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Properties Of Concrete By Using Bagasse Ash And Recycle Aggregate

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Abstract

Sustainable concrete structures which imply green building technology has been widely considering in modern structures. The objective of this study is to investigate the concrete properties by using recycle aggregate as a replacement of coarse aggregate and bagasse ash as the partial replacement of cement. Experimental investigation has been carried out by performing several tests which included slump test, compacting factor test, compressive strength test, rebound hammer test and concrete density test. A total of nine mix batches of concrete containing 0%, 25%, 50%, 75% and 100% of recycle aggregate and 0%, 10%, 15% and 20% of bagasse ash were tested to determine the increment of mechanical properties of concrete. It can be observed that significant decrease of concrete strength with the addition of recycle aggregate, and effective increment of concrete strength by using optimum percentage of bagasse ash might be possible. Finally, it can be concluded that recycle aggregate and bagasse ash with optimum percentage can be used to make recycle concrete and sustainable structures.

Keywords: recycle aggregate, bagasse ash; recycle concrete; mechanical properties; sustainable structure.

1. Introduction

In recent years, the possible use of recycled aggregates obtained from construction and demolition of wastes have received increasing interest, due to its potential to be used in environmentally friendly reinforced concrete structures. In addition, the shortage of supply of natural aggregates in some parts of the world leads to the need to produce recycled aggregate as an alternative source of aggregate. Recycling has a twofold purpose: (i) to minimize the amount of waste to be deposited and (ii) to preserve natural resources. Recycling materials allows for higher efficiency throughout their life cycle and is consistent with environmental protection trends. At the end of its life cycle, a material becomes waste, which can be transformed into a new material to make new products or to be used in structural applications. Effective recycling using a waste material is to produce a new material of similar characteristics, thereby achieving higher efficiency in its life cycle [1]. Recycled consists of hard, graduated fragments of inert mineral materials, including sand, gravel, crushed stone, slag, rock dust, or powder inert solid waste from concrete, asphalt, dirt, brick, and other rubble. When structures made ofconcreteare demolished or renovated, concrete recycling is an increasingly common method of utilizing the rubble. The issue of recycling rubbles from building demolition in the concrete industry has been widely discussed by many researchers[2-4].

Numerous researches [5-8]have been investigated on the mechanical behavior of concretes containing recycled aggregates. The test results examined that how the strength loss caused by recycled concrete aggregate at equal water to cement ratio (W/C) could be reduced if better concrete was used as coarse recycled aggregate, and if a lower proportion of fine recycled aggregate was added. Successful application of recycled aggregate in construction projects has been reported in some European and American countries. Toward the end of the 1990s, 28% of the wastes of the European Union were recycled [9]. In the United States, wastes are estimated at 250–300 million tons per year. In addition, 85 million tons of construction wastes were generated in Japan in 2000, 40% of which were concrete wastes [10].

Ordinary Portland cement is recognised as the major construction material throughout the world. Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials [11]. In addition to these, agricultural wastes such as rice husk ash and wheat straw ash are also being used as pozzolanic materials and hazel nutshell used as cement replacement material. When pozzolanic materials are added to cement, the silica (SiO_2) present in these materials reacts with free lime released during the hydration of cement and forms additional calcium silicate hydrate (CSH) as new hydration products which improve the mechanical properties of concrete formulation. Bagasse ash is one of an agricultural waste from sugar manufacturing. When juice is extracted from the cane sugar, the solid waste material is known as bagasse. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties. Therefore, it is possible to use bagasse ash as cement replacement material to improve quality and reduce the cost of construction materials such as mortar, concrete pavers, concrete roof tiles and soil cement interlocking block.

Up to now, not much research has been done to investigate the use of recycle aggregate with sugar cane bagasse (as a supplementary cementing material) in concrete production in the world. The compressive strength values increased with hydration time in the presence of bagasse ash (BA) and the values were found to be higher than that of control. Hydration of BA blended Portland cement has been studied by employing a number of experimental techniques [12]. It was found that in presence of BA setting times are increased and free lime is decreased. Payá et al. [13]reported that the BA in blended concrete had significantly higher compressive strength, tensile strength, and flexural strength compare to that of the concrete without BA. It is found that the cement could be advantageously replaced with BA up to maximum limit of 10%. Fairbairn et al. [14]conducted an experimental work on sugar cane bagasse for the pozzolan production. It was concluded that the cement could be advantageously replaced with SCBA up to maximum limit of 10%.

The main aim of this research is to identify the performance of using recycled aggregate and bagasse ash to produce high performance concrete. The performances of partial replacement of cement with different percentages of ground RHA were measured through tests ofslump test, compacting factor test, compressive strength test, rebound hammer test and concrete density test. Finally, the results of concrete strength for ordinary concrete were compared with concrete of different percentages of RA and bagasse ash.

2. Materials and experiments

2.1. Materials investigation

The size of natural coarse aggregate used in this research is 20mm, which was proven to produce excellent natural aggregate concrete, and is widely used in Malaysia. Recycled washed aggregate of 20 mm size obtained from wastes concrete that has been mixed in the laboratory. Natural concrete fine aggregate of medium grading was used throughout all the experimental work, and this fine aggregate is also widely used in Malaysia. Ordinary Portland cement (OPC) was used in this investigation. The bagasse ash used for this research is prepared in the laboratory; the bagasse was washed with water and dried. Then, the bagasse kept to the burning in an electric oven. The condition of burning was 600° and the time of residence was 4 hours. After this period, the bagasse is ready to use as a bagasse ash in the concrete. Water used in this study is available in the college campus conforming to the requirements of water for concreting.

2.2. Specimen preparation and curing

Three series of concrete mixtures were prepared in the laboratory using a Pan mixer. The absolute volume method was used in calculating the mixture proportions. SF, MK, FA and GGBS were used as cement replacements on a weight basis. In all concrete mixtures, a constant water/binder ratio at 0.50 was used.

Series Iconcrete mixtures used natural aggregate as the coarse aggregate and the mixes were designated with the following codes: C (control, natural aggregate with 100% OPC), C-SF10 (natural aggregate with 10% SF), C-MK15 (natural aggregate with 15% MK), C-FA35 (natural aggregate with 35% FA) and C-GGBS55 (natural aggregate with 55% GGBS). In Series II and Series III, recycled aggregates were used to replace 50% and 100%, respectively of natural coarse aggregate.

The mixtures were designated with the following codes: R50-SF10, R100-SF10 (50or 100% recycled aggregate with 10% SF), R50-MK15, R100-MK15 (50% or 100% recycled aggregate with 15% MK), R50-FA35, R100-FA35 (50% or 100% recycled aggregate with 35% FA) and R50-GGBS55, R100-GGBS55 (50% or 100% recycled aggregate with 55% GGBS). The mixture proportions of the concrete are presented in Table 1.

