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"Exploring Lightweight Structural Concrete Utilising Oil Palm Shell Aggregate: A Review"

Mohit Manohar Lachoria[a], Prof. Anil rajpoot[b]

[a]Research Scholar, Civil Engineering Department, Vikrant Institute of Technology & Management Gwalior, (M.P.) 474006 India
[b]Assistant Professor, Civil Engineering Department, Vikrant Institute of Technology & Management Gwalior, (M.P.) 474006 India

ABSTRACT:

Using industrial waste as building material is one technique to create environmentally friendly and sustainable structures. Oil palm shells (OPS), which are produced during the palm oil extraction process from the palm oil industry, are a potential material that can be used in place of coarse aggregate (gravel) in traditional concrete since they are lightweight. When compared to gravel aggregates, OPS are shown to absorb more water. According to a water absorption test, OPS absorb water at a rate of 20–24%, which is four–five times greater than that of the gravel aggregates. Therefore, OPS aggregates are surface treated using silicon-hydrogen (Si-H) compound. The water absorption in OPS aggregate is decreased by this surface treatment to a level that is typical. The terms "TOPS" and "NTOPS" refer to treated and non-treated oil palm shell aggregates, respectively.

The mechanical properties of normal concrete and TOPS and NTOPS concrete are compared in this research study. For 28 days, TOPS concrete showed a compressive strength of 29 MPa, while NTOPS concrete showed a compressive strength of 13.2 MPa. Using digital image processing, microstructural analysis and the interfacial transition zone for TOPS and NTOPS concretes are also examined to determine the bond break between the matrix phase and the aggregate phase. The investigation's findings are contrasted with traditional concrete. The durability characteristics of TOPS concrete are analysed and contrasted with industry norms.

Keywords: Lightweight concrete, Oil Palm Shells, Water absorption, Microstructure, Interfacial transition zone, Alkali-silicate reaction.

INTODUCTION:

One of the most important building materials is concrete, and its use is growing everywhere in the world. The materials are readily available, it is reasonably priced, and it may be used for a variety of civil infrastructure projects. The manufacture and utilize of lightweight aggregates (LWA) from wastes such as expanded pelletized fly ash aggregates, sintered fly ash aggregates, expanded slag gravel, blast furnace slag etc. have in fact demonstrated the effectiveness of waste consumption in industrially advanced countries. In addition, production of LWA from the municipal and dredging wastes in the USA, Russia, Japan and other developed nations is a very significant development (Short and Kinniburgh, 1978; Chandra and Berntsson, 2003). The modern design procedures in the industrially advanced countries speak volumes about the expertise available in terms of knowledge, research and experience. Hence, the large-scale development of new types of LWA is more rapid. Research on the utilize of industrial waste materials, such as oil palm shell (OPS) or oil palm kernel shell (OPKS), as LWA has demonstrated that OPKS can be use as a viable LWA in many developing and poor nations in Asia and Africa. There has been awareness raised about the potential use of industrial and agricultural wastes as building materials, particularly in agro-based emerging nations like Malaysia and Nigeria. Abdullah (1984) was the first person in Malaysia to employ OPKS as LWA and demonstrated that OPKS may potentially completely replace normal weight aggregate (NWA). Okafor (1988) carried out more research in Nigeria utilising OPKS and discovered that the mechanical properties of palm kernel shell-aggregate concrete are influenced by the water to cement (w/c) ratio, just as normal weight concrete (NWC). Depending on the mix design, the OPKS concrete's 28-day compressive strength ranged from 5 to 25 MPa. Later, more researchers conducted studies by Olanipekun et al. (2006), Mannan and Ganapathy (2002), Okpala (1990), The physical, mechanical, and structural characteristics of OPKS were examined by Alengaram et al. (2008) and Jumaat et al. (2009), who found that the material behaved similarly to NWC. Malaysia is the world's second-largest exporter of oil palm. On the global market, there is a growing need for vegetable oil. After producing palm oil, the palm oil industry generates a significant amount of OPKS waste material annually. By 2020, Malaysia alone is predicted to have almost 5 million hectares of oil palm trees, according to Ramli (2003). This will lead to an boost in the production of palm oil and its byproducts. Typically, fracturing the palm kernel is required to reach the OPKS. They are strong yet lightweight, and they are available in many sizes and shapes. Because OPKS are underutilised, pollution has increased. By 2020, Malaysia alone is predicted to have almost 5 million hectares of oil palm trees, according to Ramli (2003). This will lead to an enlarge in the production of palm oil and its byproducts. Typically, fracturing the palm kernel is required to reach the OPKS. They are strong yet lightweight, and they are available in many sizes and shapes. Because OPKS are underutilised, pollution has increased.

