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The Effects of Sweet Potato Peel Ash and Egg Shell Powder as Partial Replacement of Cement in Concrete Production

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ABSTRACT

This study aimed at the possibility of using eggshell powder (ESP) and sweet potato peel ash (SPPA) in place of some of the conventional cement while making concrete. The search for substitutes for conventional cement that are more ecologically friendly is becoming more and more important as the market for sustainable building materials grows. The physical, mechanical, and durability characteristics of concrete mixtures including ESP and SPPA will be the main emphasis of this study. A comprehensive investigation was conducted to determine the present level of understanding on the utilization of agricultural waste products in concrete. The aim of this research was to compare the cost-effectiveness and availability of these wastes, as well as to examine the impact of these wastes on concrete and the characteristic strength of concrete that is made partially from egg shell powder and sweet potato peel ash instead of cement. The samples were then subjected to laboratory tests including the split tensile strength test, flexural strength test, compressive strength test, slump test, and X-ray fluorescence test. The influence of SPPA and ESP on the setting time and workability of the concrete mixtures was also examined. The SPPA and ESP were both divided into 1:1 ratio and evenly split into the concrete. They samples were all divided into different percentages of 0, 5, 10, 15 and 20%. Curing was also done for 7, 14, 28 and 56 days respectively for all the percentages of samples. According to the experiment, 20% replacement had the lowest compressive strength over the course of the entire curing age, while 5% replacement had the highest value at each curing age. In terms of cost, availability of these wastes, and mechanical strength, it would be profitable to use 5% of SPPA and ESP in lieu of cement. The results of this study may help develop sustainable building methods and provide a fresh approach to the advantageous application of agricultural byproducts in the building sector.

Keywords: *Effect, Sweep Potato Peel Ash, Egg Shell Powder, Partial Replacement, Cement, Concrete Production*

INTRODUCTION

Concrete is one of the top used materials in construction industry today which consists mainly of cement and water acting as binder, aggregate acting as filler. Concrete is considered to be top used material because of it offers qualities such as durability, workability, low cost, compressive strength. Concrete has also played a role in human development such as education, providing shelter, transportation, health centers, industry etc. The first issue is the emission of carbon dioxide (CO_2) during the cement production process, which has led to a significant environmental difficulty after cement was produced so quickly. The atmosphere has changed significantly due to the extremely harmful CO_2 emissions. One tone of regular Portland is created, roughly speaking, and one ton of carbon dioxide is discharged into the atmosphere. Given that cement cannot be completely replaced by any other building material (Anand and Tharunkumar, 2019).

Cement that has been consumed worldwide produces carbon dioxide (CO_2) gas which is harmful to the environment and reduces the greenhouse gases and have been an issue of global warming (Aryal 2023). Clinker is created during the cement production process by heating the cement to extremely high temperatures. This causes a significant quantity of carbon to be released into the atmosphere, which has led to issues with climate change and the environment. Since cement in concrete cannot be fully replaced by any other building ingredient. The search for any alternative material that can complement or replace cement will ultimately result in sustainable growth and have an impact on the environment and climate change. Such as fly ash, bamboo leaves, maize cobs, sugarcane bagasse, plantain peel ash, rice husk ash, plantain peel ash, egg shell powder, granulated blast furnace slag, and sweet potato peel ash, kaolin, and basically any waste containing silica are some of the pozzolanic materials which can be used as replacement for cement in concrete production (Singh and Lalotra 2023). The manufacturing of concrete would not be possible without cement, and the production of 1000 grams of cement releases 90 grams of carbon dioxide (CO_2) into the atmosphere together with sulfur and nitrogen oxides, accounting for approximately 7% of all CO_2 emissions worldwide. For this reason, it's crucial to mix in other comparable materials with concrete. Additionally, waste resources have been the subject of investigation recently due to recycling and reusing these materials; many of these wastes end up in open fields where they spread infectious diseases into the atmosphere and environment.

Egg shell waste is trash that can be dangerous since it contains organic materials like worms and rodents found in various places like houses, farms, bakeries, eateries, factories since it is used for daily consumption. This egg shell's chemical makeup can be changed to limestone, a filler used in cement and concrete that is composed of 4% organic matter, 1% calcium phosphate ($Ca_3(PO_4))_2$, 1% magnesium carbonate ($MgCO_3$), and 94% calcium carbonate ($CaCO_3$) (Paruthi *et al.*, 2023). Tensile, compressive, and flexural strengths will all be improved by substituting these wastes for cement, which will speed up the hydration process and provide early strengths. Egg shell powder was introduced in 1999 as a calcium source for calcium phosphate integration; nevertheless, there hasn't been much research done on how egg shell powder and sweet potato peel ash affect the typical strength and characteristics of concrete. Waste is used to create sustainable building for a sustainable environment (Paruthi *et al.*, 2023).

Sweet potato peel waste causes much damage in terms of environmental pollution, cost loss and getting a solution for the environment is important and there is aim to utilize this waste on industrial application which construction industry is not left out in terms of concrete production (Gebrechristos and Chen, 2018). As per the "Food and Agricultural Organization of the United

Nations," the world produced 376 million metric tonnes of potatoes in 2021. It is projected that by 2030, over 8000 kilotons of potato peel trash might be produced, resulting in 5 million tonnes of CO_2 equivalent in greenhouse gas emissions (Khanal *et al.*, 2023). However, there hasn't been any investigation into the viability of using the ash from sweet potato peels in place of certain cement. The impact of sweet potato peel ash and egg shell powder as a partial cement substitute in the making of concrete will be thoroughly investigated as part of this project's research.

MATERIALS AND METHODS

The materials and procedures used for the research are described in depth in this chapter. It also entails modifying the methodologies used in earlier studies that are comparable to current one. This chapter examines the procedures and examinations carried out to ascertain the mechanical and chemical characteristics of potato peel ash and egg shell powder when they were utilized in place of some cement in the manufacturing of concrete. This chapter contains all information regarding all what has been done on this research including materials, mix proportioning, and test technique and processes.

Materials

To design the research project, the following resources were used:

1. Sweet Potato peel ash
2. Egg shell powder
3. Coarse aggregate
4. Fine aggregate
5. Ordinary Portland cement
6. Portable water

There is also information of the materials' suppliers, the tests done on their characteristics, and the technique of use.

Methods

The picture below depicts the methodologies that were employed for the study and include material characterization, testing of cubes, cylinders, and beam specimens, and different mix proportions in relation to the mix design outcomes.

Sweet Potato Peel Ash (SPPA)

Potato peel ash is a waste product generated from food processing industries and households. It contains high amounts of silica and alumina, which are known to possess pozzolanic properties. When this research was conducted, sweet potato peel was retrieved from various vendors in Landmark University cafeteria as shown in Plate 3.1. To eliminate all moisture from the sweet potato peel, it was thoroughly sundried for about 4-7 days. After drying in the sun, SPP was thoroughly calcinated in a furnace at 700°C and converted to ash form. The SPPA was cooled and sieved through 75 micrometers sieve to produce a fine particle size compatible with that of cement.

Sweet potato peel

Egg Shell Powder

Eggshell powder as shown in plate 3.2 is a by-product from the food industry that is rich in calcium carbonate. It has been found to exhibit pozzolanic properties when finely grounded and activated. When this research was conducted, eggshells were retrieved from the Landmark University cafeteria. The eggshells were thoroughly washed and sundried to remove dust and other organic characteristics. The eggshells were sundried for about 4-7 days. After drying in the sun, the eggshells were thoroughly in the blender to convert them to powder form. The eggshell powder was dried for 24 hours in a 105°C oven to remove any moisture that had gathered during the cleaning process. The eggshell powder was sieved through 75 micrometers sieve to produce fine particles compatible with that of cement.