The workability of the concrete mixtures was measured using the slump cone test according to ASTM C143-89a[15]. Each slump value reported in this paper is the average of three readings obtained from three different specimens in the same conditions. The test specimens prepared were concrete cubes with sizes of 100 and 150 mm for compressive strength and UPV tests. In addition, concrete cylinders with 100 mm (diameter) and 200 mm (height), and 75 X 75 X 285 mm^3 prism were cast for tensile splitting strength, chloride ion penetration and drying shrinkage test, respectively.

The specimens were cast in accordance with ASTM C192-88[16]. Plastic sheets were used to cover the specimens to prevent the water from evaporating. All concrete specimens were first cured for 24 h in laboratory conditions. After that the specimens were demoulded and placed in a water curing tank at 27^0C until the test ages.

2.3. Strength

According to BS EN 12390-3:2009 [17], for the various strength of concrete, the determination of compressive strength has received a large amount of attention because the concrete is primarily meant to withstand compressive stresses. Cubes, cylinders and prism are the three types of compression test specimens used to determine the compressive strength. The cubes are usually of 100mm or 150 mm side, the cylinders are 150 mm diameter by 300 mm height, and the prisms are 100mm ×100mm×500mm in size.

TABLE1: MIX QUANTITIES OF 9 CYLINDERS -RECYCLED AGGREGATE (RA)

Mix	Natural Aggregate (kg)	Recycled aggregate (kg)	Sand (kg)	Cement (kg)
0% (RA)	19.386	0	9.693	4.842
25% (RA)	14.539	4.846	9.693	4.842
50% (RA)	9.693	9.693	9.693	4.842
75% (RA)	4.846	14.539	9.693	4.842
100% (RA)	0	19.386	9.693	4.842

2.4. Workability and slump tests

The workability of fresh concrete is a composite property. A good concrete must has workability in the fresh state and also develop sufficient strength. The slump test is the most well-known and widely used test method to determine the workability of fresh concrete. It is tested here according to Cement Association of Canada, (2003) [18].

2.5. Compacting factor test

Compacting factor test also used to determine the workability of fresh concrete. The compacting factor test gives a more accurate workability of fresh concrete than slump test. It mentioned that the compacting factor test also known as the “drop test”, which measures the weight of fully compacted concrete and compare it with the weight of partially compacted concrete. All the procedures for the compacting factor test were carried out by according to the BS EN 12350[19]. And it is not used on site testing because the apparatus is very heavy.

Place the concrete sample gently in the upper hopper to its brim using the hand scoop and level it.Cover the cylinder and open the trap door at the bottom of the upper hopper so that concrete falls in to the lower hopper .Push the concrete sticking on its sides gently with the road. Open the trap door of the lower hopper and allow the concrete to fall in to the cylinder belowCut of the excess of concrete above the top level of cylinder using trowels and level it.

Clean the outside of the cylinder. Weigh the cylinder with concrete to the nearest 10 g. This weight is known as the weight of partially compacted concrete. Empty the cylinder and then refill it with the same concrete mix in layers approximately 5cm deep, each layer being heavily rammed to obtain full compaction. Level the top surface. Weigh the cylinder with fully compacted. This weight is known as the weight of fully compacted concrete. Find the weight of empty cylinder.

The compacting factor was determined from the following equation:

$$\text{Compacting Factor} = \frac{\text{Mass of partially compacted concrete (M1)}}{\text{Mass of fully compacted concrete (M2)}} \quad (1)$$

2.6. Testing on hardened concrete specimens

The principal properties of hardened concrete which are practical importance are those concerning its Strength, Stress–strain characteristics Shrinkage and creep deformation Response to temperature variation, permeability and durability. Of these, the strength of concrete assumes a greater significance because the strength is related to the structure of hardened cement paste and gives age under given curing conditions is assumed to depend mainly on water- cement ratio and degree of compaction. This chapter consists of three types of hardened concrete testing. They are rebound hammer test, density test and compression test. All the procedure used was according to the BS EN 12390-1:2000 [20].

2.7. Schmidt or rebound hammer test

Schmidt hammer is a device to measure the strength of concrete. Today Schmidt hammers are in use throughout the world for estimating strength of concrete. Also is equipped with a sensor which measures the rebound value of a test impact to a high resolution and repeatability. Rebound is an effective non- destructive measurement of the concrete compressive strength (to within 20%) and control of the uniform concrete quality (in -situ concrete and prefabricated structures). in this research the Schmidt hammer test is done to find out the compressive strength of concrete specimens.The specimens were carried out from the water tank after the curing days completed.

The weight of the specimens was measured, and then placed in the ground of the lab.The test was started carefully by selection and preparation the surface of the concrete. A fixed amount of energy is applied by pushing the hammer against the specimen surface. The plunger must be allowed to strike perpendicularly to the surface.The angle of inclination of the hammer affects the result.After impact, the rebound number recorded. 6 readings were taken from each specimen.

2.8. Density test

Nelson stated that the density is one of the important factors that used to determine the properties of concrete. The density of concrete is generally affected by the amount of moisture present and the geological properties of aggregate. In this project, only density of hardened concrete was carried out. The determination of density was according to BS EN 12390-7:2009 [21]. All the testing was carried out in the concrete laboratory of Linton College University.The procedures were as below:

The testing for the specimens should be carried out as soon as possible after taking out from the curing tank. The specimens need to get the measurements before the testing.The diameter and height of the specimens were measured and recorded. The weight of each specimen was measured and recorded too. The specimen is cleaned and placed in the filled water tank and the weight is measured.The weight of the empty tank is measured.The density is determined by following weight in water and weight in air method.The volume is determined from the following equation:

$$\text{Volume } (V_3) = \frac{\text{weight in air } (m_A) - \text{weight in water } (m_W)}{1000} \quad (2)$$

And the density is determined from the following equation:

$$\text{Density} = \frac{\text{weight in air } (m_A)}{\text{Volume } (V_3)} \quad (3)$$

2.9. Compressive test

Compressive test is the experiment that was used to test the concrete compressive strength. For the compressive test, concrete specimens were used and the test procedure followed the BS EN 12390-3:2009 [17]. The test specimens were rectangular cylinders were 100mm diameter and 200mm height and loaded failure.

The specimen is loaded onto the compressive test machine.The machine is switched on and a hydraulic jack starts to compress the concrete specimen until it reaches failure.At the failure, the value from the gauge is recorded and this value is used to calculate the compressive strength.The compressive strength of concrete can be calculated using the following formula:

$$f_c = \frac{P \times 1000}{A} \quad (4)$$

Where,
f_c= Compressive strength of concrete (MPa).
P= Maximum load applied to the specimen in KN.
A = Cross sectional area of the specimen (mm^2)

3. Test results and analysis

3.1. Slump test

The Slump test shows a subsidence of the graph when the quantity of the recycled aggregate increased and the rise of the graph when the percentage of the bagasse ash increased as well. Figure 1shows slump test values for different percentage of recycled aggregate.Figure 2 showsslump test values for different percentage of bagasse ash.Difference in percentage dropped for the RA and BA compared to the control batch. The experimental results showed that the slump of the recycled aggregate concrete had a decreasing trend when the percentage of recycled aggregate increased.