Greater design flexibility, significant cost savings, reduced dead load, enhanced structural response to cyclic loading, longer spans, increased fire ratings, thinner sections, smaller structural components, less reinforcing steel, and lower foundation costs are all made possible by the use of LWC. Among the structural lightweight concretes is OPKSC. The air-dry density of the PKSC was discovered to be between 1725 and 1900 kg/m3 based on earlier investigations conducted by other researchers (Abdullah, 1984; Okafor, 1988; Mannan and Ganapathy, 2002; Olanipekun et al., 2006; Alengaram et al., 2008; Jumaat et al., 2009). The compressive strength, however, was discovered to be between 5 and 25 MPa. While OPKSC's compressive strength satisfies LWC requirements, medium strength structural members are better off with a value of roughly 30 MPa. The smooth surfaces of OPKS resulted in weaker bond, which in turn affected the mechanical properties. Thus, OPKSC produced compressive strength of about 20 to 25 MPa (Abdullah, 1984; Mannan and Ganapathy, 2002; Olanipekun et al., 2006). In order to produce OPKSC of grade 30 and above, the bond between the smooth convex surfaces of cement matrix and OPKS needs to be enhanced. This makes the OPKSC's usage of mineral admixtures necessary. High strength concrete is typically made with silica fume (SF), whose particles are 100 times smaller than those of cement. The SF particles can be found in close proximity to the aggregate particles due to their exceedingly tiny size (Neville, 1996). SF might therefore be used to strengthen the zone of weakness, which is the contact between the aggregate and cement paste. The aim of this study was to enhance the mechanical characteristics of OPKSC by adding 10% of silica fume and 5% of fly ash as replacement materials for cement, respectively. Additionally, research was done on OPKSC's bond property. The qualities of both OPKSFC and NWC's fresh and cured concrete were examined. Compressive strength, modulus of rupture, splitting tensile strength, and modulus of elasticity are among the mechanical characteristics that were examined. These characteristics were contrasted with NWC of concrete of a comparable grade.

LIGHTWEIGHT CONCRETE

The most material used in the construction sector is concrete. A lot of natural and non-renewable resources, like water, sand, and gravel, are used by this sector. Every year, the concrete industry worldwide uses about 7.5 billion tonnes. This leads to ecological imbalances and a reduce in stone deposition. Concrete is not a material that is good for the environment. The construction sector has a big impact on the environment, the economy, and society. In order to achieve sustainable development of concrete, waste from industries and available byproducts can be used as raw materials or as best alternative materials.

Concrete made with lightweight aggregates to produce structural concrete is said to be Lightweight Concrete (LWC). Lightweight aggregates can either be natural lightweight aggregates or artificial lightweight aggregates. Natural aggregates are pumice, scoria and perlite. Artificial aggregates are shale, expanded clay and slate. Aggregates from industrial waste can also be used to produce lightweight concrete. Lightweight aggregates produced in the rotary kiln are expanded clays and shale which are termed as LECA aggregates. Lightweight aggregates produced by water jet or slag expanded mechanically are termed as FOAMED lightweight aggregates. Sintered pulverized fuel ash aggregates are termed as LYTAG aggregates.

NEED FOR THE STUDY

Because conventional aggregates are depleting natural resources, there is rising worry about the ecological impact of dumping garbage for the production of concrete. This research seeks to address this concern by using industrial waste as building material. Industrial waste is the finest substitute for natural resources in terms of sustainability and resource preservation. The purpose of the research study is to compare OPS lightweight concrete with ordinary concrete. A thorough review of the literature was done on OPS lightweight concrete and its differences from traditional concrete.

RESEARCH OBJECTIVES AND SCOPE OF THE THESIS.

A. To produce concrete of grade M15 using oil palm shell as light weight aggregates and cementious materials.
B. The objective of the present investigation is to study proper mix proportion of OPS in concrete to behave as a light weight aggregate.
C. To examine the oil palm shell concrete's mechanical characteristics and contrast them with those of regular weight concrete of a comparable grade.
D. To look into the durability of standard concrete and OPS lightweight concrete.
E. OPS exhibits promising qualities as a coarse aggregate in the manufacturing of structural lightweight concrete, particularly for usage in earthquake-prone locations and in the construction of affordable housing. constructions built with OPS concrete.