Eggshell

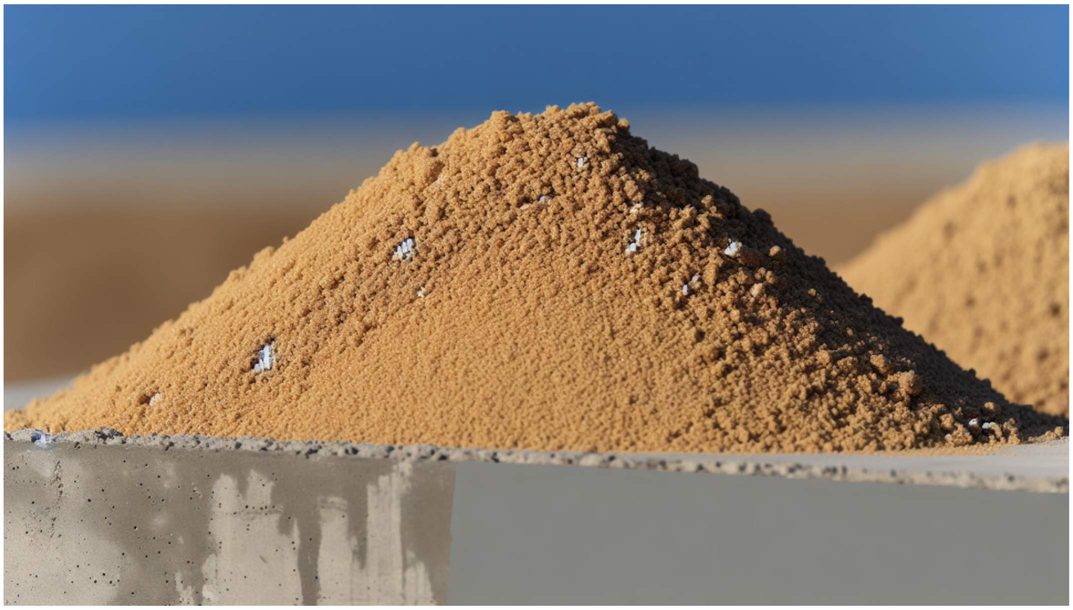
Coarse aggregate

Larger granular materials are coarse aggregates, as plate 3.3 illustrates. shattered bricks, shattered stones, gravel, and pebbles make up the coarse aggregates, which are larger-size filler materials used in construction. The aggregates that were utilized had no coatings, alkali, organic debris, or contaminants that could have decreased the concrete's strength. In order to facilitate an ideal bond with the binding agent, the aggregates utilized were elongated and did not possess a loose bulk.

Coarse Aggregate

Fine aggregates

Natural sand devoid of any organic materials or saline contaminants was utilized as the fine aggregates displayed in plate 3.4. For the purpose of producing mortar and concrete, the size of the fine aggregates utilized was established. Local rivers served as the source of the fine aggregate.



Fine Aggregate (Sand)

Cement

The type of cement that is most commonly used in this region of the world is ordinary Portland cement, which is a fundamental component of mortar, grout, and concrete, as plates 3.5 illustrate. A minimum compressive strength at various curing ages was specified for the cement, in accordance with conventional practice. The cement utilized was regular Portland cement, stored in 50-kilogram sacks for regional usage. Away from the wall and the ground, the cement bags were stored in airtight conditions to prevent moisture buildup. Brands of Dangote cement 42.3R were utilized, and they adhere to NIS 444-1:2003.

Cement

Water

Water mixed with cementitious materials forms a cement paste which binds other materials such as aggregates which forms the concrete. The cement and aggregates hydrate more quickly as a result of it. It was odorless, tasteless, and colorless water that was used for casting that was portable. All contaminants that could change the concrete's strength, durability, or setting time were absent from the water.

Concrete Mix Proportion

The mix ratio used consisted of fine aggregate, coarse aggregate, cement, ESP, and SPPA which the replacement materials were added in specific proportions in a combined manner as shown in plate 3.6. The application of both SPPA and ESP was such that both SSPA and ESP replaced cement in 5%, 10%, 15% and 20%. A concrete grade M15 at 1:2:4 mix was employed with a w/c ratio at 0.5.

Mix Proportion of Materials

Table *Showing the mix proportion*

Mix name	Percent mix	SPPA (%)	ESP (%)	Cement (%)	FA (%)	CA (%)
M1	0%	0.00	0.00	100	100	100
M2	5%	2.5	2.5	95	100	100
M3	10%	5	5	90	100	100
M4	15%	7.5	7.5	85	100	100
M5	20%	10	10	80	100	100

This table shows how the materials used were properly proportioned for all the strength test.

Procedure and Casting

The materials were weighed and batched during the course of the experiment. The cement was mixed with the fine aggregates in addition with the coarse aggregates until the mixture is thoroughly blended and is of uniform color. The mixture was spread over the batch equally as the egg shell powder and sweet potato peel ash was also distributed through the batches equally. The appropriate amount of water was also added until the concrete looks homogeneous and consistent. The concrete was also cast in molds in proper method to prevent honeycombs or segregation. The molds were immersed into water for 7, 14, 28 and 56 days.

XRF (X-ray fluorescence)

The principles of quantum chemistry and atomic physics underpin this approach as shown in plate 3.7. The whole spectrum of photons, which included primary beams released from a typical X-ray tube, was exposed to the samples. These irradiation samples produce distinct X-ray spectra in addition to secondary fluorescence in the elements they contain. The emission machines' energies and intensities were ascertained using the observing system. It is composed of two parts: a personal computer for processing and controlling data, and a primary channel simultaneous wavelength dispersive spectrometer. A pre-positioned (analyzing) crystal is used by the fast detection system to surround the sample. They result in a scattering of the secondary radiation's wavelength. In a gas mass flow detector, the intensity of a single wavelength is monitored. This apparatus permits the simultaneous measurement of up to ten elements at peak and background points. The analyzer received the output signals from the detector and stored the photon counts in the computer memory. By comparing each element's count rate to a standard with a precisely determined composition, the count rate of each element was calibrated. The spectral line energies of the emission lines' wavelengths were utilized in a quantitative examination of the sample element. For quantitative investigation, the intensities of the released lines were correlated with their concentrations.

The XRF Technology Procedure

1. Crushing each sample in an electric crusher, followed by pulverization in a Herzog Gyro-mill (Simatic C7-621) for 60 seconds.
2. The pulverized sample was first ground into pellets by pulverizing 20g of each sample for 60 seconds with 0.4g of stearic acid. To prevent contamination, the Gyro-mill was cleaned after every grinding.
3. As a binding agent, 1g of stearic acid was weighed into an aluminum cup, which was then filled with the sample until it reached the level point.
4. The cup was then transferred through Herzong pelletizing apparatus, where it was subjected to a pressure of 200 KN for 60 seconds.
5. The x-ray apparatus (Phillips PW-1800) sample holder was filled with the 2 mm pellets for examination.

XRF Test

Slump Test

The consistency of the batch of concrete was measured using the concrete slump test to observe how it flows as illustrated in plate 3.8. It required numerous trials to determine whether the concrete was adequate for use in this test. It was also applied to identify mix problems. The test was performed in compliance with ASTM C192/C192M (2006) and BS EN 12350-2 (2009).

Slump Test Procedure

1. A cone with a height of 300 mm serves as the mold for the concrete slump test. This cone has a base diameter of 200 mm and a top diameter of 100 mm.
2. The concrete mix was poured into the mold in three equal levels.
3. A tamping rod was used to uniformly tamp each layer twenty-five times.
4. To avoid any movement during the pouring process, the mold was securely pressed up against the foundation.

5. A trowel was used to remove the extra concrete and level it.
6. A gradual vertical lift of the mold was performed from the concrete.
7. After setting the cone up next to the concrete's height and covering it with the tamping rod, the slump was measured.
8. A steel ruler was used to measure the portion of the remaining concrete that was still standing.

Experiments Carried Out

The slump test, compressive strength test, flexural strength test, and split tensile test were the experiments done to see how egg shell powder and potato peel ash would behave when used in part place of cement.

