 2%, 4%, 8%, 10% of broken bottles. The

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cone is filled up to a point with the mix before it is compacted. Until the cone is filled up with mix compaction continues. When the cone is filled up it is gradually removed, the concrete formed a shape of the cone and the difference in height was measured with a t square or measuring tape. The plate 3.7 shows an illustration of a cone used for slump test.

Plate 3. 7: a picture of a cone used in carrying out the test.

COMPACTION FACTOR TEST

Compaction factor test is a test done to determine and know the workability of concrete. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. The compaction factor test was done for the control 0% and 2%, 4%, 8%, 10% of broken bottles. Workability can be defined as the ease with which concrete can be mixed, molded, compacted and transported. The plate 3.8 shows the compaction factor used in performing test.

Plate 3. 8: Compaction factor used in performing test

RESULT AND DISCUSSION

General Overview

This chapter details with the results of various tests performed as well as the discussion of the test data, which includes compressive strength test, split tensile strength test, slump test and compaction factor test. The aim of this entire test was to determine the strength, durability and other properties of the concrete used. In addition, this chapter answered all the objectives of this research through detailed discussion of the tables, graphs or bar chats

Split Tensile Strength Test

7 Days Curing

The table 4.1 and figure 4.1shows the split tensile strength result for 7 days curing

Table 4. 1: Split Tensile Strength Result 7days Curing

SPLIT TENSILE STRENGTH RESULT							
BATCH%	TENSILE FORCE			TENSILE STRENGTH N/MM^2			
CUBES	F1(KN)	F2(KN)	F3(KN)	STR1	STR2	STR3	STRENGTH AVERAGE
0%	76	66	63	1.08	1.00	0.90	0.99
2%	72	64	68	1.02	0.91	0.96	0.96
4%	56	66	61	0.79	0.93	0.86	0.86
8%	57	59	64	0.80	0.83	0.90	0.84
10%	53	65	55	0.75	0.92	0.77	0.81

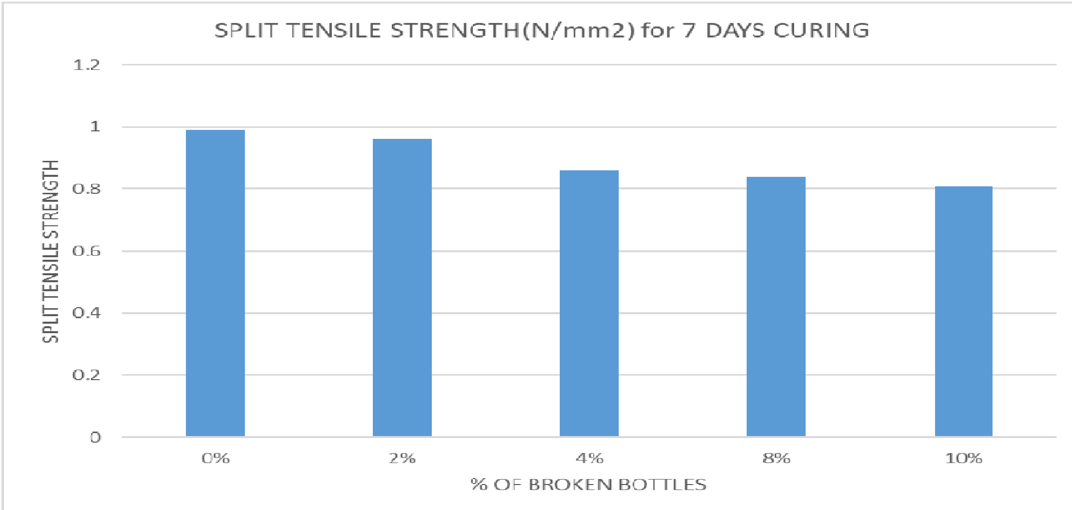

Figure 4. 1: tensile strength for 7days

The above bar chat result shows the split tensile strength for 0%, 2%, 4%, 8% and 10% partial replacement with broken bottles for 7days. From the above bar chat, the highest split tensile strength attained for 7days was 0% (control) of broken bottles with a strength of 0.99 N/mm2. The lowest split tensile strength attained for 7days was 10% of broken bottles with the strength of 0.81N/mm2.

