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AN EXPLORATIVE STUDY ON THE SUITABILITY OF SESAME PLANT MUCILAGE (SESAMUM INDICUM) AS ADMIXTURE IN CONCRETE

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ABSTRACT
Concrete's durability and strength are the most important features of structural design and are required for compliance in the construction industry. Ordinary concrete may not meet the desired quality, strength, or durability in certain circumstances. Admixture is used in these situations to change the properties of ordinary concrete to make it more suitable for any situation. The suitability of sesamum mucilage as an admixture in concrete was investigated in this research along with its chemical composition and specific gravity which was calculated to be 2.25. A mix ratio of 1:1.84:2.88, water cement ratio of 0.60 and a target mean strength of 20.65 was used. Concrete cubes, Cylinders and Beams were cast, in which sesamum mucilage was added in 0%, 1%, 1.5% and 2%. 0%(control) had a slump of 35mm and a compacting factor of 0.95 which makes it workability low, 1% had a slump of 10mm and a compacting factor of 0.89 which makes it workability very low, 1.5% had a slump of 4mm and a compacting factor of 0.89 which makes it workability also very low while 2% had a slump of 58mm and a compacting factor of 0.95 which makes it workability low. Results for the hardened properties of concrete made with sesamum mucilage in 0%, 1%, 1.5% and 2% at 28 days of hydration were found to be 0%(28.00N/mm^2), 1%(31.30N/mm^2), 1.5%(32.20N/mm^2) and 2%(30.80N/mm^2) for the compressive strength, 0%(3.34N/mm^2), 1%(3.39N/mm^2), 1.5%(3.77N/mm^2) and 2%(3.50N/mm^2) for the split tensile strength test, 0%(4.33N/mm^2), 1%(5.42N/mm^2), 1.5%(6.33N/mm^2) and 2%(5.58N/mm^2) for the flexural strength test. However, for the rate of water absorption, all the concrete specimen made with sesamum mucilage have low water absorption capacity compared to the plain concrete with result of 0%(4.93%), 1%(4.52%), 1.5%(3.52%) and 2%(3.69%). Concrete specimen subjected to heat at 1000^{o}C had a result of 0%(5.30N/mm^2), 1%(5.50 N/mm^2), 1.5%(6.70 N/mm^2) and 2%(5.70 N/mm^2). There was a general increase in the strength properties of concrete which includes compressive strength, split tensile strength, flexural strength and compressive strength of concrete cubes after being subjected to heat at different temperature due to increase in percentage content of the sesamum mucilage and increase in the hydration period. However, 2% had a slight decrease in strength, it was still higher than 0% and 1% but not high as 1.5%. This study shows that sesamum plant

mucilage can be used as an admixture, as it modifies and enhance the fresh and hardened properties it is made with.
KEYWORDS: Explorative, Suitability, Concrete, Admixture, Sesamum indicum, Sesamum mucilage.

INTRODUCTION

At just about everywhere in the world, concrete with cement as a binder is currently the most popular material in construction (Akeke, Ewa, & Okafor, 2016). Concrete is also a composite material obtained to the appropriate extent by mixing cement, coarse aggregates, fine aggregates and water. Based on its strength, longevity and fair price, concrete has been used for many years in building and civil engineering works. Throughout the prior generation, the difficulties of using concrete included practicality, earlier strengths and later concrete strengths. Different studies have been done to address these problems, which has greatly improved concrete technologies (Alsadey, 2016).

The most significant property is strength among all of the concrete's properties. This is because the main objective of a structural design is the ability to take all the loads imposed on them by all structural components and elements. Concrete these days is used in different circumstances for various purposes. The requirement of quality strength and durability may not be shown in ordinary concrete. In many cases, the admixture is used to change the characteristics of normal concrete so that it is more appropriate for all situations (Shetty, 2005).

An admixture is the component of the concrete, morter or grout inserted during mixing to change the characteristics, either during wet conditions, shortly after mixing or after hardening. These may be just a lone chemical or a combination of several chemicals and may well be supplied as powders, but most solutions are aqueous because it is easy to dispense and then disperse into concrete in this form. (Punkki, 2018). In concrete construction Admixtures are components other than the core ingredients of concrete, i.e. Cement, water, fine added materials and coarse aggregates, which are added in the batch just before or during the mixture in order to alter any of the characteristics (Benjamin & Peter, 2015).