LITERATURE REVIEW:

A REVIEW OF LIGHTWEIGHT AGGREGATES USED TO MAKE LIGHTWEIGHT CONCRETE

The use of lightweight aggregate was first proposed by Durisol and Fixolite in the year 1937. The first lightweight aggregate was wood fibres aggregate which were patented by Alex Bosshard in 1932. Lightweight aggregate wood fibres as a replacement of conventional aggregates were proposed to reduce the dead weight of the material. Lightweight concrete blocks with 200*200*500 mm were prepared to use as non-structural elements for the construction of walls. Wood fibre lightweight concrete has a density of 750 kg/m3 . Later these became the best alternative for conventional aggregates. Lightweight aggregates like pumice and scoria were used to build Port of Cosa on the west coast of Italy in 273 B.C. The builder used natural lightweight aggregates instead of locally available aggregates (beach sand and gravel). The density of lightweight concrete made with natural lightweight aggregates is in between 450-850 kg/m3 . According to reports concrete with natural aggregates shows good mechanical behaviour and this port is still in use. In 27 B.C the Pantheon Dome was constructed with a diameter of 43.3 m as shown in Fig. 2.1. The builders used two types of lightweight aggregates with varying densities. Higher densities of aggregates were used at the base to maintain the stresses coming on that and lower densities of aggregates were used at the top of the dome were the stresses are low. The Pantheon is still in use today even after hundreds of years. In between 75 to 80 A.D a massive size ancient amphitheatre Coliseum was constructed with 50 thousand seating capacity. Crushed volcanic lava lightweight aggregates were used for the foundation of the Coliseum, porous-tufa cut stone was used in the walls (ACI Committee 213, 2003). In the 20th century the manufacturing of lightweight aggregates became commercially available since the use of lightweight aggregates by Romans was limited. Producing and making of lightweight aggregates was patented by Stephen J. Hyde in 1981. He made the lightweight aggregates like expanded clay, shale or slate in a rotatory kiln through heating and expanding the process.

The American fleet's first concrete ship to use expanded aggregates was built. Lightweight concrete has been extensively employed in the construction of numerous multi-story structures since the latter part of the 20th century. In Chicago, a 42-story skyscraper was built with lightweight concrete floors, and in Dallas, eighteen-story hotels were built with flat plate floors and a lightweight concrete framework. The mechanical strength of lightweight concrete produced with lightweight particles is often lower than that of conventional concrete. Given that around 70% of the material is coarse aggregate, aggregate behaviour is important in concrete. The kind of lightweight aggregates used to make lightweight concrete affects the material's mechanical properties. Numerous kinds' light Lightweight concretes are used in a wide range of construction projects, including bridges, marine structures, and tall buildings. The 1998 construction of Norway's Stolmen Bridge is one example of a recent use of lightweight concrete structures. 1600 m3 of lightweight concrete with a mean density of 1940 kg/m3 and a 28-day compressive strength of 70.4 MPa were used to build the bridge. According to Basri et al. (1999), concrete that uses OPS in part instead of the coarse aggregate in ordinary concrete can achieve good mechanical behaviour. By using OPS, lightweight concrete can be produced with a density of 1856 and a compressive strength of 15-20 MPa. According to Shafigh et al. (2011), adding more cement can enhance the mechanical characteristics of lightweight concrete that uses oil palm shells as coarse aggregate. OPS from agricultural wastes were utilised by Mannan and Ganapathy (2002) as lightweight aggregates to make lightweight concrete. With varying mix ratios, a maximum 28-day compressive strength of around 21 MPa was reached. OPS concrete has a splitting tensile strength of 2.41 MPa and a flexural strength of 2-4 MPa when it is made without the use of any admixtures. OPS concrete has an elasticity modulus of 0.70–0.76*104 N/mm2, and it exhibits 14% more drying shrinkage than control concrete. OPS can absorb more material.