14 days curing

The table 4.2 and figure 4.2 shows the split tensile strength result for 14days curing.

Table 4. 2: Split Tensile strength result for 14 days curing

BATCH%	TENSILE STRENGTH (KN)			TENSILE STRENGTH (N/MM^2)			
CUBES	F1(KN)	F2(KN)	F3(KN)	STR1	STR2	STR3	STRENGTH AVERAGE
0%	88	93	75	1.24	1.31	1.06	1.20
2%	85	73	76	1.20	1.03	1.07	1.10
4%	61	66	73	0.86	0.93	1.03	0.94
8%	66	58	61	0.93	0.82	0.86	0.87
10%	56	66	63	0.79	0.93	0.89	0.84

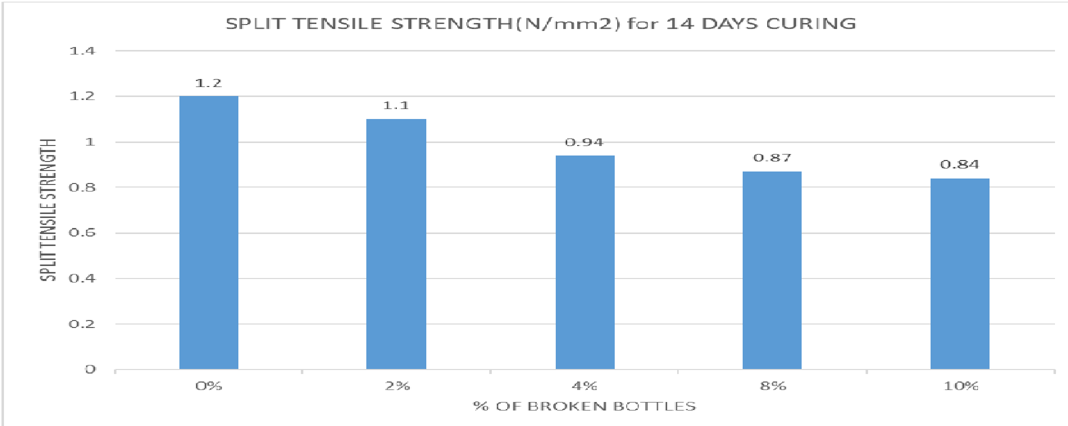

Figure 4. 2: tensile strength for 14days

The above bar chat result shows the split tensile strength for 0%, 2%, 4%, 8% and 10% of broken bottles for 14 days. From the above bar chat, the highest split tensile strength attained for 14days was 0% (control) of partial replacement with broken bottles with a strength of 1.20 N/mm2. The lowest split tensile strength attained for 14 days was 10% of partial replacement with broken bottles with the strength of 0.84N/mm2.

28 DAYS CURING

The table 4.3 and figure 4.3 shows the split tensile result for 28 days.

Table 4. 3: split tensile result for 28 days curing

SPLIT TENSILE TEST 28DAYS CURING							
BATCH%	TENSILE FORCE (KN)			TENSILE STRENGTH N/MM^2			
CUBES	F1(KN)	F2(KN)	F3(KN)	STR1	STR2	STR3	STRENGTH AVERAGE
0%	105	97	94	2.23	2.06	1.99	2.09
2%	81	81	93	1.72	1.72	1.97	1.80
4%	71	74	66	1.51	1.57	1.40	1.49
8%	63	75	60	1.34	1.59	1.27	1.40
10%	56	62	64	1.19	1.32	1.36	1.29

