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Application of Brick Dust and Sawdust in Concrete: A Movement to Sustainability

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Abstract: It has become essential to recycle materials to create a sustainable environment, the application of using brick dust and glass powder leads to the reduction in the emission co2 and environmental landfills caused by the production of cement, disposal issues relating to solid waste, and demolished structures. The outcome of this research observes that the use of brick dust and sawdust in concrete helps in reducing the cost of the product, decreasing the amount of emitted CO2 as well as providing a way for environmental byproducts to be reduced by utilized for better sustaining of the ecosystem. In accordance with this study the evaluation of several properties of concrete was determined, the properties include compression test, split tensile test, compacting factor, slump for workability, density in the fresh and hardened state, and the ultrasonic pulse velocity of the concrete. The study used 10% brick dust as cement substitute and 5% by volume as substitute for fine aggregate. The outcome shows that the incorporation of brick dust increases the compressive strength and tensile strength, reduces workability, and has excellent quality of compactness which is 0.91, the compacting factor of just sawdust is seen to be 0.86, sawdust reduces the strength of concrete, and can be almost designated as light concrete due to the low density obtained and when both materials are added in one concrete the properties values as they have a different effect on the concrete separately. Overall, the application of this material in the same concrete as replacement proves beneficial and can be applied for construction.
Keywords: Sustainable; Brick dust; Sawdust; landfills; solid waste; Municipal.

1. Introduction

Significant ecosystem contamination has been brought on by the manufacture of mortar and conventional concrete, which has used up a lot of natural mineral wealth. Concrete is made of materials that can be scarce and hard to come by in recent times, A rise in population also increased the need for natural resources and the amount of building that was done. Importing aggregates would not be cost-effective in a locality without exclusive boulders or stones. The sources of which sand and stone are procured have progressively run out in many urban regions, it steadily gets hard to come by good natural aggregates and mining is getting harder. Cement is not an environmentally friendly material, however, and is produced. When the estimate of fuel consumption is less than the rate of economic growth, these energy sources are regarded as CO2-neutral energy sources. Statistics on the generation of solid waste globally show that industrial byproducts have accumulated to a significant degree as a result of the rapid expansion of industrialization, growing energy security concerns and increased environmental awareness have increased the demand for renewable energy sources, which has resulted in a diversification of current energy production techniques. Biomass (organic plants and animals) is one of these resources and an optimistic root of renewable energy. A hydroelectric scheme that runs on biogas has low functioning costs and a steady supply of renewable fuel in the current trends of energy production. Because of ecological and financial concerns, these wastes necessitate actions for efficient reusing and application. Additionally, the world's natural sand reserves are running out because of the construction industry's overconsumption, which has lessened natural sand reserves and caused irreparable environmental damage [1]. Buildings made of clay brick are commonplace worldwide. There were a lot of structures made of clay bricks when China was first founded. Many structures eventually reached their design lifespan or developed flaws due to poor construction or the use of the wrong materials. Many nations are reusing clay brick wastes because of their high resource value in a variety of construction-related applications. Conserving energy, protecting the environment, and preserving nonrenewable natural resources are all part of the sustainable development concept. Crushed clay bricks must be investigated as a potential new civil engineering material due to the scantiness of landfill space and natural aggregates being pricey. Recycling and reusing waste are one way to conserve energy in contemporary society.

1.1 Brick dust

Brick dust, created by recycling and pulverizing unused brick or brick from demolished houses built of baked clay, was employed almost exclusively in the vast majority of evolved societies throughout time for building works. This is an ideal illustration of sustainability. Li et al., [2] decided to study the use of brick dust in making an eco-friendly mortar, they conducted a test by testing the durability properties such as attack using sulfate, drying shrinkage, and its resistance to water. The water to binder ratio was 0.40 to 0.55, when it was 0.45 or above the substitution by volume 5-20% with a difference of 5% and that of 0.4 w/b was 5-15% with the same difference, the subjected conclusion was that the sample that has brick dust has great resistance to sulfate attack as they show little or no spalling and cracking especially at 20%. The research shows that with a lesser amount of water, the rate of absorption was lower, in the case of drying shrinkage after observation for 90 days the conclusion is brick dust lessens during later days, and the samples shrinkage at a fast rate during the early stage, stating that the addition of brick dust slows down shrinkage in mortar. Zhao et al.,[3] conducted research to see how the pozzolanic properties of bricks are affected by the sizes of the particles, they explained from the SEM analysis that it is better not to mill the bricks for a very long period since this breaks down the pores and make the particle finer, which could, in turn, increases the surface area and takes a lot of time but it should be crushed to fine grains as this enhances the pozzolanic reaction and area of contact. In the study by Ma et al.,[4] using 7.5 %, 15%, and 30% brick dust as the replacement and an unvarying of 0.5 for water-cement, the research however adapted discrete grain sizes, obtained outcome exhibited that the broad surface area and irregular structure of brick dust cause an elevation in the demand of water, but the researchers noticed that with finer grains the brick dust led to a reduction in demand of water. This applies to the slump of the mix. The particle size above 18 microns started having a linear reduction, the high strength observed looking at both particle size and amount substituted showed that 15% brick dust and less than 12 µm was the material giving better results in the study. To keep the flow in the same range of 180± 10 mm Duan et al.,[5] had to keep increasing the amount of superplasticizer required for each substitution of 10, 20,30%, in terms of density the study discovered that by increasing the amount of clay brick dust the density reduced which is likely linked to the compactness, size, and hydration rate of RPs, which affect the microstructure of mortars. Mansoor et al., [6] assessed several properties of brick dust in concrete as a cement substitute ranging from 10-50% with a difference of 5% along with a 0.42 water binder ratio and 0.75% superplasticizer throughout. The fresh density result indicates that with a higher substitution amount the density decrease as it can be associated with the material the specific gravity for dry density, there was an increase at 10 and 15% which is by dint of the grain sizes filling the pores and because of the high surface area, it releases the water, as for the reduction it is the same reason as the fresh density. The result partaking to the compressive shows that 15% clay brick dust gave the highest strength and it can be because its particles filled the available voids in the sample and provided a dense structure. The ultrasonic pulse velocity of this test exhibited after 15% have a slightly lower velocity than the control mix.