The mixtures are mostly used to minimize construction costs of concrete, modify concrete's performance, improve concrete reliability while mixing, carrying, positioning and curing and avoid various problems through concrete operations. One of the many different admixtures is the affordable, easy to obtain and environmentally friendly and durable sésame plant extract, which can grow locally throughout Nigeria. Sesame plant (Sesame Indicum) is one of the earliest economically valuable oleaginous and widespread in the world. It is the member of Pedaliaceae family, it is the seeds of tropical annual sesamum indicum it is originated from dry bush savannah of tropical Africa and then spread to India and China. As per archaeological records, it has been seen that in India it was known and used for more than 5000 years. This plant is commonly grown in tropical and temperate regions. Soil with minimum irrigation or less rainfall give better yield. This crop is widely grown all over the world but the biggest producers of the sesame plants are India, China, Myanmar, Uganda and Nigeria. Sixty percent of the production of sesame plants in the world is from the Asian region (Aglave, 2018).

The world's biggest producers of sesame plants include India, China, Myanmar, Sudan, Ethiopia, Uganda and Nigeria. Sesame plants have been cultivated in numerous areas around 5 million acres (20 000 km2) in 2007. 26% of this crop is cultivated in Africa (Hansen, 2011). Sesame, a major crop of cash in many northern states, including Benue, Kogi, Gombe, Jigawa, Kano, Nasarawa, Katsina, Plateau and the Federative Capital Territory, became widely cultivated as a smaller crop in the Northern and Central Nigeria in 1974. (NAERLS, 2010). Karkashi is a flowering plant in the sesamum genus It is an annual plant that grows 50-100 cm high. Some of the flowers may be white, blue or purple. The fruit naturally split into two pores, depending on the cultivars, by splitting the septum from top to bottom or by means of two apical pores. Leaves and seeds are the most important component of sesame plants (Osemeahon et. al., 2017).

The original domestication of sesame is unclear, but probably first cultivated in Asia or India. It is known and used for more than 5,000 years in India and is documented as a crop in Babylon and Assyria 4,000 years ago (Borchani et. al., 2010). Sesame seeds include a

variety of phytochemical beneficial compounds, including flavonoids and phenolic acids, alkaloids, tannins, saponins, steroids, calcium, iron, magnesium, manganese, gold, zinc, phosphorus. Sesame has compounds such as sesamine, sesaminol, cerebrospin, and lecithin. These compounds contain a large number of pharmacological operations such as cardio-tonics, anti-bacterial, anti-diabetes, antioxidants, anti-ulcerative, cardiotoxic, anti-inflammatory and sesam analgesics (Anilkumar et. al., 2010).

Nigeria has a strong market potential for domestic and export seed production, noting that since 1980 production figures have steadily increased to 67000 MT by 1997 to 139 000 MT by 2010, according to the Federal Ministry für Agriculture und Naturale Resourcing (Jospeh, 2009). This is in line with the annual report of the Nigerian Central Bank for 2008 stating that the production of sesame seed has increased from 98 million to 152,000,000 kg between 2003 and 2007(CBN, 2009).

Although the use of sesame is progressively advanced in pharmacies and other related fields of medicine, its materials have not been created for gum. Research is needed to identify, however, how the use of sesame plant mucilage in concrete as a blend would benefit the Nigerian construction industry.

MATERIALS

The materials used for this study were;

1. Ordinary Portland cement (OPC)
2. Fine aggregates (Sharp sand/River sand)
3. Coarse aggregate (crushed granite)
4. Water
5. Sesamum plant mucilage extracted from sesame plant

Cement

Cement is the most important component of concrete, and it is any material that hardens and becomes highly adhesive after being applied in a plastic form (Li, 2011). The cement type used in this research is Bua ordinary Portland cement (OPC), of grade 42.5 which conforms to type 1 cement as specified by BS 12 (1996). The

Bua ordinary Portland cement was bought from a local supplier of cements at Katako junction, Jos north, plateau state.

Fine Aggregate

The fine aggregate used was river sharp and free from impurities, conforming to Zone 1 specification of BS 882:1992 which passed through 4.75mm sieve. The fine aggregate used was gotten from bauchi road, opposite Joshua Dariye park, Jos north, plateau state.