Alengaram and Jumaat (2010) made lightweight concrete by utilising oil palm shells from industrial waste as coarse aggregate. Oil palm shells are retrieved when palm oil is produced from palm oil fruit. The maximum dry density of concrete including OPS aggregate is 1850 kg/m3. The density of OPS concrete is 22% lower than that of ordinary concrete. In concrete beams constructed with both types of concrete, the moment capacity of the lightweight OPS concrete is greater than that of the conventional concrete. Palm kernel shells are just as hard as normal aggregate, as shown in Fig. 2.4. Both conventional and palm oil concrete exhibit comparable flexural behaviour in reinforced concrete. Comparably to conventional concrete, OPS concrete deflects. Numerous studies demonstrate the substitution of fly ash, silica fume, and furnace slag for cement. Other researchers indicate that equivalent mechanical qualities can be achieved by substituting expanded clay aggregates, pumice, scoria, oil palm shells, and other materials for standard aggregates. Ali et al. (2011) improved the ductility and mechanical behaviour of lightweight concrete by adding hybrid fibres to lightweight concrete manufactured with natural pumice. In order to enhance the seismic performance of structures, lightweight concrete is essential.. Oil palm shells come from industrial wastes, whereas the remaining lightweight aggregates used to make lightweight concrete come from naturally occurring materials. By substituting industrial waste OPS for coarse aggregate in concrete, solid waste generated during the palm oil manufacturing process can be reduced, and air pollution can also be lessened.
lightweight aggregate (LWA) (Polat et al., 2010). Lightweight aggregate concrete, or LWAC, has been there since ancient times in the history of concrete technology. The fact that some of these structures are still standing strong attests to the durability of concrete (Chandra and Berntsson, 2002). LWA can be divided into two groups: naturally occurring and manufactured. The main naturally occurring LWAs include tuff, diatomite, pumice, scoria, and volcanic cinders.

Neville and Brooks (2008). Manufactured aggregates can be divided into two groups. Natural materials such as expanded clay, shale, slate, perlite, and vermiculite require additional processing (heating). Foamed or expanded blast-furnace slag, fly ash (sintered pulverised fuel ash), sintered slate, and colliery waste are examples of materials encountered as industrial byproducts (CEB/FIP, 1977). Palm Kernel Shells (PKS), or Oil Palm Shells

(OPS), are an alternative LWA in tropical regimes and countries with a palm oil industry. The use of OPS as a lightweight or porous aggregate in the creation of lightweight concrete has been the subject of early researchby Salam and Abdullah (1985) in Malaysia. The oil palm industry is important in several countries, such as Malaysia, Indonesia, and Nigeria. Malaysia is a global leader in the production and export of palm oil, producing around 57.6% of the world's supply, according to Subramanian et al. (2008) (Ahmad et al., 2010). One of the key pillars of the nation's economy, this sector generated around RM 28.60 billion in export revenue from palm oil and oil palm products in 2006 (MPOB, 2006). Large volumes of oil palm shells are produced by the oil mills (Figure 1). For instance, it was projected that Malaysia and Nigeria produce more than 4 million tonnes of oil palm shell (OPS) solid waste annually (Teo et al., 2006; Ndoke, 2006). OPS is utilised in the production of activated carbon and as a palliative for untarred roads in addition to serving as fuel for steam boilers in palm oil mills. In contrast, estimates of different forms of agricultural residues throughout South-East Asia are given in Figure 2 (ESCAP, 2007). This makes it clear that some countries have a lot of agricultural waste.

OPS can be used as a lightweight aggregate in structural lightweight aggregate concrete, per studies (Teo et al., 2007; Abdullah, 1996; Teo et al., 2006; Basri et al., 1999; Mannan and Ganapathy, 2001; Mannan and Ganapathy, 2004). Furthermore, OPS structural lightweight concrete offers good thermal performance as a material for low-cost housing, according to research by Harimi et al. (2007). In addition to bringing down the cost of building supplies, using this agricultural solid waste as a lightweight aggregate also addresses the problem of how to get rid of waste products made at palm oil mills. The authors believe that by compiling and evaluating the existing data on OPS concrete and comparing it to other lightweight aggregate concrete, significant advancements can be achieved. Furthermore, new research topics will be identified so that scientists can explore innovative lightweight concrete solutions in the context of environmental design and budgetary constraints. stone-based aggregates. Teo et al. (2007) state that this suggests the aggregate has good shock absorption. Since these shells are subjected to intense and varying braking forces, Koya and Fono (2009) demonstrated that they can be successfully used in brake lining formulations when combined with other additives in the right amounts.

There is only one report on the compressive strength of OPS aggregate. The indirect compressive strength test result for the OPS aggregate was 12.10 MPa, with a standard deviation of about 2 MPa, according to Okpalan (1990). Table 1 presents the chemical composition of the OPS aggregate. According to the table, when OPS ignites, there is about a 100% loss. This was stated in another source (Mannan and Ganapathy, 2002).

MATERIAL AND PROPERTIES

Cement: Since it serves as the binding agent for the various components, cement is by far the most significant component of concrete. composed of primary components that are found naturally, occasionally combined or mixed with industrial wastes. According to IS 10262, OPC 43 grades Ordinary Portland Cement (OPC) ultratech was the cement utilised in this investigation.