Compressive Strength Test

An understanding of all the properties of concrete can be gained from the concrete cube test's compressive strength as shown in plate 3.9. The capacity of a material to support loads that cause the material or structural element to shrink is known as its compressive strength. The sample was compressed until it started to take on shape. The concrete cubes were crushed at 7, 14, 28, and 56 days of curing time, respectively, using a compressive testing equipment. Cubes of 150 mm by 150 mm by 150 mm were utilized and evaluated in a 2000 KN capacity compression machine, with stress applied at a rate of 10 N/s. The obtained values were used for the necessary computations after the concrete samples were totally cured for 56 days. The test was carried out in accordance with BS EN 12390-3:2009.

Compressive strength (Cu) given in N/mm^2 or MPa =

$$\frac{Force\ reading\ which\ will\ be\ obtained\ from\ the\ machine\ (KN) \times 1000}{Net\ area\ of\ the\ concrete\ cube\ (mm^2)}$$

Apparatus

- **Compression testing machine**: This is an essential apparatus used to determine the compressive strength of materials, especially concrete and other construction materials. The machine applies axial loads to test specimens in a controlled and gradual manner and to access their ability to withstand compression forces without failing or deforming.

Procedures

• After the designated curing period, the concrete was taken out of the water and any extra water was wiped off.

• The cubes of concrete were set on top of the center's compressive testing apparatus.

• The cubes were properly positioned on the machine's base plate.

• After the machine was turned on, the load was gradually applied without shock at a constant rate of 15N/mm2/minute until the specimen failed. The specimen and the spherical seated plate were carefully aligned.

• The compressive strength was determined by using the maximum load that was recorded at the time the concrete failed.

Importance of Compressive Strength

Concrete's compressive strength is its primary characteristic. This is due to the reaction that occurs between the cement and the aggregates, as well as the water that acts as a binder for both components. This reaction has a significant effect on the functionality of the finished project.

Compressive test

Flexural strength test

This test was done to determine the concrete's tensile strength indirectly as shown in plate 3.10. The flexural strength test was able to evaluate the beams' resistance to bending failure in this test, which involved casting the beams. Specific dimensions of 400mm × 100mm × 400mm beams were employed. Prior to the flexural test, they had been cured for 7, 14, 28, and 56 days, respectively. To test these, a load will be applied throughout the span until any failure occurs. Documentation shall include the kind of failure, how it showed up, the fracture stress, and the samples' flexural strength.

$$flexural\ strength\ will\ be\ given\ in\ N/mm^2 = \frac{3 \times Maximum\ loading\ that\ will\ be\ obtained\ from\ the\ machine\ (N) \times length\ of\ the\ beam}{2 \times breadth\ of\ the\ beam \times depth\ of\ beam^2}$$

Apparatus

- **Compression testing machine**: This is an essential apparatus used to determine the compressive strength of materials, especially concrete and other construction materials. The machine applies axial loads to test specimens in a controlled and gradual manner and to access their ability to withstand compression forces without failing or deforming.

Procedures

•The dimension 400 x 100 x 400 mm concrete mixtures were poured into beam molds and allowed to cure.

• After being cleaned to get rid of extra water and particles, the concrete samples were allowed to cure for the proper number of days.

• The loading block was brought into contact with the specimen's center of surface at the third point, after the sample to be examined had been centered on the support block (supported on two points).

• After that, the load was applied steadily, without shock, and at a pace that raised the tension face's stress between 0.9 and 1.2 MPa/min until the rupture.

Keep in mind that the formula was used to determine the loading.;

$$r = \frac{Sbd^2}{L}$$

Where;

$r = loading\ rate, N/min$

$S = rate\ of\ increase\ in\ maximum\ stress\ on\ the\ tension\ face, MPa/min$

$b = average\ width\ of\ the\ specimen, mm$

$d = average\ depth\ of\ specimen, mm$

$L = span\ length, mm$

- The flexural strength was calculated using the formula;

$$R = \frac{PL}{bd^2}$$

Where;

$R = modulus\ of\ rupture\ (flexural\ strength)$

$P = maximum\ load\ applied\ as\ indicated\ by\ the\ testing\ machine, N$

$L = span\ length, mm$

$b = width\ of\ the\ specimen, mm$

$d = depth\ of\ specimen, mm$

Flexural test

Split Tensile Strength Test

This test was designed to determine the hardened concrete's tensile strength as illustrated in plate 3.11. Changes in the water to cement ratio, component proportioning, and slump rise all had an impact on the needed concrete strength and, consequently, the structural stability and strength. The tensile strength of the concrete is determined using a cylinder that has been split across the vertical diameter. The average value was established following the examination of a sizable number of samples.

$$Splitting\ tensile\ strength\ of\ concrete = {}^{2P}/_{\pi LD}$$

Apparatus

- **Compression testing machine**: A crucial tool for figuring out a material's compressive strength, particularly that of concrete and other building materials, is a compression testing machine. With a controlled and gradual approach, the machine applies axial loads to test specimens to determine their capacity to bear compression pressures without breaking down or deforming.

Procedure

- To determine the concrete's dimension and to make sure both ends were in the same axial position, diametric lines were drawn on the concrete with a marker.
- On a metal bar strip that was held in place by the lower plate, the concrete was applied.
- The top plate was lowered to make contact with the metal bar strip, and the other metal strip was placed above the specimen.
- End lines were positioned such that they were vertical and centered above the bottom plate.
- The concrete was loaded by the testing apparatus using a hydraulic system at a failure rate of 15N/sec.
- A record of the maximum load applied that caused the breakdown was made. Both the type of failure and the fracture's appearance were noted.

RESULTS AND DISCUSSION

The importance and validity of every research work is practically based on the results and discussion gotten. The results from all these experiment on the mechanical properties of concrete such as compressive strength, flexural strength and split tensile strength are brought forward here alongside with the workability of the fresh concrete. Other test were carried out on the waste material which is XRF test.

Chemical composition of SPPA and ESP

According to ASTM C-618 (2005), the total amount of AL_2O_3, SiO_2, and Fe_2O_3 of a supplemwntary material should not ≥ 70%. The chemical composition was done by using XRF techniques.

Chemical Composition for SPPA

S/N	OXIDE	PERCENTAGE
1.	Al_2O_3	2.74
2.	SiO_2	75.65
3.	Fe_2O_3	1.50
		TOTAL= 79.89

Chemical composition of ESP

S/N	OXIDE	PERCENTAGE
1.	Al_2O_3	0.35
2.	SiO_2	0.76
3.	Fe_2O_3	0.52
		TOTAL=1.63

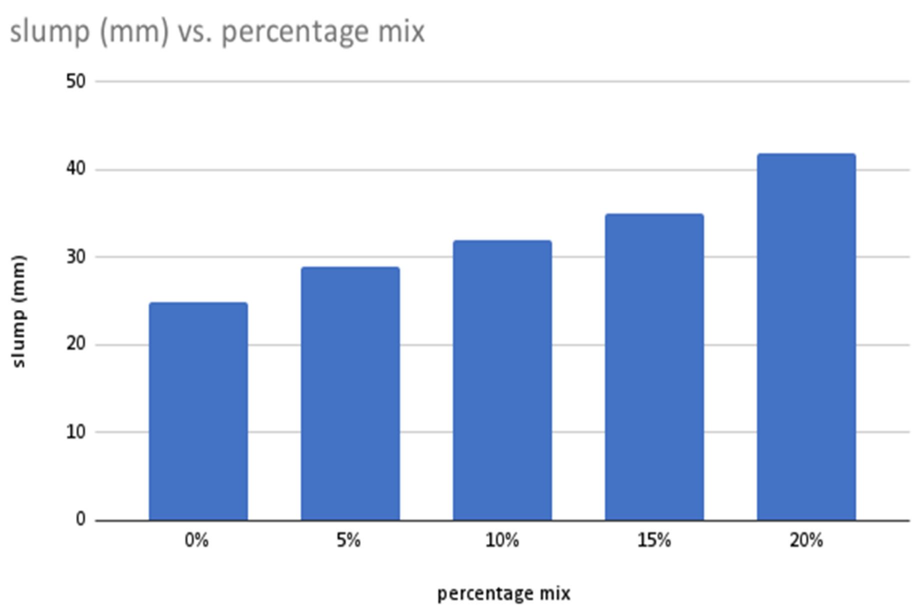
As shown in table 4.1 and table 4.2 , the total amount of chemical composition of SPPA met and passed the required standard of ASTM C-618 (2005) which was 79.89% and showed that is a good pozzolana material specued in the code of practice. But for ESP didn't meet up the expected requirement in the code of practice which was 1.166% as shown in table 4.2, which makes it not pozzolanic.