Coarse Aggregate

Coarse aggregate may be gravel or crushed stone composed of particles greater than (6.35mm) in diameter. crushed rock (granite) stone that conformed to BS EN 933-5 (1998) was used for this research and was obtained from a local crushing plant at Bauchi ring road, Jos North, Plateau State. It was in saturated surface dry condition and was also sieved to pass through 20mm sieve and retained on 10mm sieve.

Water

Bore-hole water from the University of Jos permanent site which was ensured to be free from impurities was used for this research.

Sesamum Mucilage

The admixture that was used for the research was Sesamum mucilage which was extracted from sesame plant (sesamum indicum). Fresh sesame plant was obtained from Farin gada market, Jos north in plateau state. After which the mucilages were extracted from the plant as seen in figure 1.

Figure 1: Sesame Mucilage

METHODS

Strength Properties of Hardened Concrete

Compressive Strength of Concrete

Concrete generally is weak in tension but strong in compression. The property of concrete which gives its quality and performance under load subjected to it is its compressive strength. It is used for the analysis and design of structural elements in buildings. The aim is to determine the 7, 14 and 28-days strength of concrete cubes cast using the compression testing machine.

Flexural Strength of Concrete

In the determination of flexural strength of concrete beams, certain procedures were followed. The test was carried out in accordance with BS1881: Part 4.

Splitting Tensile Strength Test On Concrete Cylinders

According to Neville (2011), the indirect method is used to ascertain the tensile strength of concrete since applying uniaxial tension to a concrete specimen is impossible. The splitting tensile strength was carried out using the compressive universal testing machine of 2000 KN capacity. The splitting tensile strength was calculated using the formula below;

$$ft = \frac{2p}{\pi Ld}$$

Where:

ft = splitting tensile strengths (N/mm^2)

P = failure load (KN)

d = diameter of cylinder (mm)

l = lenght of cylinder (mm)

Water Absorption Test

The concrete samples (cubes) were removed from the curing tank and allowed to dry, and were placed in the electronic oven to oven dry at 105^0C for 24 hours. The samples were removed from the oven and allowed to cool at room temperature then weighed to determine the initial weights (W_1). The final weight was determined after immersing the concrete samples in the curing medium for 30 minutes and then removed to cloth dry and re-weighed again as (W_2). The values obtained was recorded and the results obtained was used to assess the rate of absorption of the concrete specimens in accordance to BS 1881-122 (2016). The equation was then used to compute the absorption capacity for each of the specimens and is given as:

Water absorption $= \frac{W2-W1}{W1} \; x \; 100\%$

Firing of Concrete Cubes

The firing of the specimen took place at the Department of Industrial Design, Abubakar Tafawa Balewa University, Bauchi. Specimen were dried, weighed, placed in a kiln and heated in a temperature of 200°C, 400°C, 600°C, 800°C and 1000°C and weighed again to compare the weight before crushing.

Curing

Curing takes place after demoulding, the concrete specimens were immersed in ordinary clean water in a curing tank for 7days, 14days and 28days for compressive strength test, 14 and 28days for split tensile test, 14 and 28days for flexural strength test, 28 days for water absorption test and 28days for fire resistance test respectively so as to attain specified curing age. After curing, the specimens were air dried in the laboratory before the various tests were carried out.

RESULTS

Result of Chemical Analysis of Sesame Plant Mucilage

The result of chemical analysis carried out on the sesamum mucilage samples was obtained and presented in table 1.

Table 1: Chemical analysis of sesame plant mucilage

Elements	Percentage(%) composition
Silicon Oxide (SiO_2)	20.60
Aluminum Oxide (Al_2O_3)	4.15
Iron Oxide (Fe_2O_3)	1.10
Titanium Oxide(TiO_2)	N.D
Calcium Oxide (CaO)	1.65
Magnesium Oxide (MgO)	0.85
Sodium Oxide (Na_2O)	0.06
Potassium Oxide (K_2O)	0.22
Loss on Ignition (LOI)	70.52

N.D Denotes "NOT DETECTABLE"

Fresh Concrete

Setting Time

Table 2 shows the result of the setting time of cement made with sesamum mucilage as an admixture with a consistency of 30%. The higher the content of the sesamum mucilage, the faster the setting time which makes sesamum mucilage an accelerator.