1.2 Sawdust

Debris from the wood industry includes sawdust. It is made when timber is sheared into slabs at processing facilities situated in almost all major cities across the nation. Day after day, this procedure is done, producing mountains of sawdust at the end of each day. This industrial waste can be transformed into a beneficial by-product in several ways for example as aggregate replacement. A study on sawdust by replacing sawdust by volume for the fine aggregate of 5, 10, and 15% by Suliman et al., [7] the 5% sawdust gave a closer result to the control for compressive strength by 28 curing days, the addition of sawdust utmost decreases strength as the percentage increases. Batool et al., [8] experimented with sawdust from 10 to 60% with differences of 10 the analysis consist of checking the slump or workability, the strength of concrete containing sawdust, the microstructure, sulfate attack, and the density of hardened concrete, they found that from 10% to 60% substitution the workability reduces about 85% so to explain that as the sawdust increased slump reduces, as well the density of the concrete also reduced as sawdust increased this is to be associated to its specific gravity stating that the great reduction in its density cannot make it a lightweight concrete, as a dead load of structures will be reduced. In terms of compressive strength, the sample all had decreases in comparison to the control mix giving the reason to be due to high capacity of absorption and the porous nature of wood extractives during hydration. After curing for 56 days the tensile strength of the 10% mix showed about a 14% increase when matched to the reference mix saying in comparison to other materials in the SEM analysis the pores were filled which could be the rationale for the surge in strength. The weak bonding of sawdust grains and concrete material lead to several reductions in flexural strength as the replacement level increased. While the specimen was tested for compressive strength after the sulfate attack, they found the strength of control to have increased by 6.2% compared to when there was no attack, and the sample from 10 to 60% increased by 3.6, 5.2, 23.8, 28.7, 32.6, and 16.8 percent respectively this reason in accordance to the SEM analysis will be the filling of pores and cracks that occurred in the attribution of the ettringite developing. Ahmed et al., [9] checked the thermal conductivity, density, and strength of sawdust when it is substituted for lightweight aggregate and normal aggregate, the procured result reveal that the increment in sawdust drives a fall in compressive strength stating the reason can be associated with poor binding of sawdust to the other material and its initial free water being high. There was a decrease in density as sawdust increased but this could be a positive outcome as it reduces dead load and reduction in dead load is necessary to reduce earth tremor. The same decrease applies to the thermal conductivity result, it is because of its lightweight and porous disposition and this is good for buildings with low thermal insulation that could benefit from using materials that will increase their energy efficiency.

2. Aims and Significance of the study

The relevance of this exploration is exploratory and derived from the addition of sawdust and crushed clay brick to the concrete mix. Finding the impacts of sawdust and brick dust in conventional concrete is the prime objective of the study. Numerous researchers have already conducted studies on the utilization of waste products, each applied independently, in concrete. However, the study's main contribution is to demonstrate that recyclable materials sustainable concrete mixes are developed with brick dust (10% replacement with cement) and sawdust (5% replacement with Fine aggregate by volume) content. In this case, the concrete can be enhanced to generate recycled waste concrete mixtures with fresh and hardened physical properties like compressive and split tensile strengths, density, and ultrasonic pulse velocity (UPV) that are nearly equivalent to those of sustainable concretes, thereby optimizing the use of waste in the cement-based structure Research within this context shall assist in reducing the depletion of natural resources by the construction branch, and protecting the ecosystems for future centuries.

3. Material and method

3.1 General

By substituting distinct percentages of sawdust combined with brick dust at various percentages for a water binder ratio of 0.56, distinctive mix proportions were generated under the goals of this study. The prime purpose was to ascertain how sawdust and brick dust combined with w/b affected both physical as well as the mechanical quality of concrete. The following tests have been run for this purpose:

1) slump
2) compacting factor
3) fresh density
4) compressive strength test
5) splitting tensile strength test
6) dry density
7) ultrasonic pulse velocity

This chapter provides detailed data on the physical characteristics, chemical makeup, and other distinctive of the pozzolanic materials used in the analysis, as well as the characteristics of the main fundamental of the concrete (cement, sand, gravel, and water).

3.2 Material

The following sections define the materials that were used in this study's experiments: Binders, aggregate, and superplasticizers.

1) Cement

CEM III/A corresponding to TS EN 197-1 [10] was applied for this research, Cement grains range in size from 5 to 90 microns in mesh size. The cement is produced in Mersin 10, turkey.

2) Water

The mixing water was regular tap water with a pH balance between (6.5-7). All concrete mixtures and the curing process used a material that is free of acids, greases, and organic matter gotten from the research laboratory.

3) Fine aggregate

Fine aggregate is defined as any particle smaller than 4.75mm. the crushed fine aggregate was applied in this study. Following TS 706 EN12620+A1 [11], the sand was sieved to obtain the desired grain size distribution under control (sieve chart). the sand was utilized in a dry surface saturation state (SSD) to reduce the absorption of water during mixing.

4) Gravel

Crushed aggregate was adapted with nominal sizes of 10-20 (5.6 -22.4) mm was used as coarse, as per TS 706 EN12620+A1 [11] are revealed in Table 1.

Table 1. Properties of aggregate

Properties	Types of Aggregates	
	Fine Aggregate	Coarse Aggregate
Unit weight (kg/m^3)	1.64	1.50
Voids (%)	27.06	43.05
Apparent Density (kg/m^3)	2.85	2.61
absorption (%)	2.630	1.40
Moisture Content (%)	3.54	1.89
Specific gravity	2.84	2.59
Fineness modulus	2.92	4.34