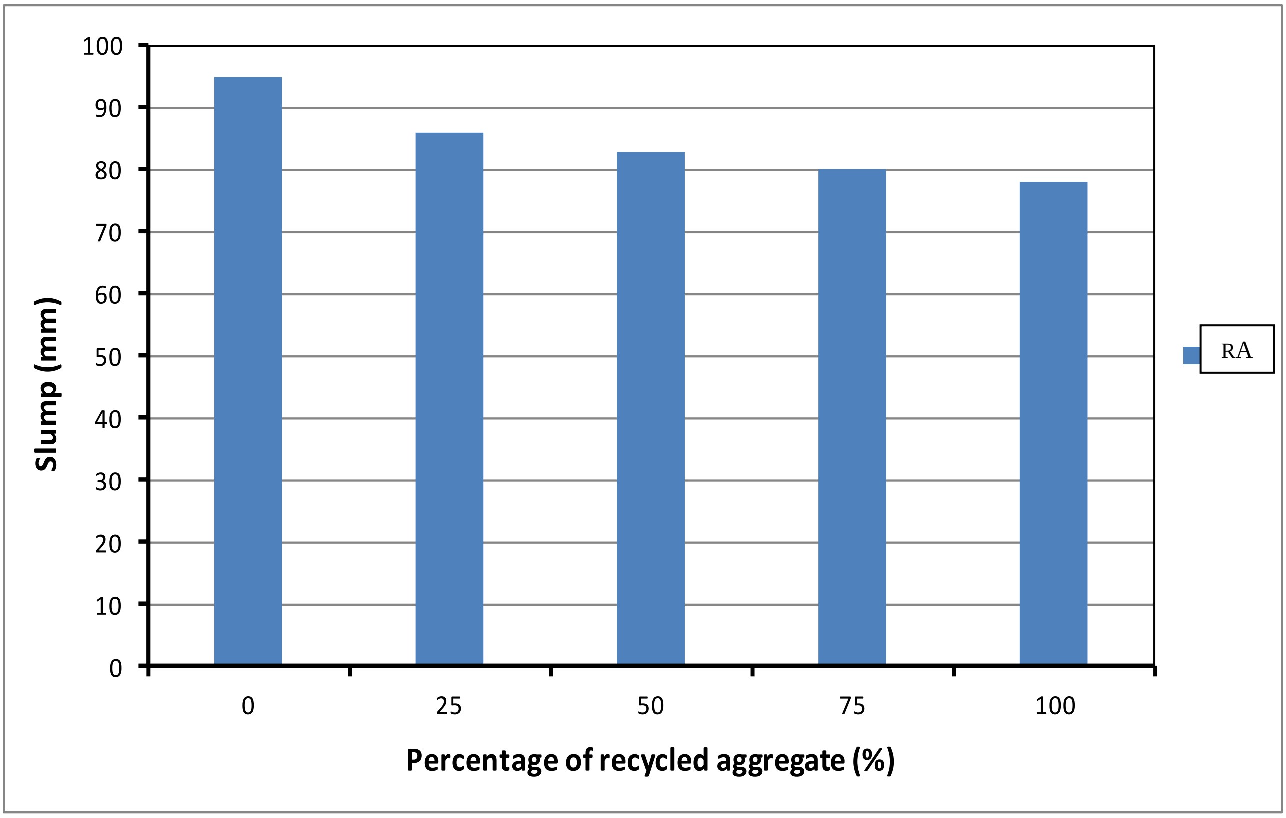

Figure 1: Slump test values for different percentage of recycled aggregate.

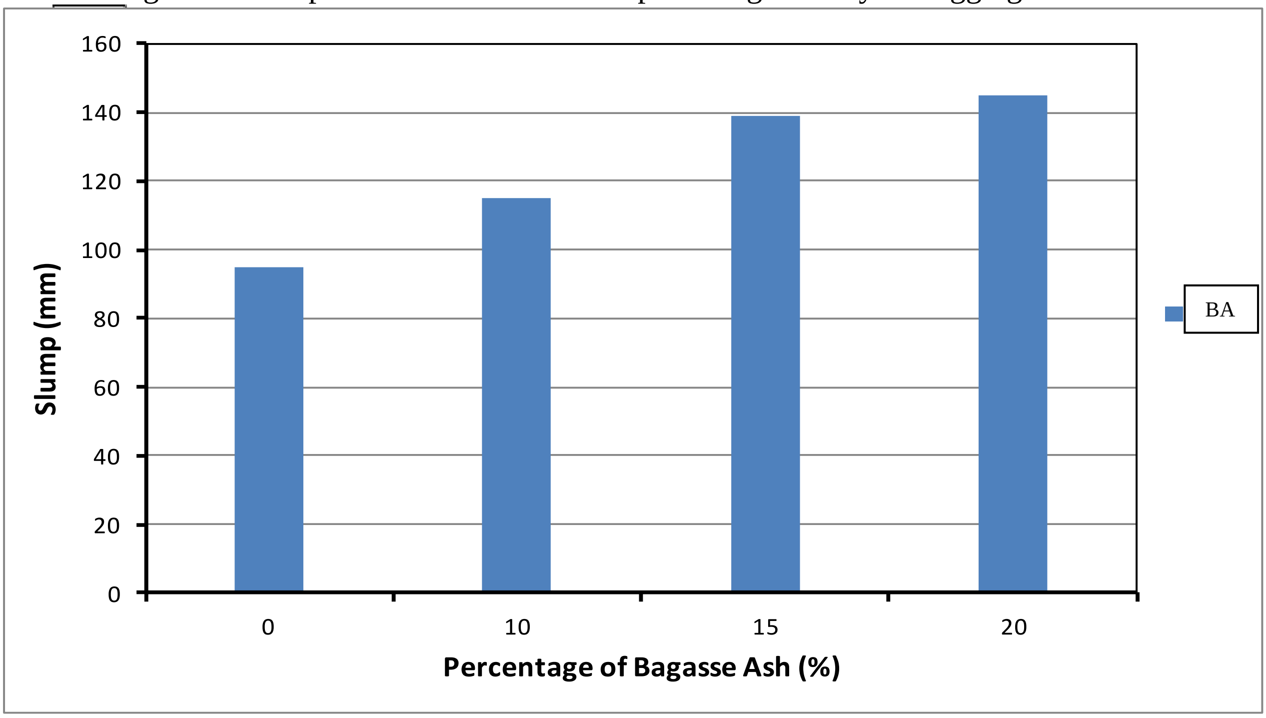

Figure 2: Slump test values for different percentage of bagasse ash.

Figure 1 shows that the slump test number figure decreases significantly to 86 mm for 25 % recycled aggregate, which is equal 9.5 % of slump dropcompared to the control batch. The slump for 50%, 75% and 100% recycled aggregate were 83 mm, 80 mm and 78 mm. The percentage drop for these three percentages of recycled aggregate compared to control batch are approximately 12.6 %, 15.8% and 17.9% respectively.