Slump Test

As seen in the table 4.3 and Figure 4.1 below, the slump value at 0% was 25, at 5% was 29, at 10% was 32, at 15% was 35 and at 20% was 42 which was the lowest. It was observed that the addition of SPPA and ESP was responsible of the increase of slump value, which made it more workable as the percentage mix increased.

Table 4.3: slump result

PERCENTAGE (%)	SLUMP (mm)
0%	29
5%	25
10%	23
15%	20
20%	15



Slump graph for all percentage samples

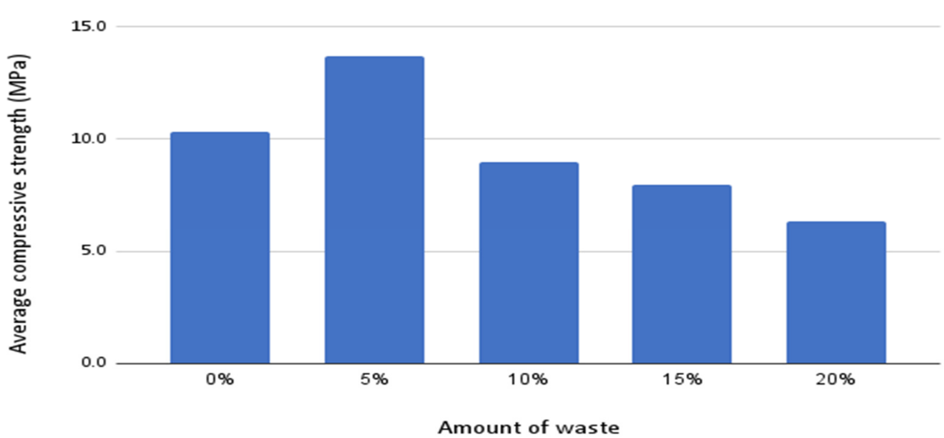
Compressive Strength Test

The compressive strength of concrete was analysed at every curing age of 7 days, 14days, 28days, and 56days after casting properly using a cube specimen of 150mm ×150mm×150mm for all percentage mixture 0%, 5%, 10%, 15%, 20% respectively. All samples were subjected to a load till it failures using the digital automated compressive machine in which the maximum load at failure was recorded in megapascal. As shown in table 4.4, the average strength of all samples for each days and the comparison of all curing age as shown in Figure 6.

Average strength across all curing age

PERECENTAGE MIX	7 DAYS (MPa)	14DAYS (MPa)	28DAYS (MPa)	56DAYS (MPa)
0%	10.33	18.33	19.00	19.12
5%	13.67	19.00	22.00	22.10
10%	9.00	17.00	18.00	18.17
15%	8.00	15.00	16.00	16.07
20%	6.33	13.00	13.67	13.77

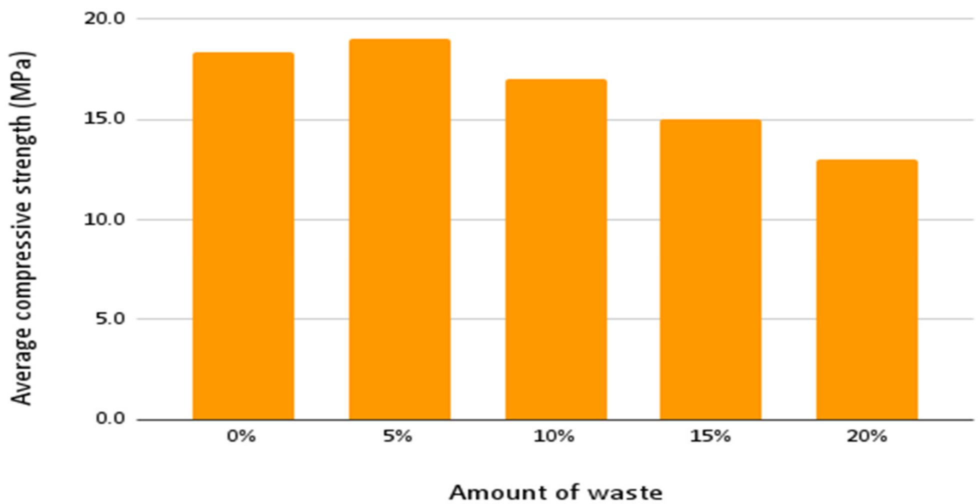
Comparing the concrete with 0% i.e no replacement for cement, it was observed that the compressive strength increased only by 5% at 13.67MPa, using the 7days curing age shown in Figure 4.2. And after the 5% increase, the strength reduced from 10% having 9.00MPa to 15% having 8.00MPa, then to 20% at 6.33MPa all in a decreasing other after the increase at 5%.



7days Compressive Strength Result

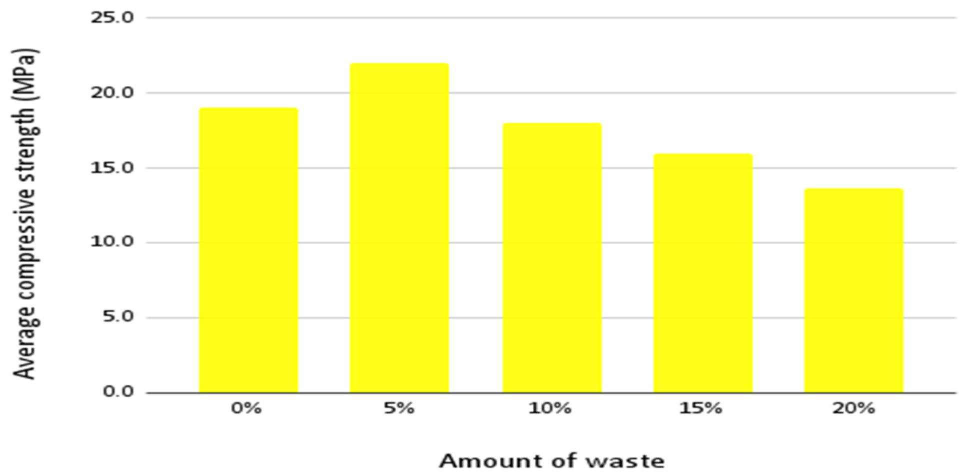
At 14days of the cubes, it was evaluated and observed that the strength at 5% addition of SPPA and ESP increased by 3.7% at

19MPa, and then at 10% addition reduced by 7%, at 15% reduced by 22.2%, at 20% the strength reduced drastically by 44% shown in Figure 4.3 .