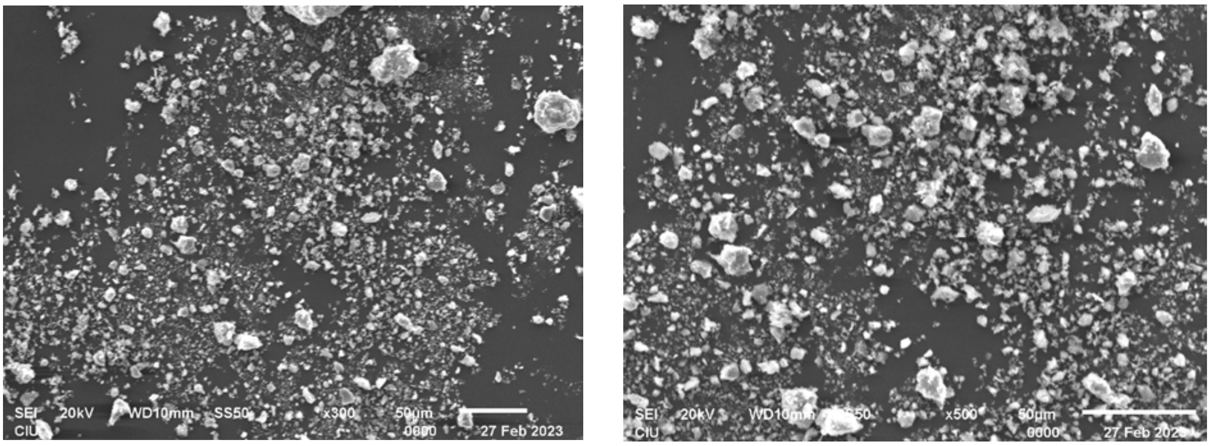
Source: TS EN 1097-Part 6

5) Ground Clay Brick

Clay brick is a material obtained from demolished mud buildings or bricks that is unable to be used for its original purpose, they are fired at about 700ºc to get its amorphous structure and apply it as SCM. The fire clay brick was gotten from the laboratory and has been pre-crushed, it was further grounded using the Los Angeles Machine to mill it with milling balls at 3000 revolutions to get finer particle sizes like cement grains of 75 µm size to achieve a matrix that is dense and void-free as much as possible. The Figure 1 below are the sem of brick dust at the fine state of 75 microns with different magnifications.

6) Sawdust

Timber is the source of sawdust. Sawdust is the result of sawing hardwood planks into different dimensions, which results in smaller, erratic shards or wooden fragments. It must have been completely dried outside and put in water-resistant packaging. Sawdust is sorted via a 0.500mm opening. The Figure 2 below are the SEM of saw dust passing through 0.500mm sieve with different magnifications. The constituents of cement, brick dust, and sawdust is displayed in Table 2.



a: SEM image of brick dust at 300 magnification magnifications

b: SEM image of brick dust at 500

Figure 1. SEM image of brick dust at different magnification

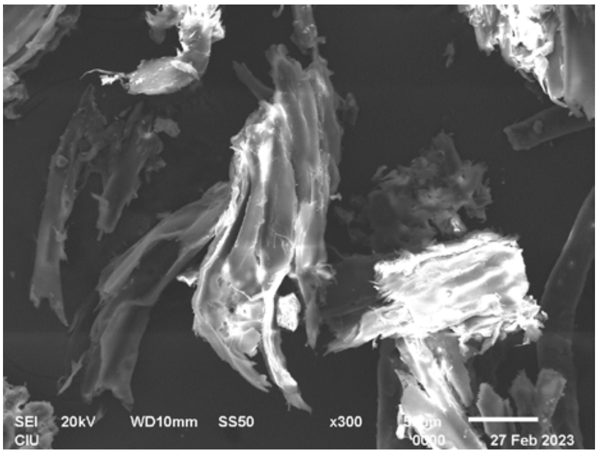
3.3 Mix design

Four mixes were created including the control mix the mix involving (5 % sawdust and 10% brick dust) as cement and fine aggregate replacement, the water-to-binder ratio was kept constant additional water was added for the mixes that have sawdust due to its high-water requirement rate. Table 3 shows the design of the mix. BRE mix calculation procedure is used to achieve the needed amount of material, after which calculation for needed waste material was made of it. Table 4 shows the mixed proportions.

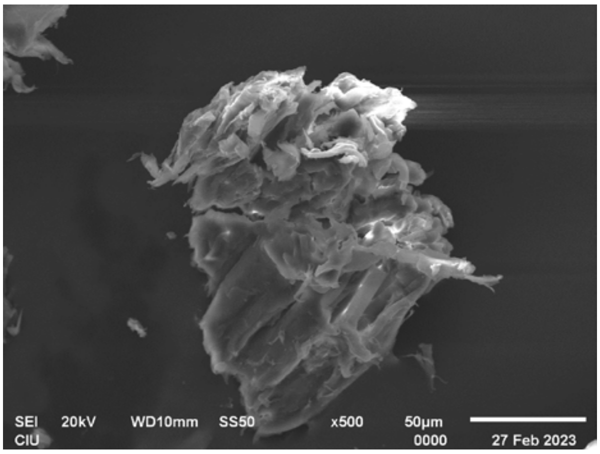
3.4 Test procedure

Four different percentages with 0.54 w/b were used to examine the outcomes of partially replacing cement with BD and SD. distinctive samples were created for the evaluations that were necessary for this and were carried out by BS 8500-1-2015+a2 [12] and BS EN 206 [13]. To learn the major consequence of sawdust and brick dust on the mechanical characteristics of the mortar, this study compares each percentage of replacement cement to specimens from the control group. All the hardened tests were carried out 7,14,21 and 28 days and all the cubes used for testing were 100 by 100 by 100 mm. Therefore, as reported by BS EN 12390-2 [14], the samples were arranged in water curing at 20–22 °C pending till the time of assessment.

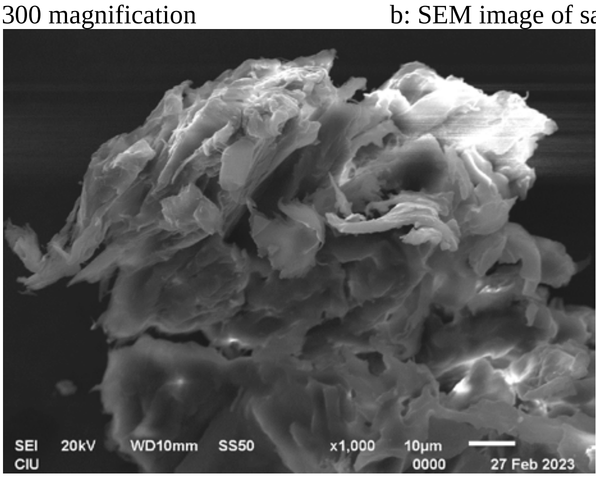
Characteristics of a fresh concrete mixture: Testing to gauge the concrete workability mixtures was conducted using slump [15] and compacting factor [16] as well as fresh density [17]. Illustration of equiplment used for sampling is shown in Figure 3 and Figure 4.



a: SEM image of sawdust at 300 magnification



b: SEM image of sawdust at 500 magnifications



c: SEM image of sawdust at 1000 magnification

Figure 2. SEM image of saw dust at different magnification

Table 2. A constituent of cement and mineral admixtures

Properties	cement	sawdust	Brick dust
Specific gravity (g/cm3)	3.15	1.47	2.58
Density (kg/m3)	2.87	325	1837
Water absorption (%)	-	98.9	4.7
Fineness modulus	-	2.17	3.18
Color	grey	Light brown	Brick red
Chemical Compound	cement	sawdust	Brick dust
CaO	49.64	9.8	23.80
SiO_2	31.43	67.9	41.60
Al_2O_3	6.31	5.1	13.24
Fe2O3	2.60	3.17	11.25
SO_3	2.87	0.41	1.116
K_2O	-	0.09	2.31
Na_2O	0.39	-	0.70
TiO_2	-	-	0.95
MgO	4.50	6.3	4.25
MnO	-	0.01	0.28
Cr_2O_3	-	-	0.08
LOSS ON IGNITION	1.56	-	-

Note: the composition of cement material in accordance with TS EN 197-1.