A high-quality concrete is one which has acceptable workability (95 mm slump height) in the fresh condition, and that contained the lowest percentage of the slump meaning it had less workability compared to the mixes with bagasse ash (Figure 2). Basically, the bigger the measured height of slump, the better the workability will be.

At the second testing, a value of 10% of bagasse ash was replaced with cement the value of the slump height were noted. The graph shows that the slump increased by 21.1% and reached 115 mm slump height.At the third testing, a value of 15% of (BA) replaced by cement it was noticed that there was increment in the value of the slump height. The slump value increased to 139 mm slump height as can be seen from the graph. And the percentage of increasing is 46.3 %, and 20.9 from the first test (Ordinary Concrete) and the second test respectively.At the fourth testing a percentage of 20% of (BA) replaced by cement it was noticed from the graph that the slump achieved a greater value comparing to the previous ones, where it has reached to 145 mm by increasing 4.3% from the third test, and this sample shows the highest workability.

All investigated of (BA) mixtures had high slump values and acceptable workability. This may be due to the increasing in the surface area of sugarcane ash after adding SCBA that needs less water to wetting the cement particles.

3.2. Compacting factor test

Compacting Factor test illustrate a decreasing in numbers figure when the quantity of recycled aggregate RA and bagasse ash BA increased. Figure 3 below represents the compacting factor observed during the test.

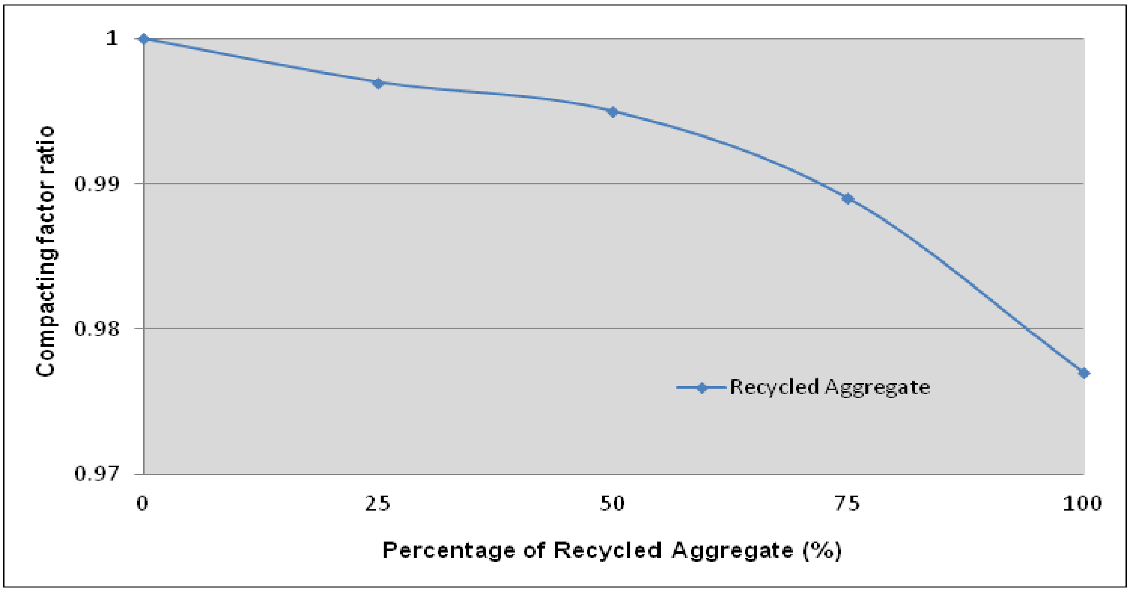

Figure 3: Average compacting factor vs. percentage of recycled aggregate

Figure 3indicates that recycled aggregate had a decreasing in number figure when the quantity of RA and BA increase. Furthermore the control mix was more workable than RA and BA as well. The slump tests were almost similar to the compacting factor in term of decreasing whenever adding materials.

When 25% was added into the concrete, the compaction factor for recycled aggregate decreased to 0.997. This may have been caused by the refilling of fresh concrete into the mould for first weight measurement, which is the mass of partially compacted concrete. With 50%, the compacting factor of RA decreased gradually to 0.995 with percentage 0.05% of compacting factor ratio compared to control mix. The compacting factor decreased rapidly for recycled aggregate, when 75% was applied in the concrete to 0.989 with percentage of 0.11%. The reason behind this is the high absorption capacity and shape of recycled aggregate. There was not much difference in the decreasing rate for 100% of recycled aggregate it has a ratio of 0.977, while the control batch has a ratio of 1.000.

Figure 4 shows the results of the compacting factor test with different percentages of bagasse ash that were replaced during the experiment which stated clearly the effect of bagasse ash at each decrement in percentage on concrete mix with bagasse ash compared to the ordinary concrete. The results that were obtained from the experiment indicated that the control sample had the highest value for compacting factor when compared with the other sample' values which means that it has a high workability. The value of the compactor factor for the control sample was 1.000. There is much difference when 10%, 15%, 20% of (BA) replaced with cement; the values 0.987, 0.981, 0.979 respectively was obtained as a compacting factor ratio. This clearly shows that there is a decreasing in the compacting factor and percentage values by 13%, 19%, 21% for (10%, 15%, and 20% respectively bagasse ash replaced by cement) when compared with control sample.