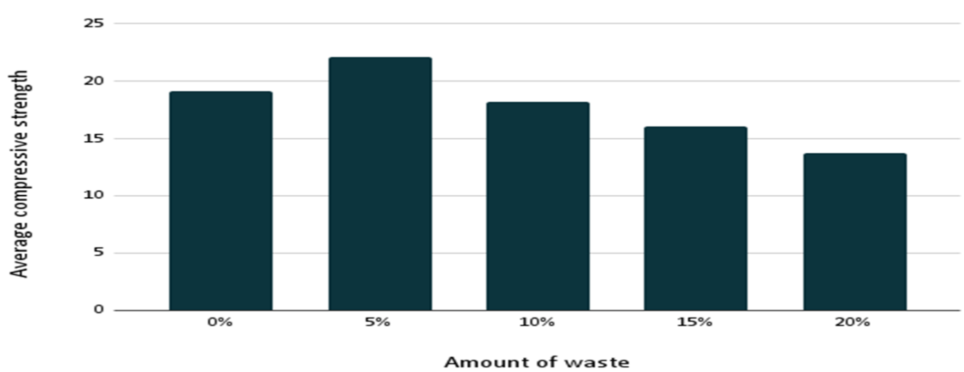
14days Compressive Strength Result

After 28 days curing age shown in Figure 4.4, it was detected and recorded that there was only an increment in the compressive strength after 5% replacement of cement using the SPPA and ESP by an increase of 13.6%, at 10% replacement there was a decrease by 5.5%, at 15% replacement of cement it decreased to 18.75% compare to the standard concrete, at 20% addition it decreased by 38.99%.



28days Compressive Strength Result

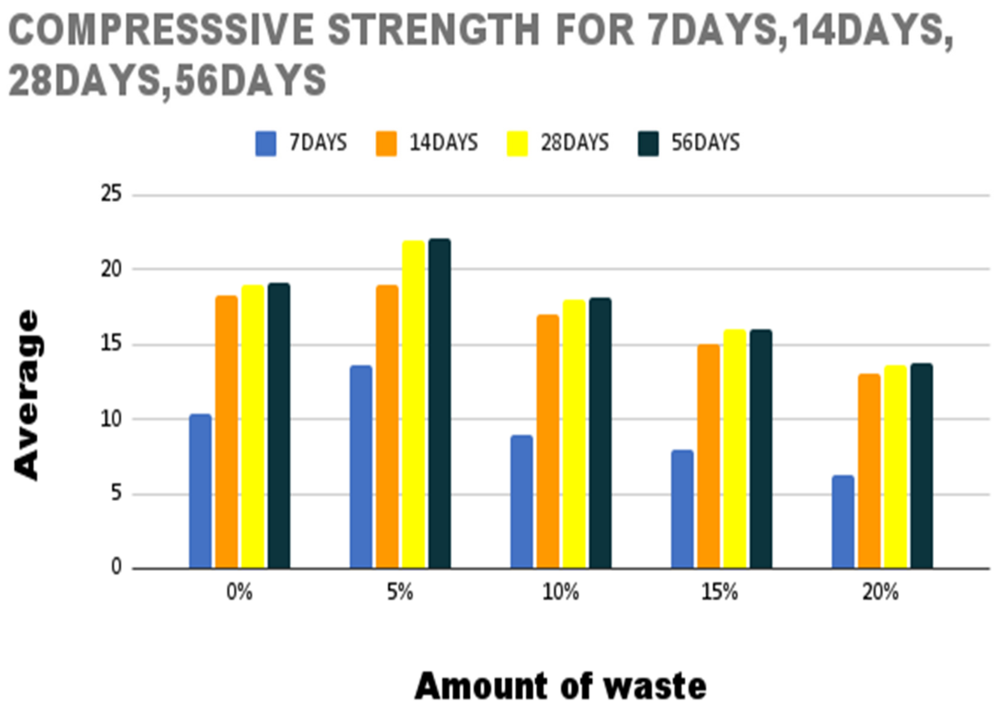
At 56days, no significant increase at 0% and 5% between 28days and 56days, the strength followed the same pattern as shown below in Figure 4.5.



56days compressive strength result

As seen in Figure 4.6 below, comparing 7 days, 14 days, 28 days and 56 days curing age, it was observed that all compressive strength across 5% replacement of each curing days increased only and exceeded the standard strength for M15 ratio 1:2:4 and started decreasing from 10% replacement to 20% replacement, i.e the compressive strength of each curing age was decreasimg as SPPA and ESP was increasing from 10% upwards . It was also observed that the highest differences betwwen these curing ages was between 7 days and 14 days compare to 14days and 28days. The highest significant strength was recorded at 28days at 22MPa. It was also observed that the strength between 28days and 56days was slightly the same which means that concrete reaches its maximum strength at 28days usually between 95% but the strength increased at 56days than 28days when 5% of SPPA ESP was added. Therefore, this shows that SPPA and ESP has some cementitious properties and can be applied in concrete without reducing the compressive strength pronouncedly.

This means that the longer the curing age the stronger the compressive strength. At 5%, the longer the cuirng age, the stronger the strength. At 10%, 15%, 20% of replacement with SPPA and ESP, the lesser the strength. i.e, as it goes on from 7 days to 14days to 28days to 56days the strength of the concrete reduces and become smaller as the curing age becomes longer.



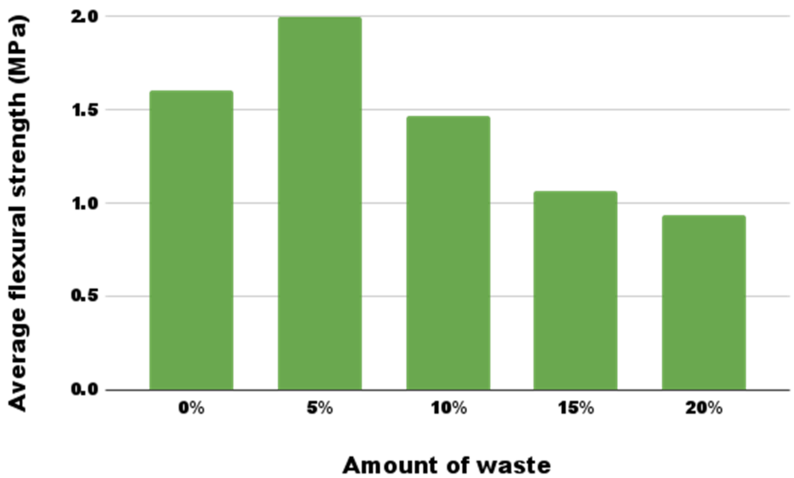
Comparison of 7days, 14days, 28days and 56days

Flexural Strength Test

The flexural strength test was analysed for 7days, 14days, 28days and 56days as follows;

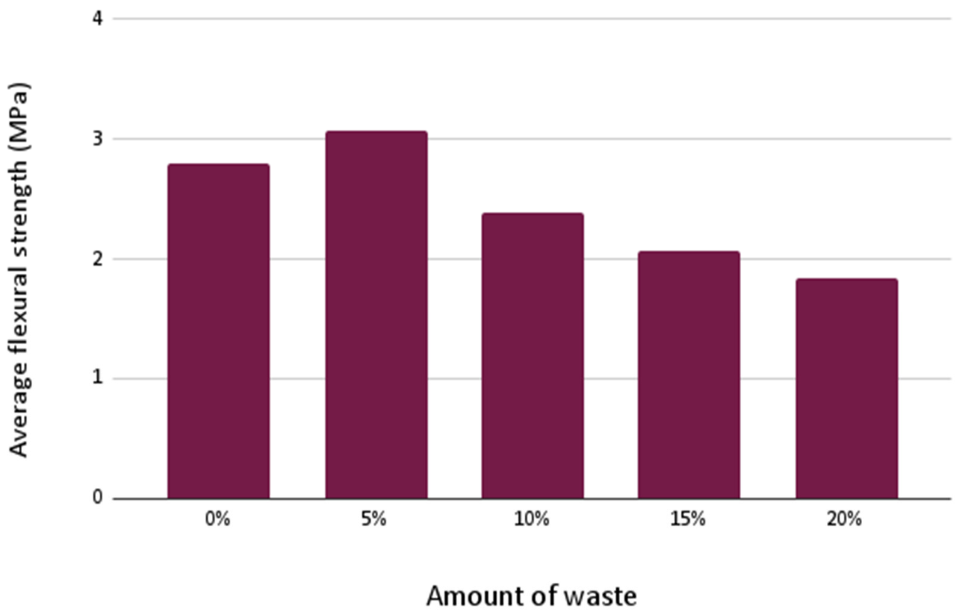
Average flexural strength for all curing age