Table 2: Result for consistency and Setting time test

Mix type Sample of cement	Water/ cement ratio	Sesame mucilage content (%)	Consistency	Initial setting time	Final setting time
SC1	0.60	0%	30	1:55 (115mins)	3:55 (235mins)
SC2	0.60	1%	30	1:40 (100mins)	3.35 (215mins)
SC3	0.60	1.5%	30	1:30 (90mins)	3:05 (185mins)
SC4	0.60	2%	30	1:25 (85mins)	3:15 (195mins)

Workability of Concrete Made With Sesamum Mucilage (Slump Test)

Table 3 shows the water-cement ratio and slump result of wet concrete made with sesamum indicum concrete. A free water/cement ratio of 0.60 was used for all the mixes. The slump obtained ranges from 4mm to 58mm. with 0% having a slump of 35mm, 1% having a slump of 10mm, 1.5% having a slump of 4mm and 2% having a slump of 58mm. The slump was tested according to BS EN 12350-2 (2009).

Table 3: Workability of concrete made with sesamum mucilage (Slump test)

Sesame content	W/c ratio	Slump	Degree of workability	Uses
0%	0.60	35	Low	Mass concrete foundation without vibration and simple reinforced sections with vibration.
1%	0.60	10	Very low	Vibrated concrete in roads or other large sections.
1.5%	0.60	4	Very low	Vibrated concrete in roads or other large sections.
2%	0.60	58	Medium	Section with congested reinforcement. Not normally suitable for vibration

Workability of Concrete Made With Sesamum Mucilage (Compacting Factor Test)

Table 4 shows the water-cement ratio and compacting factor values of wet concrete made with sesamum indicum concrete. A free water/cement ratio of 0.60 was used for all the mixes. The compacting factor obtained ranges from 0.88 to 0.95with 0% having a compacting factor of of 0.95, 1% having a compacting factor of 0.89, 1.5% having a compacting factor of 0.88 and 2% having a compacting factor of 0.95.

Table 4: Workability of concrete made with sesamum mucilage (compacting factor test)

Sesame Content	W/C Ratio	Compacting factor	Degree Of Workability	Uses
0%	0.60	0.95	Medium	Normal reinforced work without vibration and heavily reinforced sections with vibration.
1%	0.60	0.89	Low	Mass concrete foundation without vibration and simple reinforced sections with vibration.
1.5%	0.60	0.88	Low	Mass concrete foundation without vibration and simple reinforced sections with vibration.
2%	0.60	0.95	Medium	Normal reinforced work without vibration and heavily reinforced sections with vibration.

HARDENED CONCRETE TEST

The test conducted on hardened concrete made with sesame plant mucilage include compressive strength, flexural strength splitting tensile strength, water absorption and fire resistance test.

COMPRESSIVE STRENGTH

Density of Concrete Cubes for Compressive Strength Test

The density of the concrete cubes for compressive strength is presented in table 5 in which there was a decrease in density at 14 days of hydration for all the mixes except for 2%. At 28days of hydration, the specimen with 0% and 1.5% sesamum mucilage content increased in density while the specimen with 1% and 2% decreased in density.

Table 5: Densities of Concrete cubes cured in H_2O in Kg/m^3 (At 7, 14 and 28 days).

Sesame content	3 cubes at 7 days (Kg/m^3)			3 cubes at 14 days (Kg/m^3)			3 cubes at 28 days (Kg/m^3)		
0%	2380	2500	2380	2400	2140	2360	2420	2360	2500
Average	2420			2300			2427		
1%	2360	2580	2580	2440	2440	2446	2420	2400	2340
Average	2547			2442			2387		
1.5%	2580	2500	2560	2460	2520	2500	2540	2820	2500
Average	2547			2493			2620		
2%	2280	2400	2340	2440	2260	2440	2240	2420	2420
Average	2340			2380			2360		

Compressive Strength of Concrete Cubes

The compressive strength of the concrete specimen made with sesamum mucilage is presented in table 6. The compressive strength increased during all the period of hydration. With 1% higher than 0% (control), 1.5% higher than the 1% and 2% higher than 0% (control) and 1% but was lesser than 1.5% thereby making 1.5% the mix with the most compressive strength.

Table 6: Compressive Strength of Concrete cubes (At 3, 7 and 28days of hydration).