Table 3. Concrete mix description

Mix Name	Description
Control / CEM / Reference	100%CEM + 100%FA + 100%CA
BD10	90%CEM + 10% BD + 100%FA + 100%CA
SD5	100%CEM + 95%FA + 5%SD 100%CA
BD10SD5	90%CEM + 10%BD + 95%FA + 5% SD + 100%CA

Note: FA = fine aggregate; CA = coarse aggregate; BD = brick dust; CEM = cement; and SD= sawdust

Table 4. Mix proportion of concrete based on BRE mix design

Concrete type	Cement	Brick dust	Fine aggregate	Saw dust	Coarse aggregate	Water
Control Mix	375	-	817	-	998	210
10BD-90CEM	337.5	37.5	817	-	998	210
5SD- 95 FINE	375	-	794	23	998	233
10BD-5SD	337.5	37.5	794	23	998	233

Figure 3. Slump to test workability

Figure 4. Compacting factor testing

Concrete hardened characteristics were assessed using 100 by side cubes, and the split tensile strength was evaluated using BS EN 12390-6 [18] standards. The properties of hardened concrete applied for strength by compression is in conformance with BS EN 12390-3 [19] standards. Figure 5 and Figure 6 displays the samples under testing.

Figure 5. Cube strength by compression

Figure 6. Strength of cube by tension

Concrete density: Using a cube 100m3 properly calculated from the mass of a specimen as received in the light with BS EN 12390-7 [20], the density experiment method was applied.

Ultrasonic Pulse Velocity: the approach method is based on BS EN 12502-4 [21] using 100mm cubes. Figure 7 shows cube testing during pulse velocity.

Figure 7. Pulse velocity on concrete sample

4. Result analysis

The fresh density, index of compaction, and slump of concrete are reckoned with to assess the characteristics of freshly mixed concrete.

4.1 Slump

The measurement of slump indicated that the addition of the brick dust (BD) and sawdust (SD) lead to a decrease in the flowability, the associated case for the brick dust further in water requirement is the late reaction with CaOH that occurs after cement hydration, the same reaction was found in [6, 22]. In the case of sawdust, the water absorption is very high, surface and fiber nature which takes in a lot of water. [23] obtained similar results and noticed that with the addition of water, the lump increased, stating the chipping from wood loses its water content when it is saturated and is attributed to its sponge properties. The result of sawdust reducing the workability or slump was also found in research conducted by [24, 25]. The type used of crushed aggregate created more surface-to-volume tension which requires it to have more cement for coaptation in order to produce a more workable mixture. Mamaru [26] explained with finding that the crushed aggregate requires a more water-binder ratio to facilitate the particles. The two materials have quite a high level of absorbing water which led to a reduction in the slump that is requiring more water and reduces the compacting factor.

4.2 Compacting factor

Table 5 of this study shows the obtained result in relation to compacting factor and slump. The value of compacting factor ranged from 0.82 – 0.91 which is in alignment with [16] of 0.7 to 0.98 for the index, the compacting factor exhibit the workability of this research concrete to be applicable and acceptable. brick dust is found to cause increases in compacting factor (CF) and saw dust leads to reduction, this result of decreasing also indicates that more water is needed for workability. Saw dust demands a higher amount of water due to the high presence of silica in it [27, 28]. Figure 8 is the graphical representation of slump and compacting factor.

4.3 Fresh density

The Figure 9 displays the obtained result relating to the fresh density of the blends, as seen with the addition of debris substance the density starts to drop, in more observation the mixes that consist of sawdust provided very low densities.