PERECENTAGE MIX	7DAYS (MPa)	14DAYS (MPa)	28DAYS (MPa)	56DAYS (MPa)
0%	1.6	2.80	3.20	3.33
5%	2	3.07	3.60	3.87
10%	1.47	2.39	2.60	2.81
15%	1.07	2.07	2.35	2.52
20%	0.93	1.84	1.97	2.00



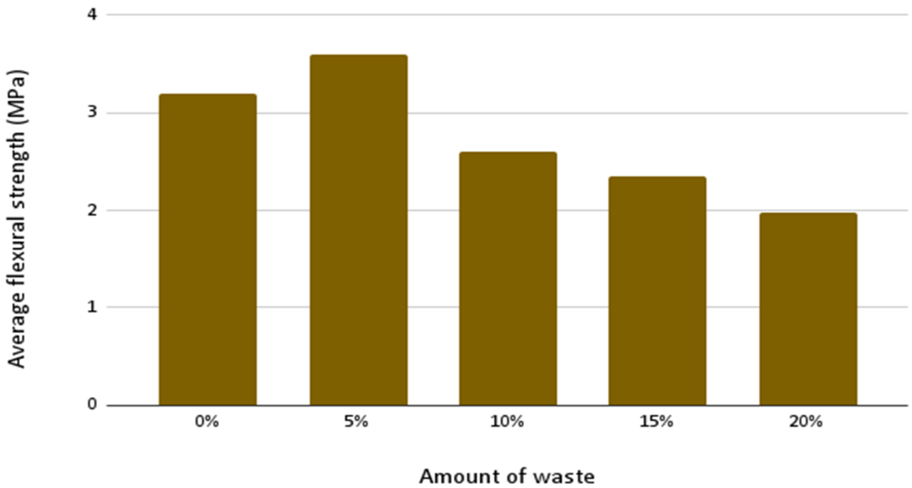
7days flexural strength result

Based on the data given above, also shown in Figure 4.7, the average flexural strength of concrete was analysed and following a pattern decreasing from 10% to 20% but only increased at 5% replacement of cement with SPPA and ESP. The results obtained at 0% was 1.6MPa and at 5% 2MPa. However, it can be clearly stated that the significant increase at 7days curing age was 5% replacement and that as a results of the presence of SPPA and ESP but above 5% the flexural strength reduced drastically.



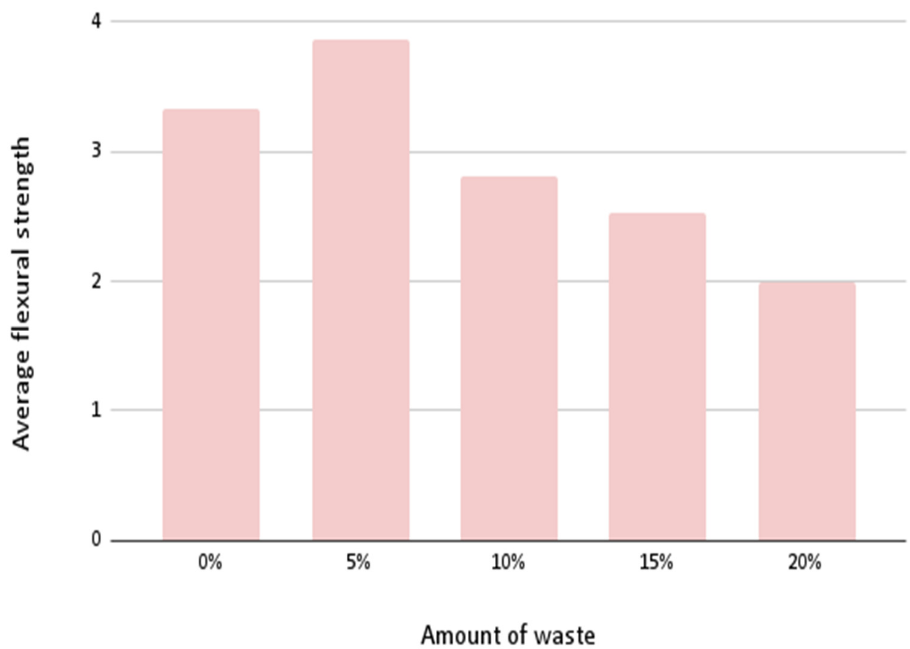
14days Flexural Strength Result

The flexural strength was carried out at 14days and the results given showed at Figure 4.8 above that at 0% it was 2.8MPa, at 5% it was 3.07MPa, at 10% it was 2.39MPa, at 15% it was 2.07MPa, and at 20% replacement it was 1.84MPa, the increase rate between the 0% of replacement and 5% was 8.8%. Hence it can be seen at fig.4.7 that the highest value of the strength is at 5% replacement.



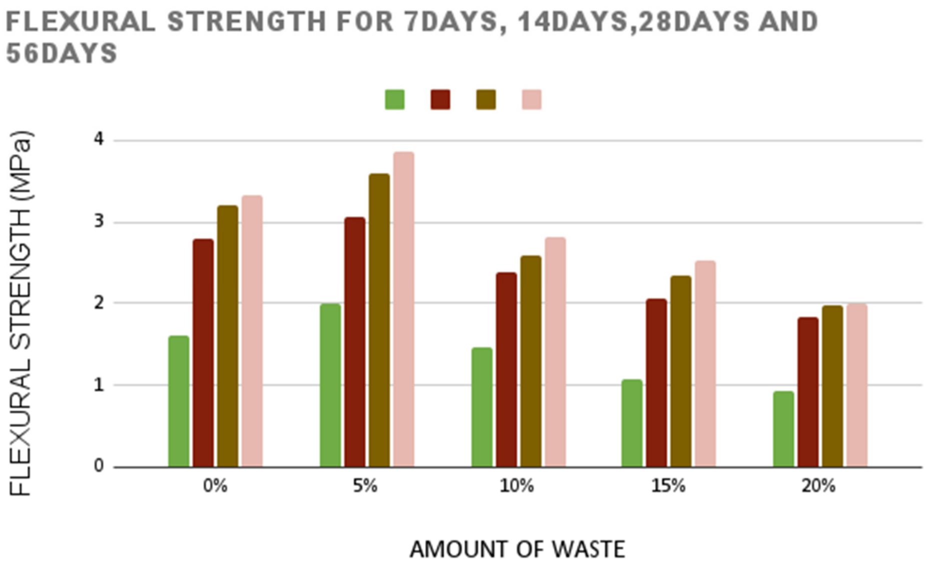
Flexural strength result for 28days

At 28days which had the highest increase in strength as shown above in Figure 4.9, the average flexural strength amongst all the percentage replacement was 5% having the value of strength of 3.6MPa. 0% had a value of 3.2MPa , 10% had a value of 2.6MPa , 15% had a decreasing value of 2.35MPa and 20% had a decreasing value of 1.97MPa which was the least value amongst all. This shows that 5% increased by 11.11% compared to 0% of replacement of cement with SPPA and ESP.



56days flexural strength result

The 56days strength for 0% had a value of 3.33MPa, as the percentage increases to 5%, the value increased to 3.87MPa due to the addition of SPPA and ESP which icreased the flexural strength of the concrete shown in Figure 4.10 above. However, as the percentage continues to increase from 10% to 20%, the values dcreases respectively indicating a degradation of the strength.



Comparison of flexural strength for all curing age.

The flexural strength increased only at 5% replacement of each curing age, exceeding the standard strength for M15 ratio 1:2:4, and then started to decrease from 10% replacement to 20% replacement, as can be seen in Figure 4.11 above, which compares curing ages of 7 days, 14 days, 28 days, and 56 days. This means that the flexural strength of each curing age decreased as SPPA and ESP increased from 10% upwards. Additionally, it was noted that, in comparison to 14 and 28 days, the biggest variations in these curing ages occurred between 7 and 14. At 3.87 MPa for 56 days, the maximum meaningful strength was measured. Consequently, this demonstrates that ESP and SPPA have certain cementitious qualities and may be added to concrete without lowering the flexural strength. This implies that the flexural strength increases with increasing curing age. At 5%, the strength increases with the length of the cuirng age and shows that it has a better resistance to deformation under bending forces.