Sesame content	3 cubes at 7 days (N/mm^2)			3 cubes at 14 days (N/mm^2)			3 cubes at 28 days (N/mm^2)		
0%	19.0	20.0	19.0	24.0	21.0	20.5	34.0	27.5	22.5
Average	19.3			21.8			28.0		
1%	18.5	21.0	20.0	24.0	21.0	22.0	31.5	35.0	27.5
Average	19.8			22.3			31.3		
1.5%	25.0	20.0	27.5	22.0	29.5	26.0	33.0	36.5	30.0
Average	24.2			25.8			33.2		
2%	21.0	20.0	24.0	24.0	24.0	22.0	35.5	29.5	27.5
Average	21.7			23.3			30.8		

Flexural Strength of Concrete Samples

Density of Beams For Flexural Strength Test

The density of the beams for flexural strength test is presented in table 7 in which the density of the beams made with sesamum mucilage in 1% increased along with the plain concrete at 28 days of hydration while of beams made with 1.5% and 2% content of sesamum mucilage decreased in density.

Table 7: Densities of Beams cured in H_2O in Kg/m³ (At 14 and 28 days)

Sesame content	3 beams at 14 days (Kg/m³)			3 beams at 28 days (Kg/m³)		
0%	2348	2488	2350	2544	2528	2532
Average	2395			2534		
1%	2440	2368	2440	2596	2700	2588
Average	2416			2628		
1.5%	2456	2400	2458	2480	2340	2460
Average	2436			2427		
2%	2652	2620	2630	2500	2488	2470
Average	2634			2486		

Flexural Test

The flexural strength test of the specimen is presented in table 8. The specimen with sesamum mucilage content of 1% and 1.5% increase in strength. The specimen with 2% sesamum mucilage also increased but was lesser than 1.5%.

Table 8: Flexural strength of Concrete Beams in N/mm² (At 14 and 28days of hydration)

Sesame content	3 beams at 14 days			3 beams at 28 days		
0%	3.50	3.50	3.50	4.50	4.25	4.25
Average	1.05			4.33		
1%	4.50	4.75	4.50	5.00	6.25	5.00
Average	4.58			5.42		
1.5%	6.50	5.25	6.50	7.00	5.00	7.00
Average	6.08			6.33		
2%	5.00	6.25	5.00	5.00	6.25	5.50
Average	5.42			5.58		

Splitting Tensile Strength of Concrete Sample

Density of Concrete Cylinders for Split Tensile Strength Test

The density of the cylinders for split tensile test is presented in table 9. There was an increase in the density of the cubes in the various curing days in all mixes except for the 2% mix which decreased in density.

Table 9: Densities of Concrete cylinders cured in H_2O in kg/m^3 (At 14 and 28 days).

Sesame content	3 Cylinders at 14 days (kg/m^3)			3 Cylinders at 28 days (kg/m^3)		
0%	1553	1426	1413	2521	2686	2673
Average	1464			2627		
1%	2877	2419	2934	2813	2839	2813
Average	2743			2822		
1.5%	2623	2444	2610	2495	2724	2737
Average	2559			2652		
2%	2724	2813	2737	2673	2712	2934
Average	2758			2773		

Split Tensile Test

The result for the split tensile strength is illustrated in table 10. The specimen with sesamum mucilage content of 1% and 1.5% increase in strength while the specimen with 2% sesamum mucilage also increased in strength but was lesser than 1.5% which makes 1.5% with the most strength.

Table 10: Splitting tensile strength of Cylinders in N/mm^2 (At 14 and 28 days of hydration)

Sesame content	3 Cylinders at 14days (N/mm^2)			3 Cylinders at 28days (N/mm^2)		
0%	2.71	2.86	2.55	3.50	2.86	3.66
Average	2.71			3.34		
1%	2.86	2.55	3.02	3.52	3.18	3.18
Average	2.81			3.39		
1.5%	3.02	3.18	3.02	3.98	3.34	3.98
Average	3.07			3.77		
2%	3.18	2.55	2.86	3.02	3.82	3.66
Average	2.86			3.50		

Water Absorption Test of Concrete Samples

The rate of water absorption test was carried out and the result obtained is illustrated in table 11. Concrete made with sesamum mucilage as an admixture in 1% has the rate of water absorption of 4.52%, 1.5% has the rate of water absorption of 3.52%, 2% has the rate of water absorption of 3.69% while the plain concrete 0% (control) has the rate of water absorption of 4.92%. 1.5% has the lowest rate of water absorption among all the specimen.

Table 11: Water Absorption of Cubes cured in % (3 cubes at 28days of hydration).