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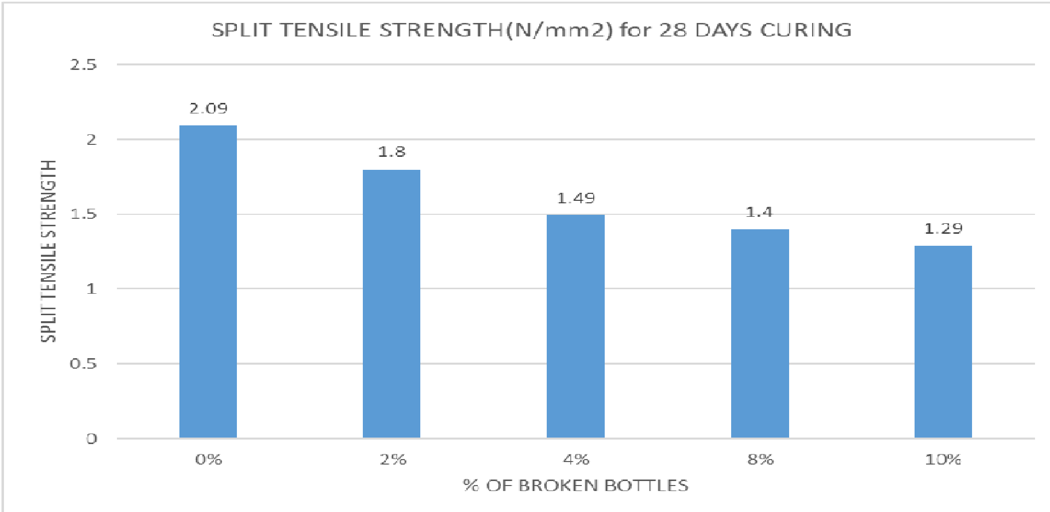

Figure 4. 3: Tensile strength for 28 days

The above bar chat result shows the tensile strength for 0%, 2%, 4%, 8% and 10% of broken bottles for 28 days. From the above bar chat, the highest tensile strength attained for 28 days was 0% (control) of partial replacement with broken bottles with a strength of 2.09 N/mm2. The lowest tensile strength attained for 28 days was 10%) of partial replacement with broken bottles with the strength of 1.29 N/mm2.

Overall Split Tensile Strength Result for All Curing days

Table 4.4 and figure 4.4 shows the split tensile strength for all curing days.

Table 4. 4: split tensile strength for all curing days

SPLIT TENSILE STRENGTH (N/mm2)					
DAYS	0%	2%	4%	8%	10%
7 DAYS	0.99	0.96	0.86	0.84	0.81
14 DAYS	1.20	1.10	0.94	0.87	0.84
28 DAYS	2.09	1.80	1.49	1.40	1.29

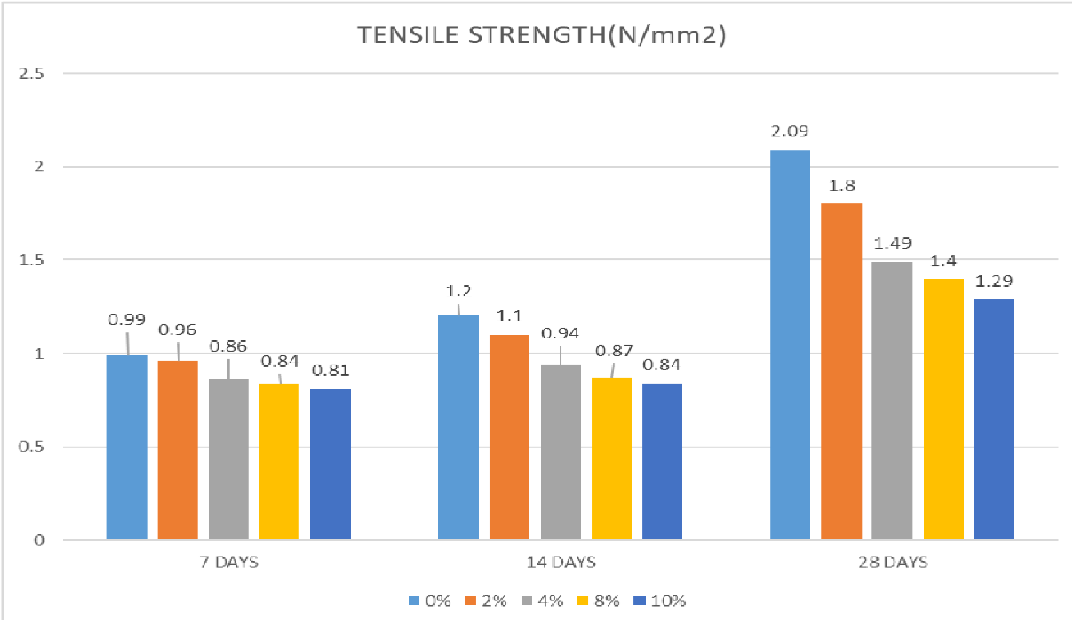

Figure 4. 4: bar chat comparing tensile strength value from 7 to 28 days of curing=`