Table 5. Result obtained for slump and compacting factor

mix ID	slump (mm)	Cf
M1	45	0.88
M2	35	0.91
M3	21	0.86
M4	20	0.82

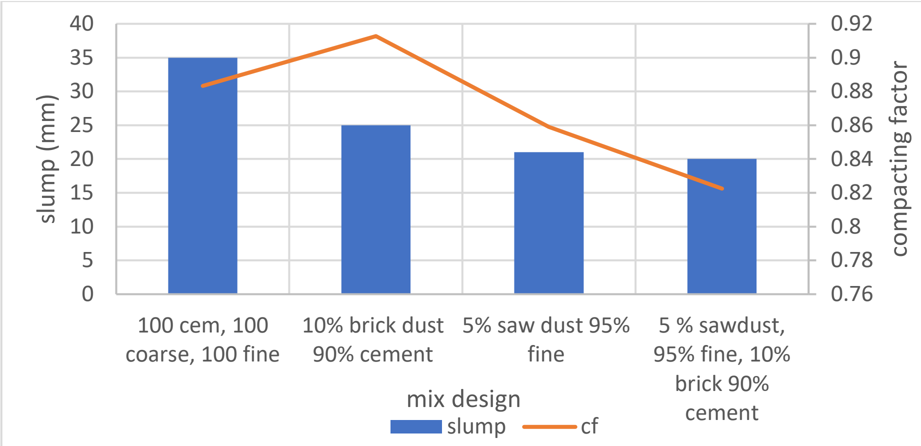


Figure 8. Graphical representation of slump and compacting factor

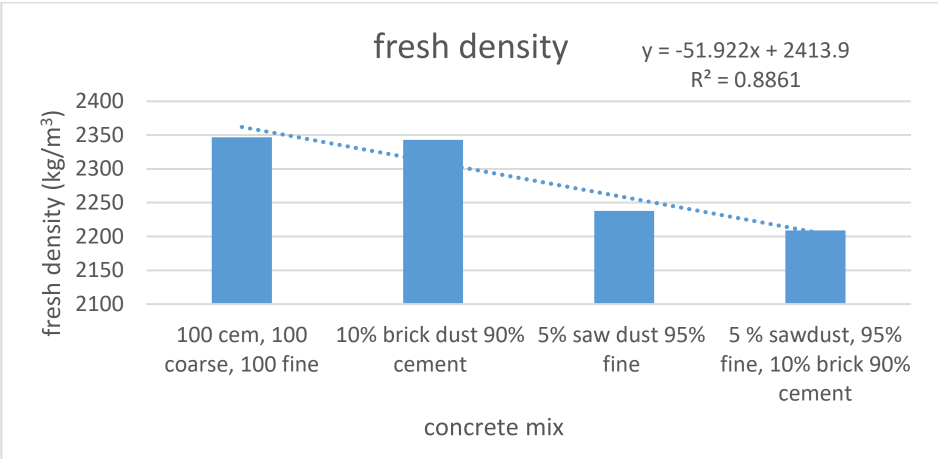


Figure 9. Fresh density of all concrete mix

Sawdust addition caused the concrete to be in the array of light concrete, the shaving from wood is a material that is potentially light in nature, in comparison to the other material used in this research bulk density of sawdust is about 325kg/m^3, another reason for the linear regression is because of the specific gravity of the waste materials that were used. There is a relative study that agrees that sawdust reduces the unit weight of fresh concrete [28] Siddique et al., [29] found a similar outcome stating one of the reasons is the water produced by sawdust creates air to fill the pores of the concrete. The density of brick dust material has a similar appliable reason as to sawdust, the density of brick dust is lower than that of cement, naturally leading to a decrease in its density this agrees with [6] The sample had a reduction of 0.16%, 4.65%, and 5.88% for BD10, SD5, AND BD10SD5 simultaneously in comparison to the reference, that's to show the waste material used for substitution based on their physical properties such as specific gravity, water absorption has an impact to reduce the concrete density when observed by comparing to tradition mixes.

4.4 Dry density

The density of the mixture ranged very differently from 7 days up to 28 days of testing, Figure 10 demonstrates that the addition of sawdust and clay brick dust reduces the density of the concrete which can be explained by the lightweight of both materials, the inclusion of this material based on the fineness would enhance the packing of the concrete, filling the voids and pores available.

At 28 days the BD10 increased by 0.85% and a reduction of 5.6% and 6.8% for SD5, and BD10SD5 respectively was observed by contrasting to the control mix. The cube consisting of sawdust by 5% showed increasing density with the passage of days and decreased after 28days, it went from 2220, 2212.5, 2250, and 2235, for 7,14,21, and 28 days respectively, the observation exhibit that the hygroscopic nature of sawdust can be the possible reason for this reduction in density, as well as the light nature, the heavy bulk density and specific gravity of crushed fine aggregate, allowed the concrete involving sawdust to remain in the range of normal concrete (2200-2800kg/m3). However, the finding is like some research findings [8, 9] The possibility of BD at a low percentage level to have slightly higher density in a hardened state has been found by some researchers [6] the reason for the slight increase in this study can be attributed to the fineness of the particles filling many pores structures in the concrete, this statement is synchronization with some prior studies [30, 31] BD10SD5 has increased unit weight when compared to SD5 and is lesser than BD10, this is the stabilization of both materials, the increase is because brick dust is heavier than sawdust as well as it already filled available pores in the concrete and sawdust brings down the weight of the material let go of the water it has absorbed. Figure 11, demonstration of fresh and hardened density in the primary and secondary axis

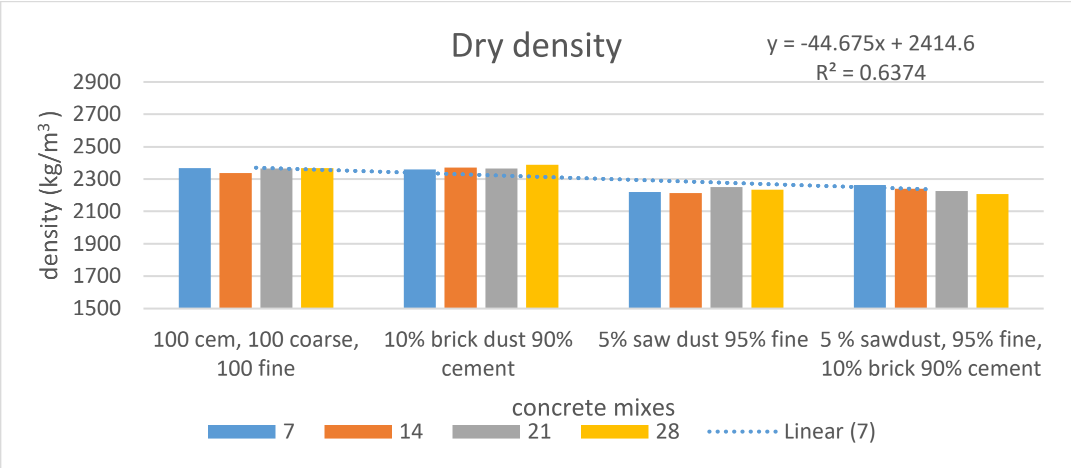


Figure 10. Representation of dry concrete density

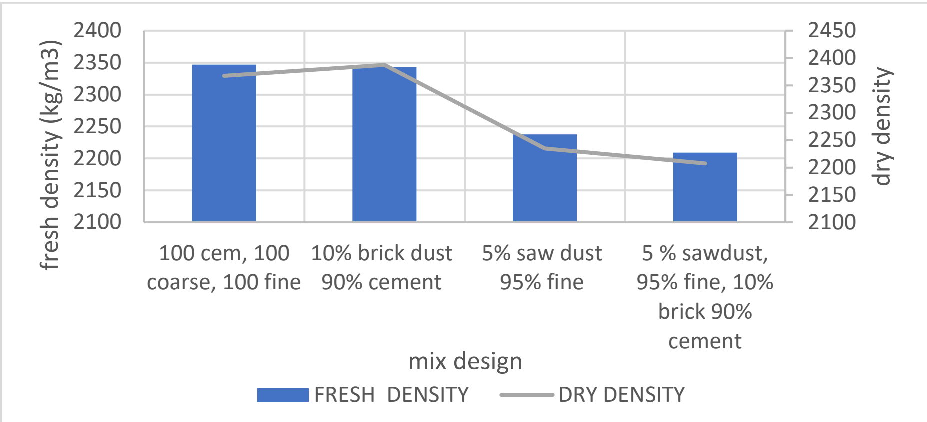


Figure 11. Demonstration of fresh and hardened density in the primary and secondary axis