Sesame content	Wet weight (kg)	Dry weight (kg)	Water absorption (kg)	Percentage of water absorption (%)	Average (%)
0%	2.46	2.34	0.12	4.88	4.92
	2.45	2.32	0.13	5.31	
	2.41	2.30	0.11	4.56	
1%	2.35	2.21	0.14	5.96	4.52
	2.42	2.29	0.13	5.37	
	2.42	2.31	0.11	4.55	
1.5%	2.47	2.38	0.09	3.64	3.52
	2.43	2.35	0.08	3.29	
	2.33	2.26	0.07	3.00	
2%	2.35	2.25	0.10	4.26	3.69
	2.35	2.25	0.10	4.26	
	2.35	2.26	0.06	2.55	

Fire Resistance Test of Concrete Cubes

Density of Cubes after Subjected To Heat at Temperature of 200°C, 400°C, 600°C, 800°C AND 1000°C

The density of the concrete cubes after subjected to heat at temperature of 200°C, 400°C, 600°C, 800°C and 1000°C is presented in table 12. There was a decrease in density at all temperature except for the specimen fired at 1000°C in which an increase in density was observed.

Table 12: Density of Concrete cubes after firing in Kg/m^3 (3 cubes at 28days of hydration)

Sesame content	Temperature					
	0°C (Kg/m^3)	200°C (Kg/m^3)	400°C (Kg/m^3)	600°C (Kg/m^3)	800°C (Kg/m^3)	1000°C (Kg/m^3)
	0%					
C1	2420	2320	2240	2180	2190	2190
C2	2360	2310	2240	2170	2060	2190
C3	2500	2300	2320	2190	2120	2170
Average	**2427**	**2310**	**2267**	**2180**	**2123**	**2183**
	1%					
C1	2420	2340	2250	2120	2100	2200
C2	2400	2320	2240	2140	2090	2190
C3	2340	2310	2230	2130	2090	2120
Average	**2387**	**2323**	**2240**	**2130**	**2093**	**2170**
	1.5%					
C1	2540	2470	2280	2250	2200	2330
C2	2820	2560	2340	2500	2160	2390
C3	2500	2400	2490	2270	2140	2420
Average	**2620**	**2477**	**2370**	**2340**	**2167**	**2380**
	2%					
C1	2240	2340	2290	2090	2070	2200
C2	2420	2360	2280	2110	2110	2290
C3	2420	2310	2300	2180	2115	2160
Average	**2360**	**2337**	**2290**	**2127**	**2098**	**2216**

Compressive Strength of Cubes after Subjected To Heat at Temperature of 200°C, 400°C, 600°C, 800°C AND 1000°C

The compressive strength of the concrete specimen made with sesamum mucilage after heated on high temperature is presented in table 13. The compressive strength decreases the higher the temperature. Though there was a decrease in the compressive strength, all the specimen containing sesamum mucilage as an admixture had higher compressive strength than the plain concrete. The specimen containing 1.5% of sesamum mucilage as an admixture had the highest compressive strength.

Table 13: Compressive strength of Concrete cubes after firing in N/mm^2 (3 cubes at 28days).

Sesame content	Temperature 0°C (N/mm^2)	200°C (N/mm^2)	400°C (N/mm^2)	600°C (N/mm^2)	800°C (N/mm^2)	1000°C (N/mm^2)
	0%					
C1	34.00	22.00	14.00	9.50	6.00	5.00
C2	27.50	21.50	12.00	10.00	7.00	6.00
C3	22.50	21.50	18.00	11.50	9.00	5.00
Average	**28.00**	**21.70**	**14.70**	**10.30**	**7.30**	**5.30**
	1%					
C1	31.50	22.50	15.50	10.00	8.50	6.00
C2	35.00	23.00	17.50	11.00	9.00	5.50
C3	27.50	22.00	14.00	12.00	9.00	5.00
Average	**31.30**	**22.20**	**15.70**	**11.00**	**8.83**	**5.50**
	1.5%					
C1	33.00	28.50	25.00	22.00	13.00	7.00
C2	36.50	28.00	28.00	23.00	12.00	6.50
C3	30.00	27.00	23.50	23.50	15.50	6.50
Average	**33.20**	**27.70**	**25.5**	**22.70**	**13.50**	**6.70**
	2%					
C1	35.50	24.00	16.50	12.00	9.00	6.00
C2	29.50	25.00	18.50	11.00	9.50	5.50
C3	27.50	23.50	17.00	11.00	10.00	5.50
Average	**30.80**	**24.10**	**17.30**	**11.3**	**9.17**	**5.70**