The above bar chat result shows the split tensile strength for 0%, 2%, 4%, 8% and 10% of broken bottles for all curing days. From the above bar chat, the overall result shows that there is an increment in the tensile strength as the curing day's increases for all mixture. The result above shows that, there was a reduction in the tensile strength as the percentage of broken bottles increases for each curing day of 7days, 14days, and 28days. The highest tensile strength of % of broken bottles attained is 2.09 for 0% (control) and the lowest split tensile strength of % broken bottles attained is 1.29 for 10%. The next highest percentage of broken bottles partial replacement is 2%. It can be observed that the addition of broken bottles as a coarse aggregate lead to a decrease in the split tensile strength of the concrete cubes. Also, it can be observed that there was a higher increment for 0% and 2% of broken bottles at 28days.

WORKABILITY AND CONSISTENCY TEST

The workability and consistency of the fresh concrete was determined through a slump test and compaction factor test. The slump test was used in finding the workability and consistency of the concrete, while the compaction factor was used mainly to determine the workability of the fresh concrete. The compaction factor test and slump test were done for 0%, 2%, 4%, 8%, 10% Of cubes and cylinders. In total the test was done for 45 cubes and 45 cylinders in accordance to their percentages. The slump test and compaction factor test were done immediately after the mix, so has to preserve materials. Immediately after the test, the results were documented and the same mix was used in casting the concrete cubes and cylinders. The slump and compaction factor result obtained for 0%, 2%, 4%, 8%, 10% are shown in the table 4.5.

Table 4. 5: Slump value and compaction value

WORK ABILITY		
% OF BROKEN BOTTLES	SLUMP VALUE (MM)	COMPACTION FACTOR VALUE (MM)
0%	74	0.86
2%	67	0.87
4%	62	0.89
8%	58	0.92
10%	54	0.94

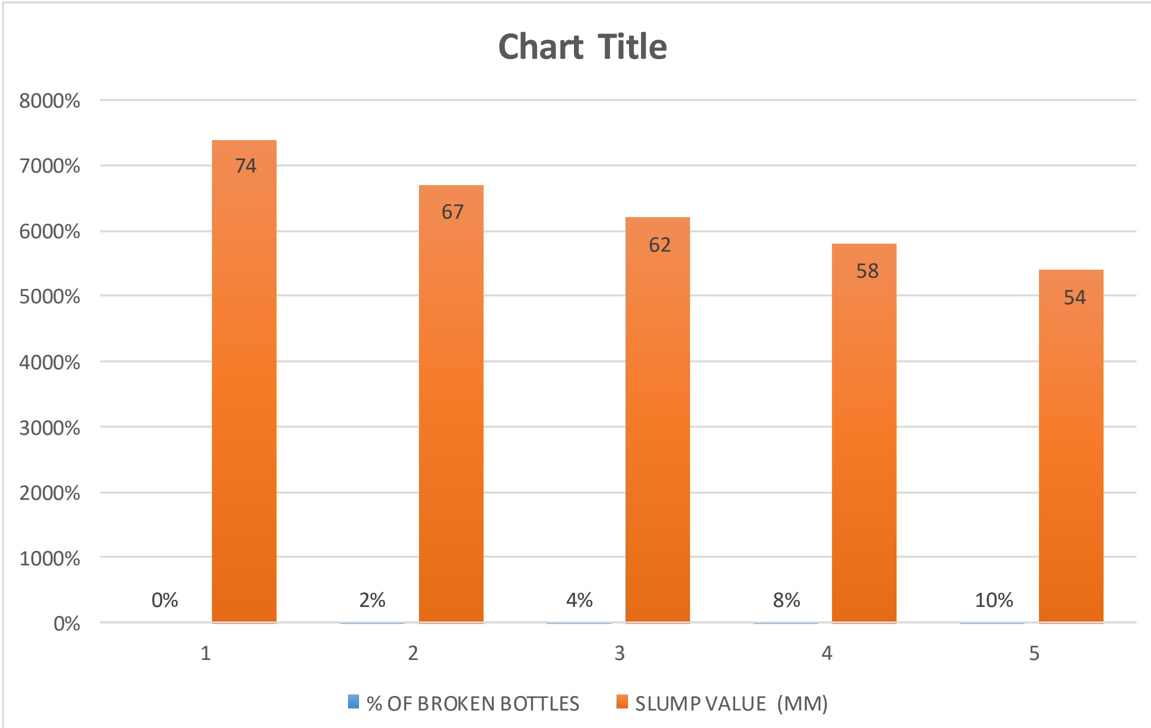

Figure 4. 5: Bar Chat of Slump Test

From the figure 4.5 above, it can be observed that there was a decrease in the slump value as the percentage of broken bottles increased. The highest slump value was 74 mm at 0% and the lowest slump value was 54mm.