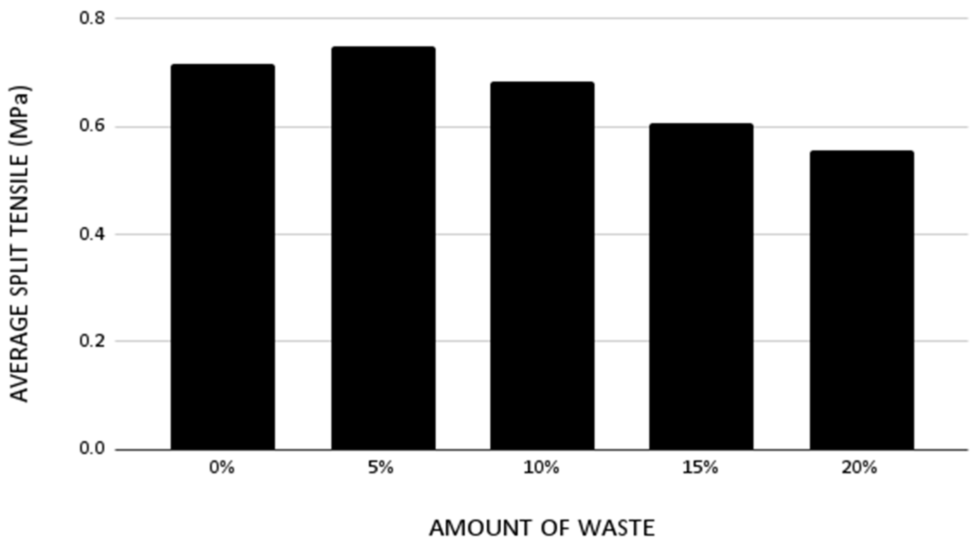
Split Tensile Strength

The split tensile strength of concrete was measured at 7, 14, 28, and 56 days after appropriate casting and for all percentage mixtures of 0%, 5%, 10%, 15%, and 20%, respectively. Using a digital automated compressive machine, all samples were loaded until they failed, with the maximum load at failure being recorded in megapascals. The average results are tabulated below in table 4.6 below.

Average split tensile strength for all curing age

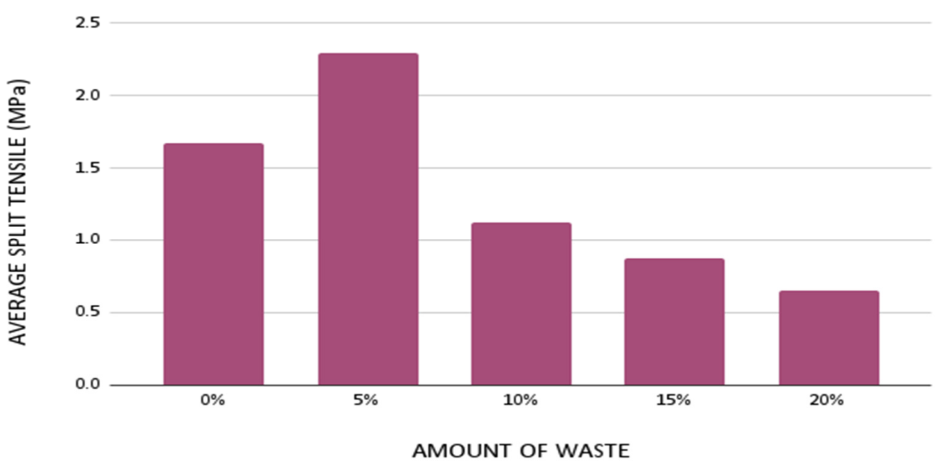
PERECENTAGE MIX	7DAYS (MPa)	14DAYS (MPa)	28DAYS (MPa)	56DAYS (MPa)
0%	0.72	1.67	1.83	1.91
5%	0.75	2.29	2.28	2.32
10%	0.68	1.13	1.19	1.32
15%	0.61	0.88	0.79	0.99
20%	0.56	0.65	0.67	0.75

At 7days curing age, the split tensile strength at 0% was 0.72MPa which then increased to 0.75MPA at 5% but started decreasing at 10% with a value of 0.68MPa, at 15% decreased with a value of 0.61MPa and at 20% which had the least value of 0.56MPa as shown in Figure 4.12.



7days split tensile strength

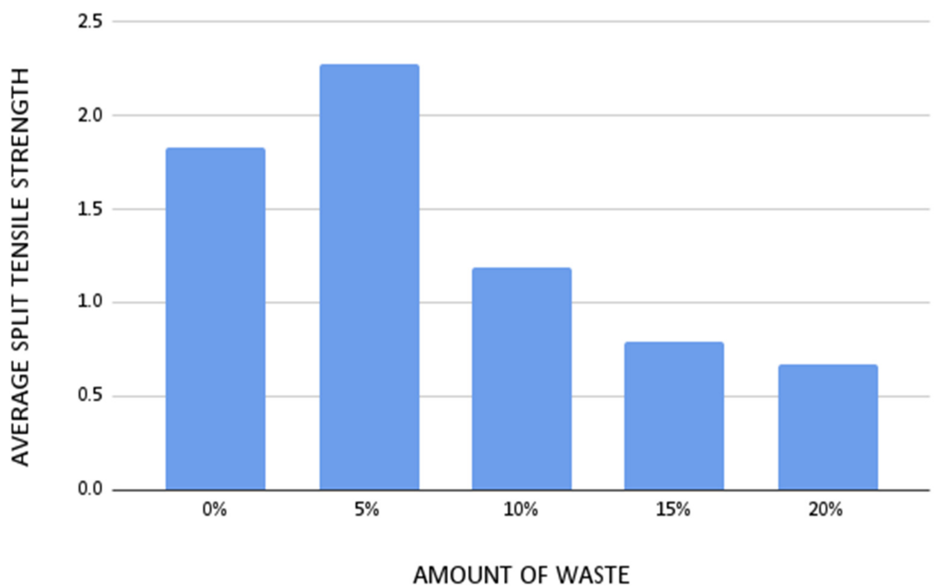
The 14days split tensile strength increased compare to that of 7days having 0% to be 1.67MPa, with an increase at 5% replacement of SPPA and ESP having a value of 2.29MPa which after that the split tensile strength values decreased at 10%, 15%, and 20% shown in Figure 4.13 below.



14days split tensile strength

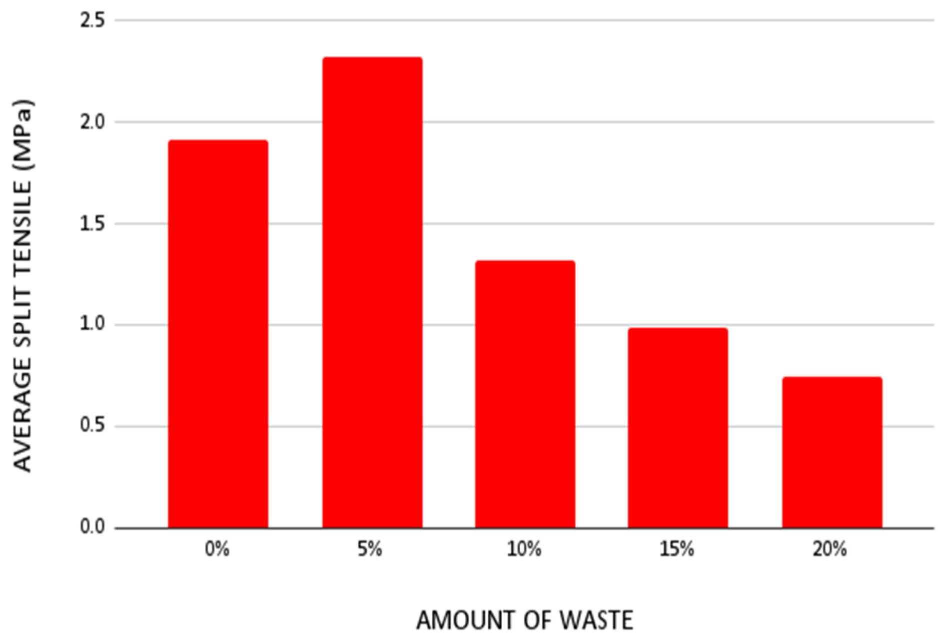
Figure 4.14 shows the 28days split tensile strength of the concrete value, which at 0% had a value of 1.83MPa, at 5% with

2.28MPa, 10% with 1.19MPa, 15% with 0.79MPa, 20% with 0.67MPa. This indicate that SPPA AND ESP had a significant impact to the concrete sample at 5% only by increasing the split tensile strength compare to 0% but also reduced the strength from 10% upward.