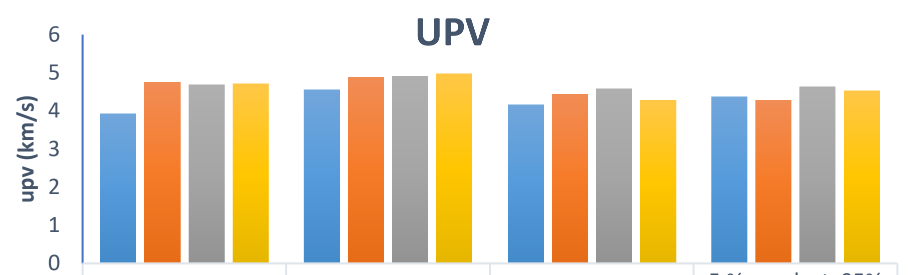
4.5 Ultrasonic pulse velocity (UPV)

Generally, the ideology of UPV is related to the elasticity and properties or attributes of concrete material. The velocity of the different samples obtained is shown in the Figure 12 below, it is evident that the specimen having brick dust slightly increases even above the control, and the BD10SD5 sample has decreased because of the involvement of sawdust in it. The velocity of this research was placed under quality distribution using classification by Neville in 1995 [32] given in Table 6, the categorization of the samples into places of good and excellent, all testing days for BD10 samples falls into the excellent category, in 7 days the reference mix was labeled good after which it is excellent for 14, 21 and 28 days, almost all SD5 specimen were considered to be in good condition but it had a slight increase and was taken to be excellent at day 21 and fell back to be in condition, while the sample of BD10SD5 was considered good in day 7 and 14 and taken as excellent in day 21 and 28 respectively.

Table 6. Neville table of UPV categorization [32]

Quality of concrete	Value range of UPV (km/s)
Excellent	> 4.5
Good	3.5 – 4.5
Doubtful	3.0 – 3.5
Poor	2.0 – 3.0
Very Poor	< 2.0

Note: adapted from “Properties of Concrete”, by Neville AM, 1995 Longman Group Limited. Harlow Essex, England, 346-350.



	100 cem, 100 coarse, 100 fine	10% brick dust 90% cement	5% saw dust 95% fine	5 % sawdust, 95% fine, 10% brick 90% cement
7	3.923	4.557	4.1615	4.3765
14	4.7555	4.8775	4.434	4.2825
21	4.6895	4.9135	4.5765	4.6295
28	4.7065	4.975	4.273	4.5245

Figure 12. Ultrasonic pulse velocity values.

BD 10 samples over the curing days continue to increase similar outcome was found by Al-kroom et al., [33]. The SD5 samples increased up to 28days its value being lesser than the others is attributed to the negative impact that the density and microstructure get due to the porous attribute of sawdust, when checked with control the UPV of sawdust dropped over the days of curing, this can be correlated with the density and porosity, as seen in the figure the UPV is equality as affected as the density, some studies[7], [34], [35] this reduction is similar with Bourzik et al., [36] explaining that cavities become present in the mix with the addition of sawdust which in turn decreases density and thereby causes Acoustic immittance also lessen wave reading.

4.6 Compressive strength

The average strength obtained on 7, 14, 21, and 28 for every mixture is shown in the Figure 13, The cubes were subjected to water curing for an interval of 7 to 28 days with two cubes of 100 by 100 by 100 for each day of test on compression. The addition of brick dust and sawdust certainly showed an increase overall, although the sawdust being a feather-weight like material has caused quite a noticeable impact on the compressive strength. Amongst all make cubes the samples containing brick dust have elevated the strength to a certain degree, the sample of 10% brick dust as an alternative to cement showed the greatest strength of all, following the control mix, the mix of 10BD and 5 SD as replacement of fine aggregate and finally the sample with 5SD displaying the lowest strength. The indication of results shows that with the passage of time, the strength of each concrete continues to increase. From the start of 7 days till 28 days, the sample of BD10 outperformed every other cube in regards to strength gotten by compression, it is understood that the properties of brick dust as a pozzolanic material are very. Similarly in physical form after sawdust concrete is made and compacted or vibrated little forms or bubbles are noticeable, this could be seen that when sawdust produces or release water it allows air entrainment for this created fresh mix concrete which potentially causes weakness in strength.

The control mix increased 65.5% at 14 days, 29.07% at 21 days in comparison to 14 days, and 23.83% at 28 days compared to 21 days. the BD10 was checked for the difference for each result after every week of test and it increased 49.38%, 32.04%, and 2.76% compare to the last time it was tested, this was also applied for SD5 AND BD10SD5 where the increase of SD from 7- 28 days strength with 7 days interval sows 67.90%, 29.96% and 8.60% increase with BD10SD5 Having 64.10%, 17.97%, and 9.43% increase simultaneously. The control mix increased by about 165%, 59.8%, and 24% from 7,14, 21 days to 28days, BD10 increased by 26.7% than the control mix on day 28, SD decreased by 29.6%, and BD10SD5 increased by 6.94% at 28days when collated to the control mix, evidently, from the list and graph all of the samples continue to increase in strength as the curing days go on, the reactivity of brick dust as a pozzolanic material is has been discern to be late, the can be due to its larger area of surface and thus when these particles react during curing and hydrate can lead to increase in strength, the pores structures that have been filled by the fineness of BD could potentially lead to stronger bond of concrete improving the achieved strength, researchers [33, 37] agrees with the statement about increase of strength when brick dust is used, results showed by Ortega et al., [38] although the prototype were cured for a very long period about 400 days, the strength continue to increase and even at 400 days the sample named BP10 had higher strength than CEM I. the bonding of concrete with the involvement of wood chipping is weakened this weakness might be due to higher porosity as sawdust releases its absorbed water and most pores are filled with air in the concrete, the study find similarly that this result were obtained in other research, [34, 39], Raheem and Ige [40] discovered that with passing of days the strength of SD concrete can increases but possibly with higher rate of substitution(> 15%) the strength decreases, he stated the reason of increasing strength to be associated to the steady hydration of cement.