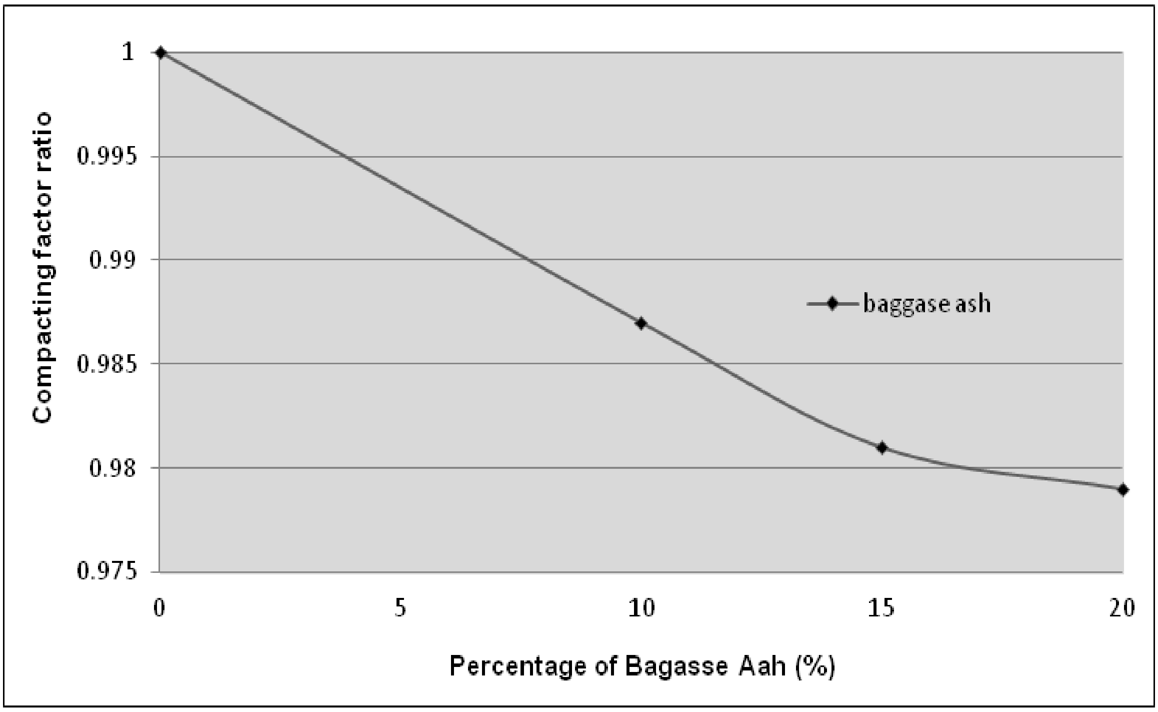

Figure4: Average compacting factor vs. percentage of bagasse ash.

However, as can be seen from the results of the compacting factor in Figure2, significantly there was decreased in the workability but it is counterproductive in terms of compressive strength specially the 10% (BA) gave increasing in the compressive strength as can be seen in the compressive strength test result values.

3.3. Compression test

The records of compressive strength test illustrate that the compressive strength did not increase when the percentage of recycled aggregate and bagasse ash increased. The compression test indicates that an increasing trend of compressive strength in the early age of the concrete specimens. Furthermore, it shows that the strength of recycled aggregate specimens is greater than bagasse ash samples. Table 2 below shows the difference of compressive strength recorded during the tests and Table 3 shows the average compressive strength and the strength difference in percentage for all mix batches compared to control batch.

TABLE 2: VARIATION OF COMPRESSIVE STRENGTH (N/MM^2) WITH AGE FOR RECYCLED AGGREGATE

Percentage of recycled aggregate	*0 %*	*25 %*	*50 %*	*75 %*	*100 %*
Day					
3	32.03	30.2	26.5	21.2	19.0
7	39.9	36.7	33.9	31.5	27.9
28	51.6	42.4	40.9	37.0	33.9

The compressive strengths records of the difference mixes are shown in Table6for curing days of 3, 7 and 28 days. The difference in the quality of the two types of recycled aggregate is clearly seen when comparing the 28-daycompressive strengths of the control mix; the loss of strength of the concrete made with recycled aggregate was 33.4% weaker than the control mix. The percentage of 25%, 50%, 75% and 100% for 3 curing days compared to the control mix has decrease percentage of 5.7%, 17.3%, 33.8%and 40.7 respectively, and for 7 curing days we find that the decreasing has change to 8%, 15%, 21%, 30% respectively, and finally for the recycled aggregate concrete that has curing of 28 days is 17.8%, 20.7%, 28.3%, and 33.4%, respectively.

Table 3 shows the average among all records of control mix and recycled aggregate (RA). it illustrate that when it compared between control mix and 25%,50%,75% and 100% percentage of recycled aggregate a decreasing by 11.7%,18%,27.4% and 34.7% which represent the maximum number figure according to the recycled aggregate concrete (RA) records.

TABLE 3:AVERAGE COMPRESSIVE STRENGTH AND PERCENTAGE DIFFERENCE COMPARE TO CONTROL BATCH FOR RECYCLED AGGREGATE

Type of mix batch	*Average compressive strength (N/mm^2)*
Control (0%)	41.2
25% RA	36.4
50% RA	33.8
75% RA	29.9
100% RA	26.9

In general, a lesser workability concrete mix tends to provide a higher strength concrete. However, after evaluating the compressions test, it shows there is no relationship between the additions of recycled materials for the compressive strength to the workability of each concrete mix. Hence, the ultimate compressive strength for all mixed materials concrete does not depend on their workability.

TABLE 4: VARIATION OF COMPRESSIVE STRENGTH (N/MM^2) WITH AGE FOR BAGASSE ASH (BA)

Percentage of bagasse ash	*0 %*	*10 %*	*15 %*	*20 %*
Day				
3	32.03	34.2	28.7	25.8
7	39.9	41.3	37.4	34.5
28	51.6	53.4	49.7	45.6

The highest value of compressive strength was obtained 53.4 N/mm^2 at the age of 28 days at 10% of bagasse ash as mentioned in Table 4. And also the compressive strength was reached (34.2, 41.3) N/mm^2 on 3 and 7 days respectively for 10% bagasse ash, while the highest strength of the concrete at the three different curing days was obtained at 10%. Compared with the control sample, by comparing the rest of the percentages which was replaced by the cement, it was noticed that the strength of the concrete has increased by replacing 10% bagasse ash, but when the percentage of (BA) in concrete exceeded more than 10%of (BA) , it showed decrement in the strength values. This decrement of the strength may be due to the bagasse ash probably cover partly the surface of cement and aggregate, therefore reduces the bonding between the aggregate and cement in concrete mix.

It also shows the lowest compressive strength value when 20% of (BA) was replaced which was 25.8 N/mm^2 Compared with the control sample.Also 15% and 20% of bagasse ash showed a high strength at the curing days 7 and 28 days more than the control sample at day 3, and the results were noted at Table 6; which the value of compressive strength for the control sample was 32.03 N/mm^2 at day 3, and for 15% and 20% of (BA) at day 7 the values were 37.4 N/mm^2 and 34.5 N/mm^2 respectively, for day 28 the values were obtained 49.7 N/mm^2 for 15% of (BA) and 45.6 N/mm^2 for 29%(BA).

From the above graph it is clear that the mixture that contains 10% bagasse ash has an increment at the strength level, where on the 3days it had a value of 34,2 N/mm^2 and it has increased by 7.1 N/mm^2 on 7 days, and on 28 days by 12.1 N/mm^2 on day7 and 19.2N/mm^2 on day3.

By taking the average for all the different percentages mixture and the ordinary concrete, the results obtained from the test shows that 10% of (BA) showed the highest strength level compared with other percentage mixtures, 10% of bagasse ash replaced by cement was obtained value 43 N/mm^2 higher than the control sample which obtained 41.2 N/mm^2 by 1.8 N/mm^2 and percentage of 4.4%. (Figure 5).

The others percentages obtained decreasing in the values compared with the control sample; 15% of (BA) compressive value was 38.6 N/mm^2 which decreased 2.6 N/mm^2 and percentage 6.3% compared with the ordinary concrete, and 20% of (BA) compressive value obtained was 35.3 N/mm^2 which decreased 5.9 N/mm^2 and percentage of 14.3% compared with the ordinary concrete.