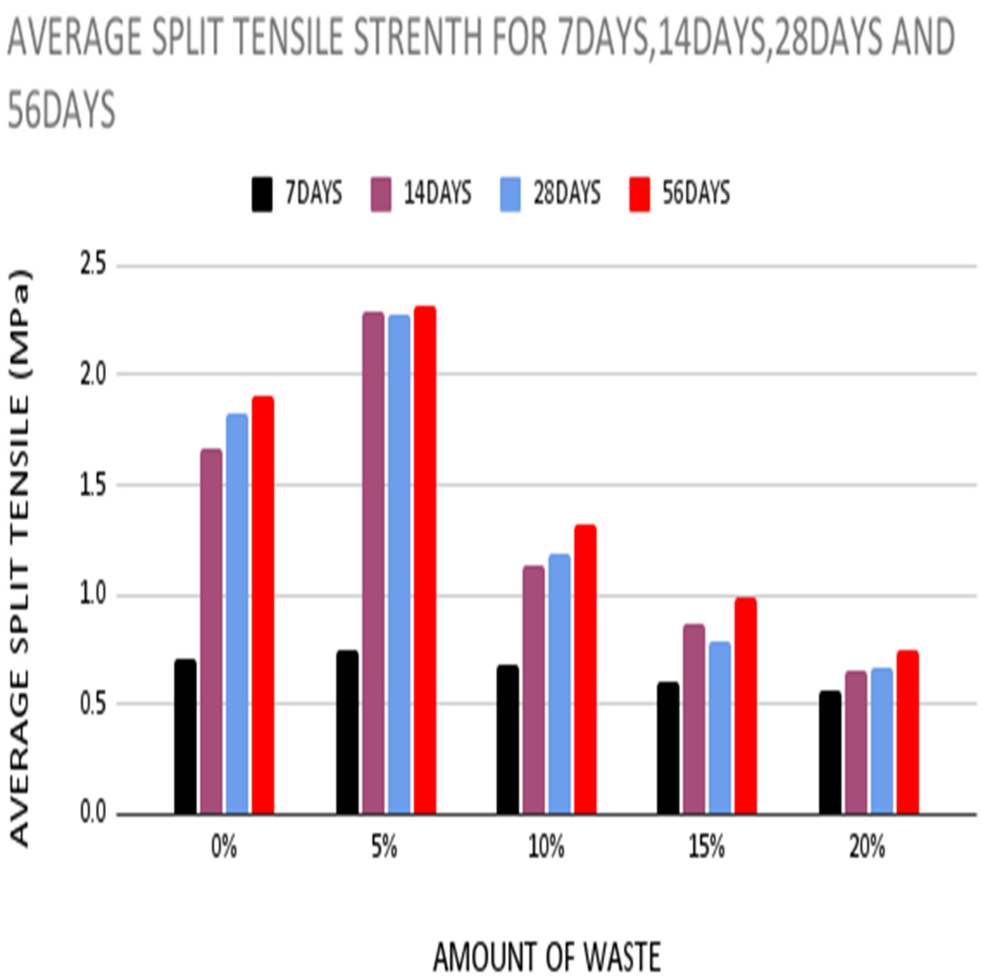
28days Split Tensile Strength

The 56days curing age result is shown in Figure 4.15 indicating the increase of the split tensile strength only by 5% with a value of 2.32MPa, and at 10% decreased to 1.32 MPa drastically, at 15% decreased to 0.99MPa and at 20% decreased to 0.75MPa.



56days Split Tensile Strength

Comparing 7days, 14days, 28days and 56days split tensile strength as ashown in Figure 4.16 below, it clearly seen that the split tensile strength increased as the curing age increased but at 28days and 56days, the differences was very little at 0%. At 5% the split tensile strength between 14days, 28days and 56days was slightly different. At 10% replacement, 7days strength was the least, then started increasing at 14days, and the increased again at 28days, at 56days the strength also increased compare to 28days. This same pattern followed across 15% and 20% replacement with SPPA and ESP. This result shows that the concrete sample with replacement of cement at 5% of SPPA and ESP which had the highest split tensile strength indicates a good resistance to cracking and better durability of a concrete.



Comparison of split tensile strength for all curing age

CONCLUSIONS AND RECOMMENDATIONS

Using all the data and information gathered from this research project on the substitution of cement in different proportions for the production of concrete, the objective of this study is to examine the impact of these wastes on concrete, compare the characteristic strength of concrete made with egg shell powder and sweet potato peel ash substituted for some of the cement, and assess the availability and cost-effectiveness of these substitutes. Therefore, the following conclusions are drawn:

1. SPPA is a pozzolanic material because it met the necessary requirement of aluminium, silicon and ferric oxide which was 79.89% which is more than 70% according to ASTM C-618 (2005) and BS EN 197-1:2000 specification. ESP was 1.63% which didn't meet up the specification.
2. The workability of this concrete using SPPA and ESP at water cement ratio of 0.5 increased as the portion of these waste increases which means that while using this concrete with this water cement ratio, the slump value increased as the percentage mix increased.
3. At 7, 14, 28, and 56 days, the compressive strength of the 5% replacement was the highest. Because 20% replacement had the lowest compressive strength during the course of the curing age, SPPA and ESP can only be utilized for concrete production between 0% and 5% replacement.
4. The flexural strength varied across all the curing age increased as the curing age increased from 7days to 14days to 28days but there wasn't a significant increase between 28days and 56days. These increase only occurred between 0% and 5% but decreased from 10% to 20%.
5. The split tensile strength at 0% was 0.72MPa for 7days, 1.67MPa for 14days, 1.83MPa for 28days, 1.91MPa for 56days and then increased only by 5% replacement of SPPA and ESP at 0.75MPa for 7days, 2.29MPa for 14days, 2.28MPa for

28days 2.32MPa for 56days which from 10% to 20% replacement of SPPA and ESP the split tensile strength decreased.

In summary, the utilization of SPPA and ESP as a partial replacement for cement at a rate of 5% proves to be highly advantageous in terms of expenses, the accessibility of these waste materials, and the greatest values for split tensile strength, flexural strength, and compressive strength.

RECOMMENDATIONS

This research study comprises of a lot more, leaving room for many questions, details and information. Therefore, it is recommended that;

1. Some other mix ratio should be used for this research verification.
2. Another percentage values should be tested as partial replacement for cement in concrete production so as to attain a better percentage replacement for cement.
3. Other water cement ratio should be examined for various mix to attain a suitable workability for the concrete.
4. Other test should be carried out on the concrete to obtain further information such as SEM, water absorption.
5. The shared percentage of the waste an be shared uneven leaving SPPA to be higher in value than ESP and carryout various investigation and test on such recommendation to attain a better result since SPPA is a pozzolanic material compare to ESP.

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