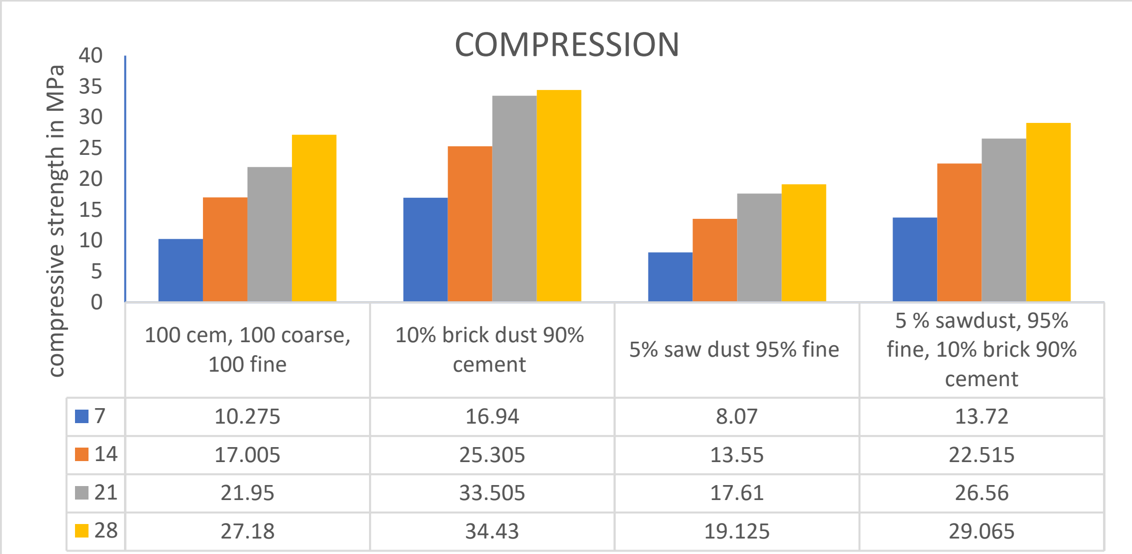


Figure 13. values of compressive strength for all concrete mix

4.7 Association linking pulse velocity & Compressive Strength

The relation of compressive strength with pulse velocity was established by 28 days result, the linear relationship between them was good, given that the correlation coefficient $R^2 = 0.8481$ and R-value using the Karl Pearson formula too is 0.9209. it is best to say the compressive strength result variation can be liable for with linear relation of 85% to Ultrasonic pulse velocity. Figure 14 displays the variation of how the pulse velocity could possibly impact the concrete compressive strength.

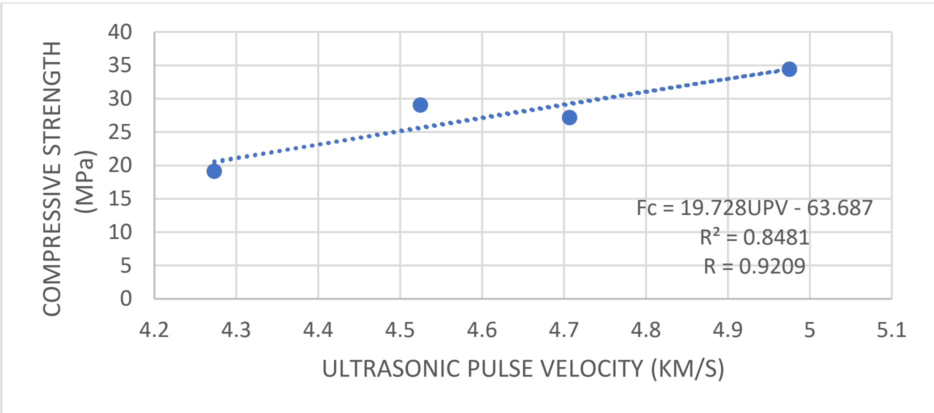


Figure 14. Connection of Ultrasonic pulse velocity and compressive strength at 28days

4.8 Relationship between Compressive Strength & Density

The mechanical qualities of a concrete masonry unit are directly impacted by its dry unit weight, demonstrating the significance of mechanical performance with unit weight. Analyses of the details acquired are shown in Figure. For formulations from which the behavior of dry density can be extrapolated, a polynomial regression equation is displayed. The trend line indicates a positive slope, and the polynomial correlation coefficient for R^2 was determined to be 0.992. R^2 is 0.3374 linearly, as well. In compliance with the outcome gotten from assessment, compressive strength and density of concrete have a direct relationship. The relation is outlined in Figure 15. The linear relation of materials density to compression is relatively low exhibiting that the impact of density on the strength is not the only effect.

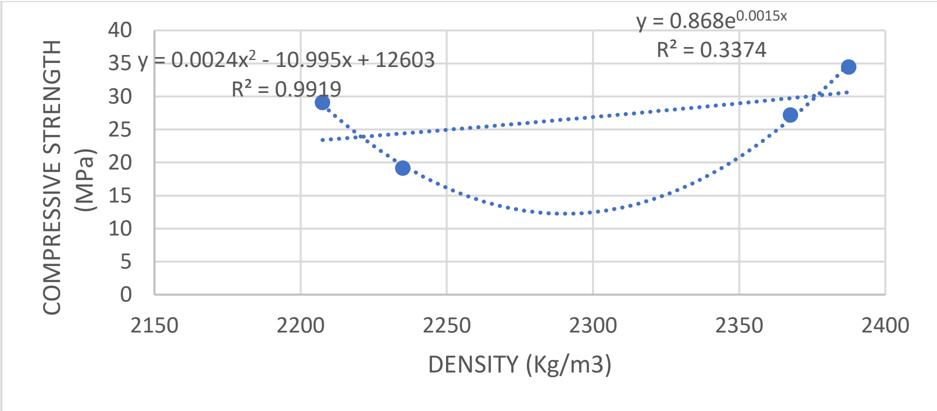
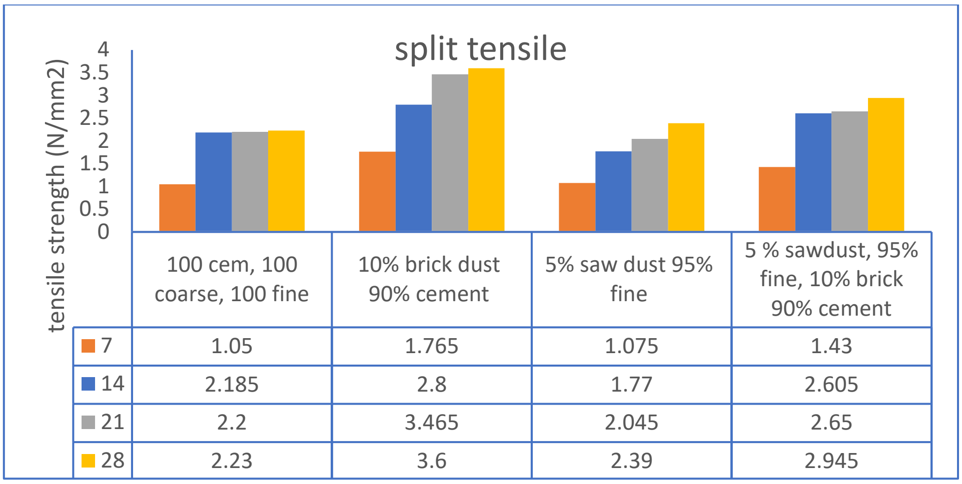


Figure 15. relationship of dry density and compressive strength.