SUMMARY OF FINDINGS

In this research, the chemical constituents of sesamum mucilage was evaluated after which the workability, the strength properties, rate of water absorption and fire resistance of concrete made with sesamum mucilage was evaluated so as to investigate its suitability in concrete in line with the set research objectives, the highlights of the major findings are discussed below;

1. The Chemical properties of sesamum mucilage was investigated and the result showed that sesamum mucilage comprises of Silicon Oxide (SiO_2) of 20.60%, Aluminum Oxide (Al_2O_3) of 4.15%, Iron Oxide (Fe_2O_3) of 1.10%, Calcium Oxide (CaO) of 1.65%, Magnesium Oxide (MgO) of 0.85%, Sodium Oxide (Na_2O) of 0.06% and Potassium Oxide (K_2O) of 0.22% which are identical constituent of ordinary Portland cement.
2. The tests on the Physical Properties of fine and coarse Aggregate revealed sieve analysis of Fineness modulus of 4.33 was obtained for the fine aggregate while 2.88 was obtained for the coarse aggregate, specific gravity of 2.50 for the fine

aggregate and 2.50 for the coarse aggregate, bulk density of 1606kg/m^3 was obtained for the fine aggregate and 4380kg/m^3, for the coarse aggregate and result of void percentages of 6.29% for the fine aggregate and 7.39% for the coarse aggregate respectively.

3. Test on physical properties of cement and Sesamum mucilage revealed a specific gravity of 3.22 for cement and 3.89 for sesamum mucilage respectively.
4. The workability of concrete made with sesamum mucilage as an admixture at different percentage using a water-cement ratio of 0.60 revealed a very low degree of workability for 1%, a very low degree of workability for 1.5%, a medium degree of workability for 2% and a low degree of workability for the plain concrete with respect to slump test, with values of 10mm for 1%, 4mm for 1.5%, 58mm for 2% and 35mm for the plain concrete (0%). Compacting factor of 0.89 for 1%, 0.88 for 1.5%, 0.95 for 2% and 0.95 for the plain concrete (0%) which indicates a low degree of workability for 1% and 1.5%, and a medium degree workability for the control (0%) and 2%.
5. There was an increase in the rate of setting time of the specimen with sesamum mucilage.
6. There was an increase in the compressive strength, splitting tensile strength and flexural strength of the concrete specimen with increase in curing age of the concrete cubes.
7. The water absorption test revealed that the plain concrete has higher water absorption than the concrete made with sesamum mucilage as an admixture.
8. Specimen heated at 600^{o}C, 800^{o}C and 1000^{o}C developed cracks and turned dark after which expansion and shrinkage was observed on specimen fired at 1000^{o}C
9. There was a reduction in the density of the concrete specimen which was increasing tremendously on concrete specimen in all the heat temperature it was subjected to. 200^{o}C, 400^{o}C, 600^{o}C, 800^{o}C and 1000^{o}C decreases. But the concrete specimen heated at 1000^{o}C also decreased in density but gained weight and was lesser than only the concrete specimen heated at 200^{o}C and 400^{0}C.
10. There was a reduction in the compressive strength of concrete which increasing tremendously on concrete specimen in all the heat temperature it was subjected to.

11. The density of the concrete specimen subjected to fire Concrete made with sesamum mucilage in 1.5% as an admixture had the highest compressive strength when subjected to heat at all the temperature.

CONCLUSION

After carrying out the experiments, observations, analysis and discussions on an explorative study on the suitability of sesame plant mucilage as admixtures in concrete, the following conclusions were drawn:

1. Concrete made with sesamum mucilage as an admixture has low workability except for the specimens in 2% with a slump of 58mm which makes it workability high.
2. Sesamum mucilage can be used as an accelerator as it speeds up the rate of setting time.
3. Concrete made with sesamum mucilage low water absorption capacity.
4. The strength properties of hardened concrete specimen Shows that concrete made with sesamum mucilage of 1.5% as admixtures have a higher compressive strength, split tensile strength and flexural strengths to that of 0% (control), 1% and 2% which makes 1.5% the optimum mix.
5. The optimum mix of the percentage content of the admixture is 1.5%

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