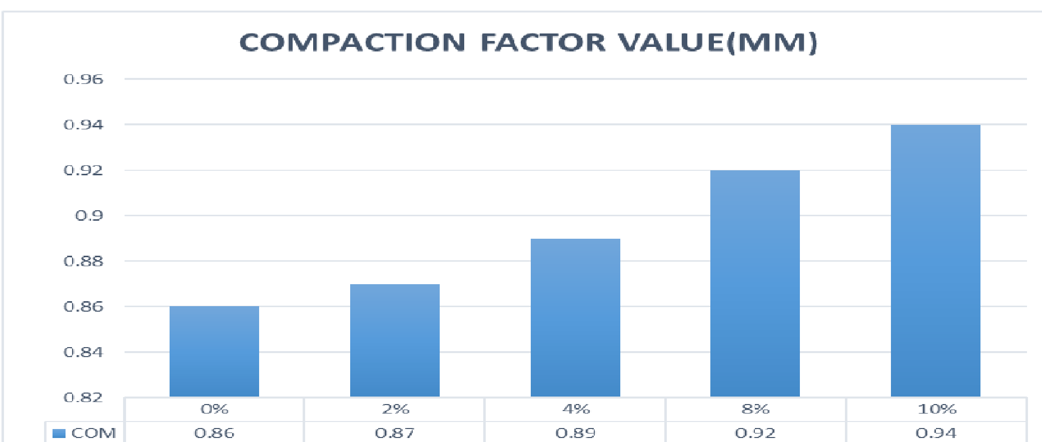

Figure 4. 6: Compaction Factor

At above, there was an increase in the compaction factor value as the percentage broken bottles increased. The highest compaction value was 0.94kg at 10% and the lowest compaction value was 0.86 at 0%. The percentage added to the concrete lead to a higher value, which is more workable.

COMPRESSIVE STRENGTH TEST

The compressive strength test was carried out on the concrete cubes to determine the compressive strength of the concrete cube samples. Three (3) concrete cube samples were casted and crushed for 0%, 2%, 4%, 8%, 10% of broken bottles. The result obtained for 7days, 14days, and 28days for 0%, 2%, 4%, 8%, 10% of broken bottles are shown below;

7DAYS CURING

The table 4.6 and figure 4.7 shows the compressive result for 7 days.

Table 4. 6: COMPRESSIVE STRENGTH RESULT FOR 7 DAYS CURING

COMPRESSION STRENGTH RESULTS							
BATCH %	COMPRESSIVE FORCE (KN)			COMPRESSIVE STRENGTH N/MM2			
CUBES	F1(KN)	F2(KN)	F3(KN)	STR1	STR2	STR3	STRENGTH AVERAGE
0%	254	280	250	11.29	12.4	11.11	11.61
2%	227	240	222	10.09	10.67	9.87	10.20
4%	200	215	225	8.89	9.56	10.00	9.48
8%	188	190	214	8.36	8.44	9.51	8.77
10%	180	175	207	8.00	7.78	9.20	8.33