4.9 Split tensile strength

The average of two specimens for tensile splitting test results of thirty-two concrete mixes of different contents with constant water-binder ratios is exposed in Figure. In all mixes, the highest value achieved for the splitting test was BD10 after curing for 21 days, while at 28 days all compounds had improved strength of splitting even higher than the control mix. Figure 16 displays the outcome.



	100 cem, 100 coarse, 100 fine	10% brick dust 90% cement	5% saw dust 95% fine	5 % sawdust, 95% fine, 10% brick 90% cement
7	1.05	1.765	1.075	1.43
14	2.185	2.8	1.77	2.605
21	2.2	3.465	2.045	2.65
28	2.23	3.6	2.39	2.945

Figure 16. Splitting tensile strength value for concrete mix

The sample of reference sawdust exhibited the strength that is corresponding to the reference mix, at the age of 28 when the specimen was tried out noticeable differences from the concrete shows that there was an increase of 61.4%, 7.2%, and 32.1% from BD10, SD5, and BD10SD5 respectively, BD10 AND BD10SD5 increased by 57.5 and 20.45% on 21 days equally while SD5 decreased 7.05%, understandably from the chart and table of figure the strength of sawdust continually increased and exceeded that of control at 28days. Due to the sawdust's poor adhesion to paste and the microstructural quality of the concrete being inferior, the split tensile strength of concrete decreased when it was used in place of sand. Because of the sawdust, the cementitious matrix had heterogeneous discontinuities and the transition zone is feeble [9]. As was previously mentioned, fractures begin to appear soon in the loading process because there is a weak connection amongst the sawdust bits and concrete mixtures. All of these elements together lead to a reduction in tensile splitting strength. The heterogeneous inconsistency of the composite material with the weakened transition zone grows as sawdust there is sawdust and thus affects the strength. Result of similar was found in research [29] The uprise in concrete tensile splitting strength with BD10 in contrast to reference concrete at every time of curing is owing to the formerly clarified surge in the brick powder pozzolana response at longer curing periods. The aggregate's angular form and the presence of pozzolans from BDW, which produce a high C-S-H gel after hydration, may be relevant for the increased tensile strength that was found. A similar finding for increases in split tensile strength agrees with Khan et al., [41].

5. Conclusions and recommendation

5.1 Conclusions

The presented work will be concluded by giving the following:

1) Generally, the compressive strength continues to increase, the optimum obtained strength on 28days for admixture cubes turns out 27.18MPa,34.43MPa, 19.13MPa, 29.07MPa for control, BD10, SD5, BD10SD5 simultaneously, the concrete was designed for grade 30MPa all material falls in the category of close to the strength expect SD5 which has produced significantly low strength

2) The workability or slump of the concrete declines with the inclusion of both materials, especially the sawdust due to its high-water absorption level, this projected its effect on the compacting factor indicating the level of compactness of each concrete mix.

3) In the fresh state of density there was a slight decrease in BD10 and a largely noticeable difference for SD5 and BD10SD5 but in relation, the cause of this reduction is highly due to their specific gravity, and naturally, sawdust is light in weight.

4) Dry density state, the BD10 shows slightly higher than the reference mix this is because the material has settled and filled existing pores in the concrete, the reason sawdust decrease is like its fresh state as specific gravity is way lower than the fine aggregate. For the cross-sectional dimensions of structural components and the imposed loads to reduce, it is desired for dry density to decline.

5) The good and exceptional quality concrete mix was created using an ultrasonic pulse velocity (UPV) method utilizing sawdust and brick dust at a ratio of 5% by volume of fine aggregate to 10% by weight of cement and control mix. With a compressive strength and determination correlation coefficient (R2) of UPV of 0.8481, the series has the most dependable compatibility. As a result, it is possible to conclude that the material influences the link between compressive strength for long-term curing days.

6) When compared to sawdust and the reference mix, the addition of brick dust shows a rise in the splitting tensile strength. The information at hand appears to support the idea that BD may be partly responsible for these kinds of increases. BD addition to concrete would typically control a greater pozzolanic response at prolonged curing times.

7) In producing precast concrete with low load-bearing capacity the use of sawdust and brick dust is applicable such as concrete pavement, tiling, hollow concrete, and even flooring.

8) Considering the categorization of BS8110-1997 the strength of SD5 causes the concrete to be used as reinforced lightweight concrete, but due to its high absorption of water, it will be preferable for internal use.

9) The addition of creating SD5 can be used in the production of floor panels [42, 43] in a partition of the wall, loading bearing for light stocks such as poultry. To use these materials with sawdust included it is recommended that the external use has a surface covering of more impervious material

10) Sample of brick dust, depending on the content or amount of clay brick dust in the concrete mixture it is feasible to produce structuring that has high load-bearing capacity such as masonry.

11) Overall use of both materials in concrete can be used for places such as sandwich panels, and internal parts of the building, especially in environments prone to earthquakes as it reduces the weight of the structure.

Although both materials have good advantages such as sawdust for its thermal insulation as a light material and brick dust for fire resistance as it tends to hold in a high fire to break down its structure, the research has a certain limitation when it comes to the use of brick dust and sawdust for making a concrete, Brick dust trash is frequently mixed with other byproducts from building and excavation, including concrete, plastics, wires, steel, and wood, making extraction complicated and time-consuming. Using a piece of large crusher equipment to process bricks into fine dust produces a lot of pollution and carbon dioxide (CO2) that has an adverse effect on the environment. Sawdust is a material that can expand in an environment with moisture, the type of wood used, and the weather condition of the place it is applied to. But in terms of this study, BD10SD5 material has shown a close comparison to the control which will make it a good recommendation, as it will cut down on the emission of CO_2 and cost of production.

5.2 Recommendation

Based on this assessment, concrete with a brick dust percent of 10% by mass cement and sawdust ratio of 5% by volume of fine aggregate, was made and few properties were investigated.

Further research can be carried out on the long-time curing of concrete with both materials incorporated and checked for its durability properties, reinforcement should be considered as well to analyze and have better knowledge of this material in growing a sustainable environment and construction materials. The use of treated sawdust can be applied with brick dust to explore the differences.

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