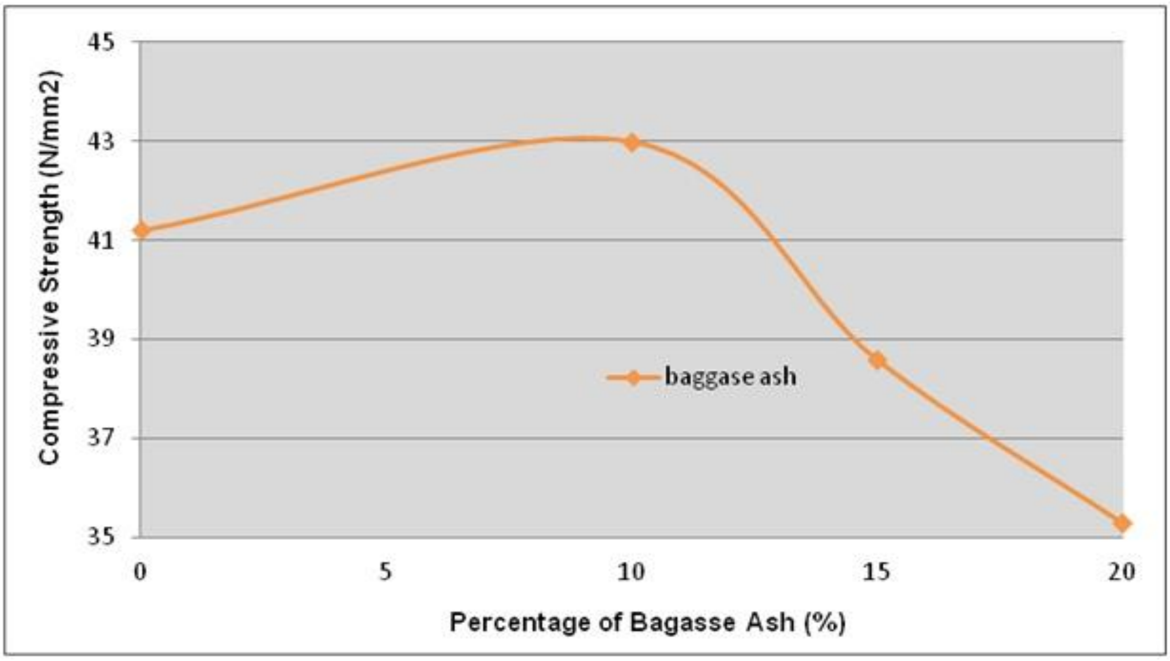

Figure 5: Average bagasse ash compressive strength vs. percentage of bagasse ash

3.4. Rebound hammer test

The results of Schmidt Hammer Test were obtained from the *Schmidt Hammer Conversion Diagram*, it was obtained by calculating the average of the three readings that were taken through the test process, and the results of the Schmidt Hammer Test are shown in the Table 5.

Clearly there is a light decrease in the readings of rebound hammer test results compared to compression test. This is due to the fact that the compression strength test is carried out on the whole concrete sample by crushing it while the rebound hammer test is carried out on the surface of the concrete sample so when the hammer strike the aggregate on surface it gives high value as compared to when it strike the mortar**.**

TABLE 5: VARIATION OF COMPRESSIVE STRENGTH (N/MM^2) WITH AGE

Percentage of recycled aggregate	*0 %*	*25 %*	*50 %*	*75 %*	*100 %*
Day					
3	31	28.4	19.6	17.2	16.1
7	38.9	35.4	32.7	28.3	25.87
28	47.9	36.1	35.1	31.7	30.6

Figure 6 illustrates that the compressive strength of the control concrete is consistently higher than the compressive strength of recycled aggregate concrete; a lower tendency of average compressive strength occurs to recycled aggregate concrete after the percentage starts to increase. However, recycled aggregate concrete tends to have an increasing tendency with time duration.

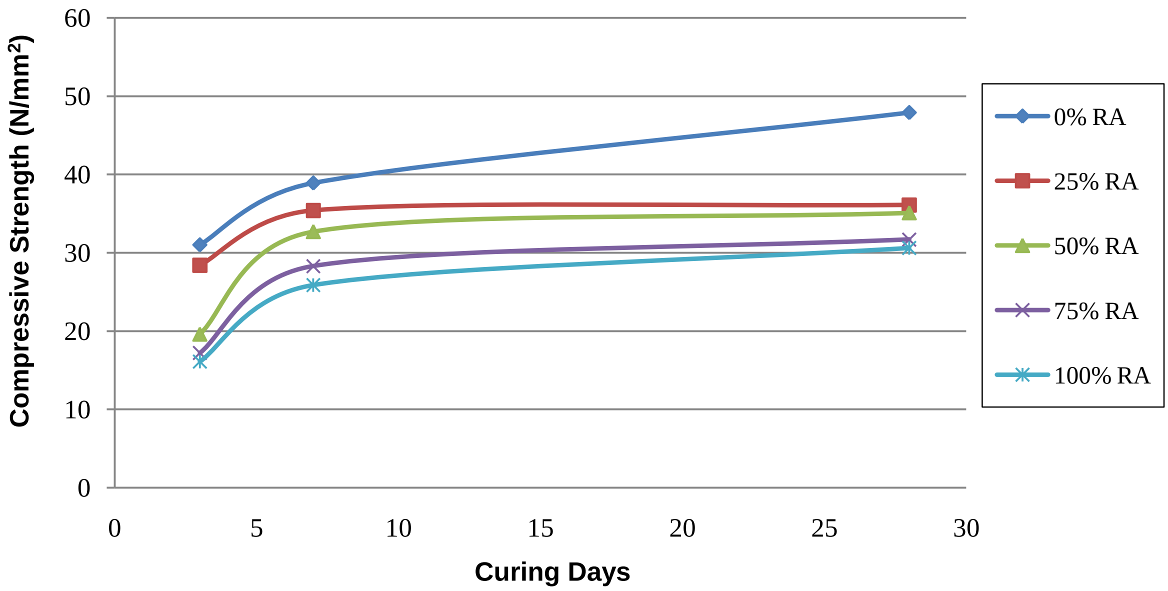

Figure 6: Average recycled aggregate compressive strength vs. concrete age

Figure 6 shows the average number among all records of control mix and recycled aggregate (RA). It illustrates that when it compared between control mix and 25%, 50%, 75% and 100% percentage of recycled aggregate a decreasing by 15.3%, 25.9%, 34.6% and 38.4 % which represent the maximum number figure according to the recycled aggregate concrete (RA) records regarding to rebound hammer test.

Figure 7 and Table 6 show that the concrete mix with 10 % of (BA) had the highest value of strength among all the other samples which was 48.8 (N/mm^2) at 28 days. 20% of (BA) showed the lowest strength value for the Schmidt Hammer obtained by 22.3 N/mm^2 at day 3. The value of (31 N/mm^2) after 28 days was obtained for the Schmidt Hammer Test.Through these studies it has been concluded that the compressive strength the increases with increasing the percentage of bagasse ash respect to the number of curing days.