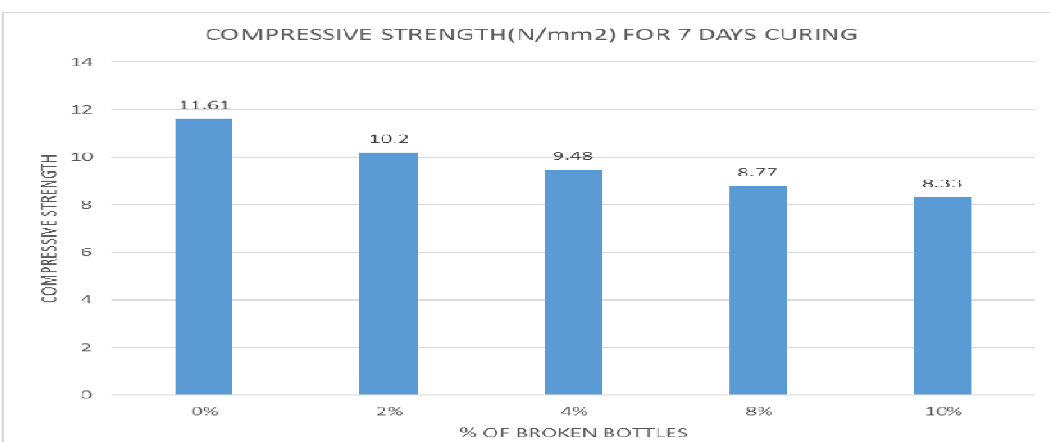

Figure 4. 7: Compressive strength for 7days

The above bar chat result shows the compressive strength for 0%, 2%, 4%, 8% and 10% of broken bottles for 7days. From the above bar chat, the highest compressive strength attained for 7 days was 0% (control) of broken bottles with a strength of 11.61 N/mm2. The lowest compressive strength attained for 7days was 10% of broken bottles with the strength of 8.33 N/mm2.

14 Days Curing

The table 4.7 and figure 4. 8shows the compressive strength result for 14 days curing.

Table 4. 7: COMPRESSIVE STRENGTH RESULT FOR 14DAYS CURING

COMPRESSION STRENGTH RESULTS							
BATCH%	COMPRESSIVE FORCE (KN)			COMPRESSIVE STRENGTH (N/mm2)			
cubes	F1(KN)	F2(KN)	F3(KN)	STR1	STR2	STR3	STRENGTH AVERAGE
0%	280	277	302	12.4	12.31	13.42	12.73
2%	293	280	284	13.02	12.44	12.62	12.70
4%	240	270	237	10.67	12.00	10.53	11.07
8%	220	244	242	9.78	10.84	10.76	10.46
10%	238	224	190	10.58	9.96	8.44	9.66

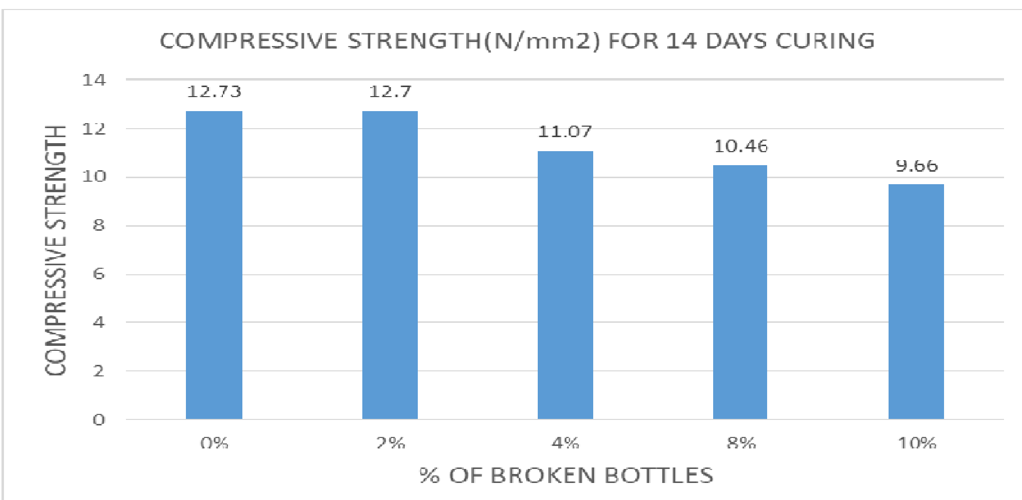

Figure 4. 8: compressive strength for 14days

The above bar chat result shows the compressive strength for 0%, 2%, 4%, 8% and 10% of broken bottles for 14days. From the above bar chat,

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the highest compressive strength attained for 14 days was 0% (control) of broken bottles with a strength of 12.73N/mm2. The lowest compressive strength attained for 14days was 10% of broken bottles with the strength of 9.66 N/mm2.

28 Days Curing

The table 4.8 and figure 4.9 shows the result for 28 days.

Table 4. 8: Compression Strength Result for 28days Curing

COMPRESSION STRENGTH RESULTS							
BATCH%	COMPRESSIVE FORCE (KN)			COMPRESSIVE STRENGTH N/MM^2			
cubes	F1(KN)	F2(KN)	F3(KN)	STR1	STR2	STR3	STR
0%	469	394	430	20.84	17.51	19.11	20.01
2%	421	448	442	18.71	19.91	19.64	18.47
4%	410	400	391	18.22	17.78	17.38	17.79
8%	320	382	340	14.22	16.98	15.11	15.44
10%	300	288	306	13.33	12.80	13.60	13.24

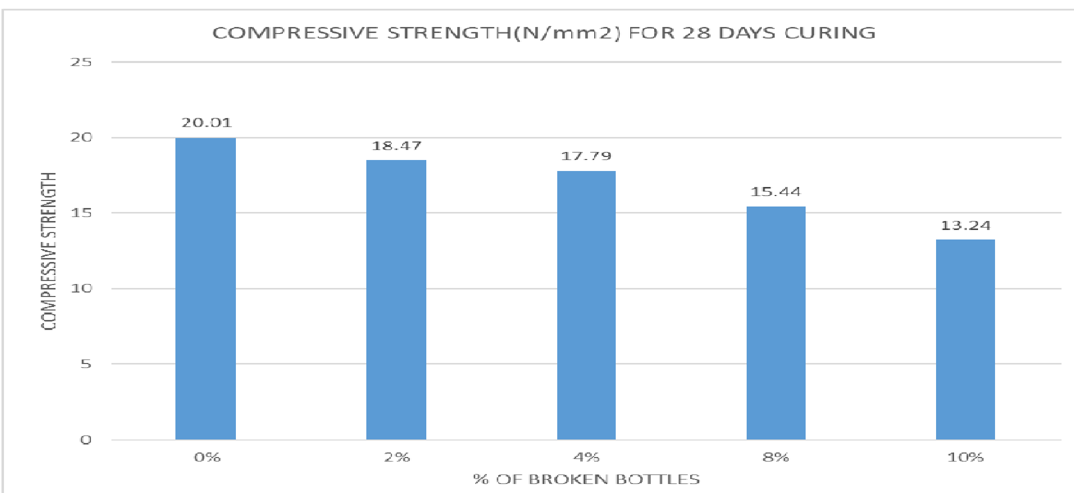

Figure 4. 9: compressive strength for 28 days

The above bar chat result shows the compressive strength for 0%, 2%, 4%, 8% and 10% of broken bottles for 28days. From the above bar chat, the highest compressive strength attained for 28 days was 0% of broken bottles with a strength of 20.01N/mm2. The lowest compressive strength attained for 28days was 10% of broken bottles with the strength of 13.24 N/mm2.

OVERALL COMPRESSIVE STRENGTH FOR ALL CURING DAYS

The Table 4.9 and figure 4.10 shows the overall compressive strength for all curing days.

Table 4. 9: Compressive Strength Result for all Curing Days

COMPRESSIVE STRENGTH (N/mm2)					
DAYS	0%	2%	4%	8%	10%
7 DAYS	11.61	10.21	9.48	8.77	8.33
14 DAYS	12.73	12.70	11.07	10.46	9.66
21 DAYS	16.89	17.30	14.19	13.81	15.44
28 DAYS	20.01	18.47	17.79	15.44	13.24