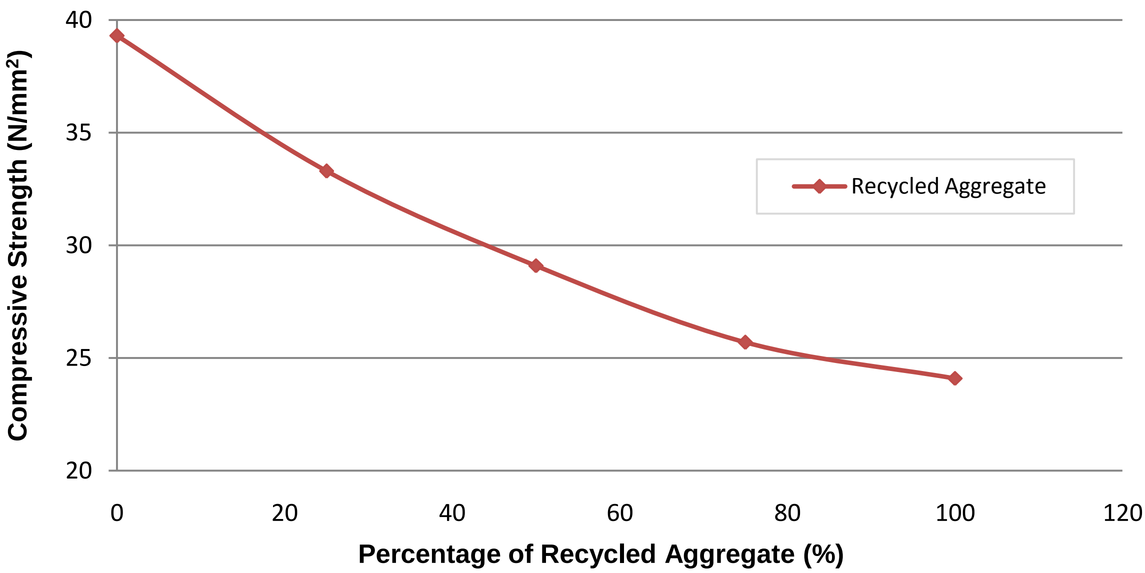

Figure 7: Average recycled aggregate compressive strength vs. percentage of recycled aggregate

TABLE 6: VARIATION OF COMPRESSIVE STRENGTH (N/MM^2) WITH AGE

Percentage of bagasse ash	*0 %*	*10 %*	*15 %*	*20 %*
Day				
3	31	32.1	28.1	22.3
7	38.9	39.6	35.1	31.1
28	47.9	48.8	43.8	41.7

Figure 8 shows an increase in the strength at 10 % of (BA) replaced by cement in concrete and this strength decreases after 10 % of (BA) through by 15% of (BA) and reached the lowest strength at 20% of (BA).

10 % of (BA) replaced by cement was increased by 0.9 N/mm^2 and 2.3% percentage compared with the control sample which obtained 39.3 N/mm^2, 15 % of (BA) replaced by cement was decreased by 3.6 N/mm^2 and 9.2% percentage compared with the control sample, 20 % of (BA) replaced by cement was decreased by 7.6 N/mm^2 and 19.3% percentage compared with the control sample which it's the lowest value obtained for the strength in both strength tests compressive strength test and rebound hammer test.

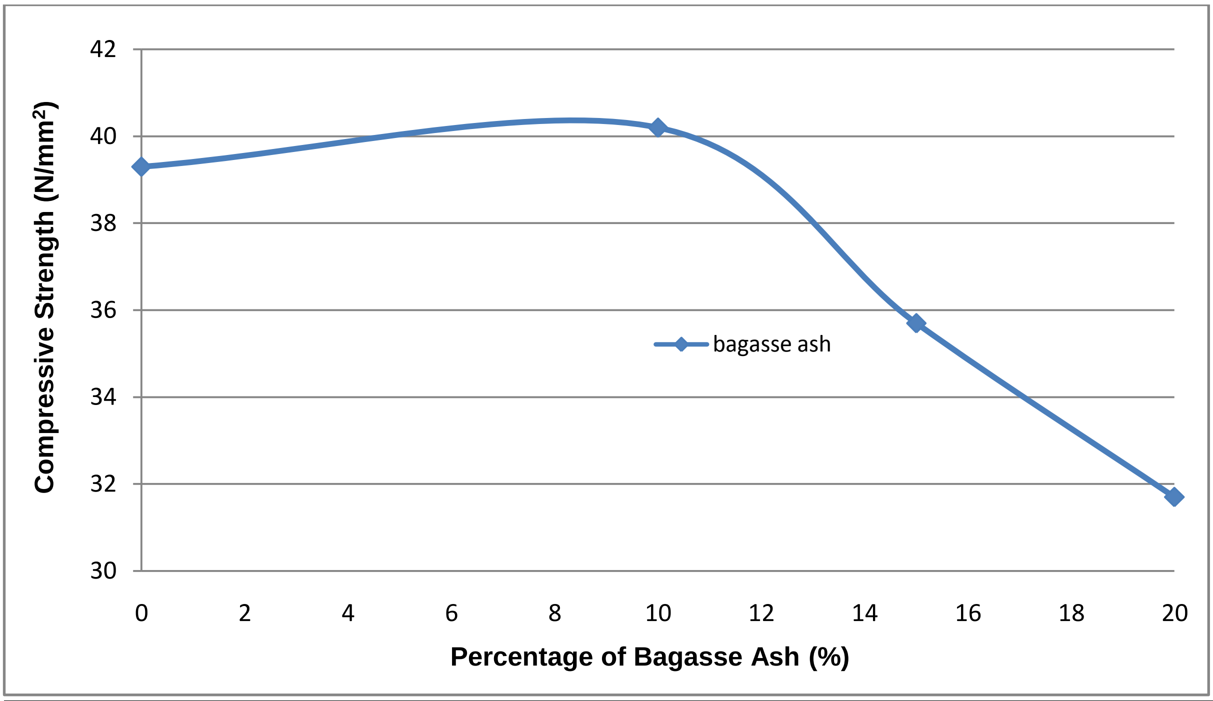

Figure 8: Average bagasse ash compressive strength vs. percentage of recycled aggregate

3.5. Density of hardened concrete

According to BS EN123900 part 7:2009 [21] the density of concrete must be measured before crushing in terms of weight and volume, also the range of concrete must be about 2400 kg/m^3 [22].

The density of all the concrete samples at 7 days for recycled aggregate has increased by 2.4 % .In general, density of recycled aggregate concrete was noticed to be less than that of similar natural aggregate concrete (Figure 9). And whenever the recycled aggregate percentage increased the density decreased. The lower value of the density of recycled aggregate may be attributed to its higher porosity than that of natural aggregate.