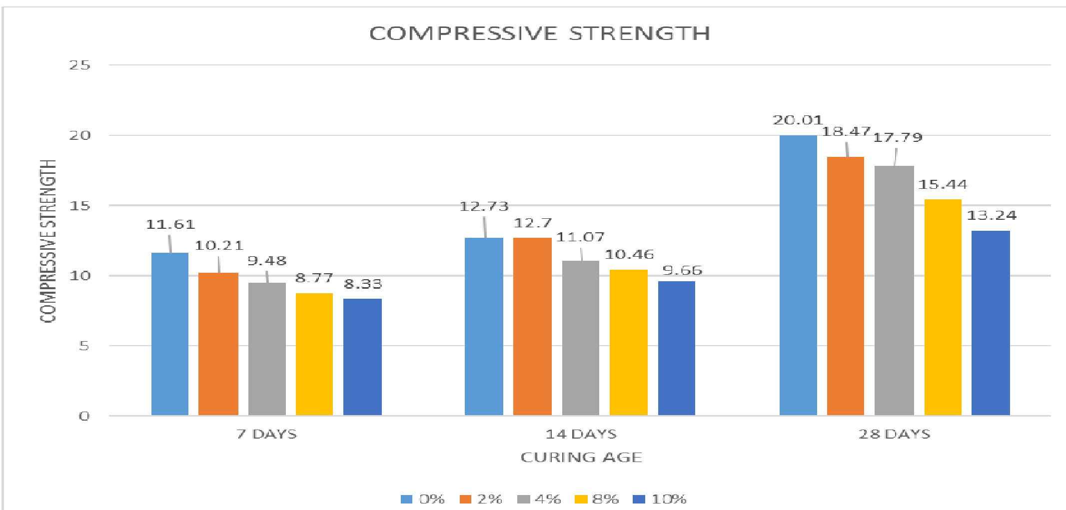

Figure 4. 10: Bar chat comparing compressive strength value from 7 to 28 days of curing

The above bar chat result shows the compressive strength for 0%, 2%, 4%, 8% and 10% of broken bottles for all curing days. From the above bar chat, the overall result shows that there is an increment in the compressive strength as the curing day's increases for all mixture. The highest compressive strength of percentage of broken bottles attained is 20.01N/mm2 for 0% and the lowest compressive strength of percentage of broken bottles attained is 13.24N/mm2 for 10%. There was a gradual increase in the 2% of broken bottles as the curing days increased up to 28days. It can be observed that the addition of broken bottles lead to an increase in the compressive strength at 2%, which was the highest compressive strength at 14days; afterwards there was a

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reduction in the compressive strength of the concrete cubes. In addition, it can be observed that there was a higher increment for 2%, 4% of broken bottles compared to that of 8% and 10% at 28days.

CONCLUSION

The aim of this study was to evaluate the characteristic comparison of concrete produced partially with broken bottles in place of coarse aggregate for civil engineering construction, and to find out which percentage of replacement of broken bottles that gives the highest compressive strength and tensile strength. At the end of the project, it was discovered that:

1. The slump of the concrete containing broken bottles reduced with increase in the percentage of broken bottles content, despite the reduction in the slump value as the percentage of broken bottles increased, the lowest slump test attained at 10% is workable.
2. The compaction factor of the concrete containing broken bottles increased as the percentage of broken bottles content increased. The highest compaction factor value was at 10% replacement with broken bottle, and the lowest compaction value was at 0%. The increase in the compaction factor as the percentage of broken bottles increase was due to the weight of the broken bottles.
3. The compressive strength of the concrete for 4%, 8%, 10% of broken bottles led to a reduction in the compressive strength of the concrete compared to the 2% replacement of broken bottles. The 2% replacement with broken bottles had the highest compressive strength of 12.70 N/mm2 at 14days but at 28days the controlled concrete (0%) had the highest compressive strength of 20.01N/mm2. The compressive strength attained at 2%, 4%, 8% exceeded the minimum compressive strength attained at 28days, which is 15 N/mm2 for Grade 15.
4. Result from the present study indicates that 2% partial replacement of broken bottle can be satisfactorily substituted with coarse aggregates.
5. The tensile strength of the concrete reduced as the percentage of broken bottles was increased. The highest tensile strength attained

was at 0% which was the controlled concrete and the lowest tensile strength attained was at 10%. The percentage of 2% had the highest tensile strength compared to the 4%, 8%, 10%.

RECOMMENDATION

1. More project work and experiments should be done with industrial waste, so as to reduce the level of environmental pollution and to reduce the amount of waste produced.
2. Concrete produced with broken bottles at a replacement of 2% can be used as wall loading structures, like slabs, beams without load, and it is more economical.
3. Further Experiment should be done with different mixes of grades (m10, M20, M25), so as to determine which mix gives the highest replacement for 2%-10% and which mix of grade provides for compressive strength capable enough to withstand heavy loads since it is more economical.
4. Substantially, more research and experiment should be done on how to make glass bond better in a concrete mix, when used as a replacement for coarse aggregate.
5. "Ready to deliver" concrete mix partially replaced with broken bottles would be a great addition to the civil engineering and construction industry.

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