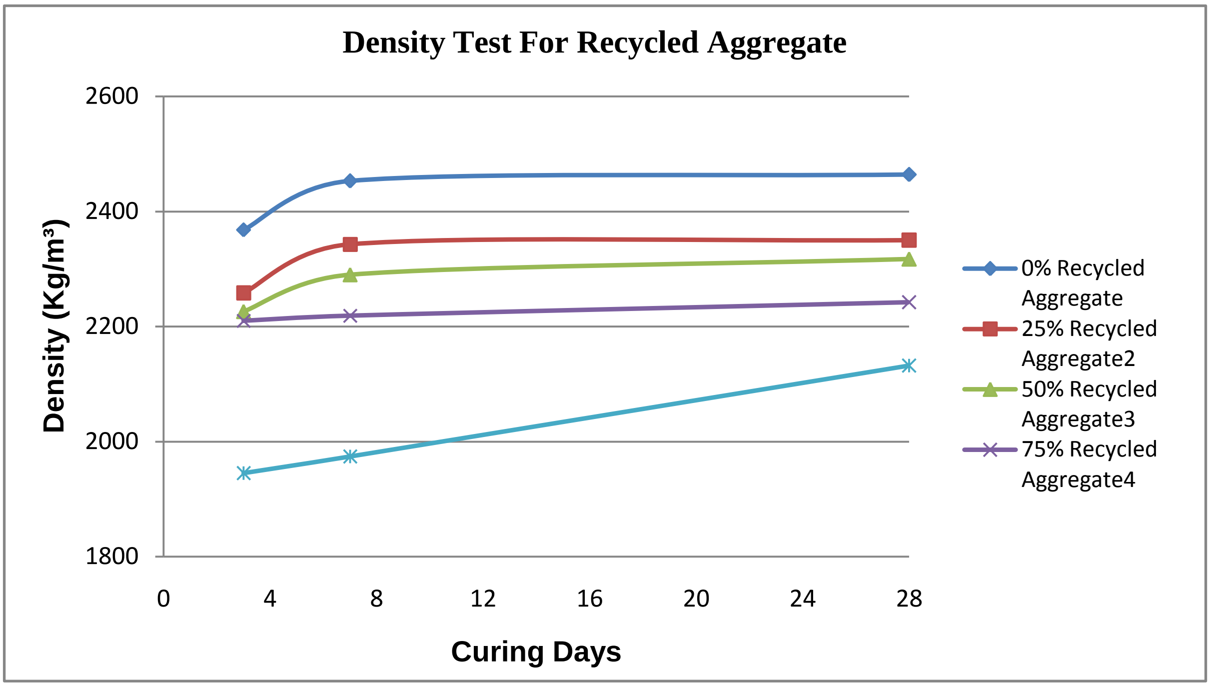

Figure 9:Average recycled glass density vs. curing days

The results of the density test obtained the replaced of different amounts of bagasse ash to concrete which has various effects on the weight and density as well (Figure 8). From Figure 8, it obtained a clearly decreasing trend of average density occurs to this bagasse ash replaced with cement in concrete after the percentage starts to increase. And at the same time there were an increasing with curing days due to assimilation capacity of sand and aggregate for the water that may affect the weight.

At 3 days, control mix concrete has a higher value 2368 kg/m^3 compared with other (BA) percentages, 20% has a lower density 2288 kg/m^3. The effect of bagasse ash percentage to density can clearly see from the Figure 10. Density decreased by 0.93%, 1.82%, and 3.38% for 10%, 15%, 20% of (BA) respectively compared by the control sample.

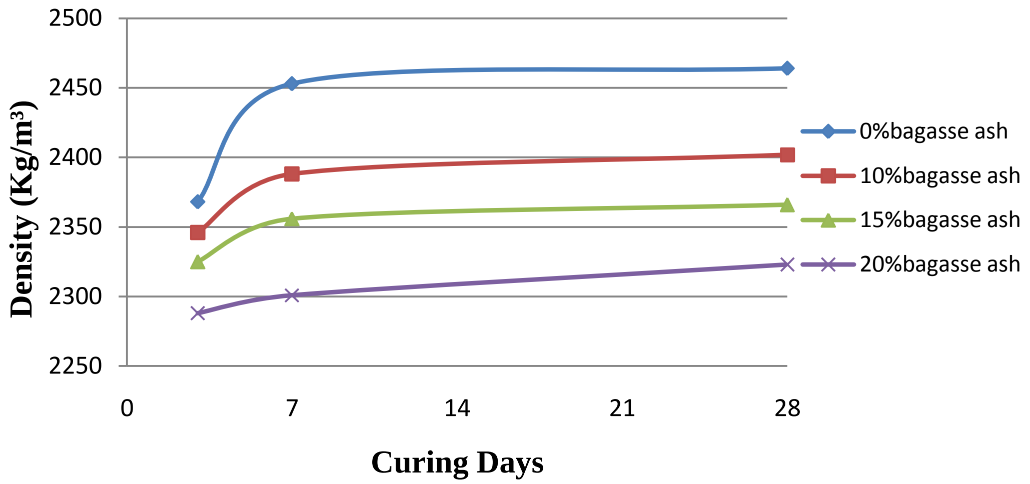

Figure 10: Average bagasse ash density vs. curing days

At 7 days, all concrete density increased and this increase was predictable due to water assimilation capacity, Density decreased by 2.65%, 3.95%, and 6.12% for 10%, 15%, 20% of (BA) respectively compared by the control sample.

At 28 days, a slight increase occurred for all batches that are because the concrete sample has reached its maximum assimilation capacity and it cannot absorb any more water from 7–28 days thus no much increase in density.

4. Conclusions

The following conclusion points are based on the research results, the following conclusionscan be drawn:

- The bagasse ash improves the compressive strength of concrete as noticed from the Compression Test and the strength increased for 10% (cement replaced by bagasse ash) by percentage of 4.4% compared with control specimen.
- The optimum percentage that can be added to concrete from the results obtained for the Compressive strength and Rebound Hammer Test is 10% of bagasse ash replaced cement which showed the highest strength. Other percentages of bagasse ash and recycled aggregate showed a decrement on the compressive strength. This decrement of the strength may be due to the surface of cement and aggregate being covered partly therefore reducing the bonding between the aggregate and cement in concrete mix for the bagasse ash, and for recycled aggregate, this may be attributed to the superior quality of natural granite aggregate used to create control concrete mixes, and the presence of Impurities in recycled aggregate.
- This research indicated that recycled materials (recycled aggregate and bagasse ash) decrease the workability of the fresh concrete. This was shown through the results of workability test obtained in standard slump test and compacting factor test. It was concluded that the increasing percentage volume of recycled materials added into the concrete would lead the workability to decrease except for the bagasse which showed an increment in slump test and that may be due to the fact that the bagasse ash does not absorb much water and this leads to the concrete to have much more water and this makes the cement more workable and have a high slump value.

- Strengths improved with age. Higher strengths could have been produced if high-strength cement was used (the compressive strength of cement used was 53.4 N/mm^2 after 28 days) (10% (BA)).
- Although a 100% recycled aggregate was used as replacement for coarse aggregates, it proved possible to produce recycled materials concretes capable of achieving the design slumps and compressive strengths within the range of 40 N/mm² after 28 days.
- Densities of all recycled materials samples are less than control samples. This is because recycled materials concrete are lighter than control concrete.

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