Figure: Cement

Table: Properties of cement

Characteristics	**Value obtained Experimentally (opc)**	**Value specified By is 8112:1989 (opc-43 grade)**
Normal consistency, Percent	**34**	**Na**
Fineness (m2/kg)	**330**	**225(min)**
Initial setting Times (minutes)	**125**	**30(min)**

Final setting Times (minutes)	**420**	**600(max)**
Compressive Strength, mpa (3 days)	**30.05**	**23 (min)**
Compressive Strength, mpa (7 days)	**45.75**	**33(min)**
Compressive Strength, mpa (28 days)	**52.39**	**(min)**
Specific gravity	**3.15**	**3.15**

Table: Chemical composition of cement

Type	**OPC %**
Sio2	**22.48**
Al2o3	**37.12**
Fe2o3	**33.01**
Cao	**59.03**
Mgo	**1.77**
K2o	**1.33**
Na2o	**0.36**
Tio2	**0.37**
So3	**4.20**
Loi	**3.486**

Fine Aggregate: Some people consider aggregates, which make up between 70 and 75 percent of the volume of concrete, to be inert substances in more than one way. Nonetheless, it is now well acknowledged that aggregates' physical, chemical, and thermal characteristics have a significant impact on the characteristics and functionality of concrete. Clean, dry sand was utilised as the fine aggregate, and it was sieved through a 4.75 mm sieve to eliminate any stones.

Figure: Fine Aggregate

Table: physical Properties of fine aggregate

Properties	**Value**
Specific Gravity	**2.63**
Fineness Modulus	**3.295**
Water absorption	**0.9%**
Bulk density	**1647kg/m3**

Coarse Aggregate: Concrete is made with coarse aggregate. They could take the shape of naturally existing pebbles or crooked pieces of stone. Coarse aggregates are materials too big to be retained on a 4.75 mm filter size. Its largest possible dimension is 63 mm.

Figure: Course aggregate

Table: physical Properties of coarse aggregate

Properties	Values
Specific Gravity	2.84
Size of Aggregates	20mm
Fineness Modulus	7.95
Water absorption	0.10%
Aggregate Impact value	24%
Aggregate Crushing value	28.70%
Abrasion value	27.02%

Water: Due to its participation in a chemical interaction with cement, water is crucial to the creation of concrete. The gel that forms as a result of the water serves to strengthen the concrete. You can use almost any naturally occurring water that is safe to drink, has no distinct taste or odour, and is suitable for blending. Generally speaking, water from lakes and streams that support marine life is also appropriate. The water utilised for the mixing and curing process needs to be pure and devoid of any harmful amounts of alkalies, acids, oils, salts, sugar, organic components, vegetable growth, or any other substances that could harm steel, concrete, bricks, or stone. For mixing, potable water is usually deemed adequate. The maximum allowable values (of harmful compounds in water) are represented by the following concentrations, where the pH value of the water cannot be below:

Table : Maximum limits of solids in water

Types of solids	Limits
Organic solids	200 mg/liter
Inorganic solids	3000 mg/liter
Sulphates	400 mg/liter
Chlorides	2000 mg/liter for concrete not containing embedded steel, and 500 mg/liter for reinforced concrete work
Suspended matter	2000 mg/liter

Oil Palm: As seen in Figure, OPS can be found in a variety of shapes, including curved, flaky, elongated, roughly parabolic, and other irregular shapes. Prior to being used as aggregate, the OPS was sieved; only aggregate that was kept on the 4.75 mm sieve and passed through the 12.5 mm sieve was used. Tables 5 and 6 present the chemical composition and physical characteristics of OPS, respectively.

Figure: oil palm shell

Table: Chemical properties of oil palm shell

Chemical Component	% of chemical Component
SiO_2	0.0146
Fe_2O_3	0.0333
Al_2O_3	0.130
CaO	0.0765
Na	0.00156
K_2O	0.00042
N	0.41
ASH	1.53
S	0.000783
MgO	0.0352
Cl^-	0.00072
Loss of ignition	98.5

Table: Physical properties of ops

Bulk density	0.74Mg/m3
Dry density	0.65Mg/m3
Void ratio	0.40
Porosity	28%
Water content	9%
Water absorption	14%
Specific gravity	1.62
Impact value	4.5%

METHODOLOGY

The aim of the experiment was to assess the properties of concrete made with Fine aggregates, coarse aggregate, cement and oil palm shell to study the various important aspects such as compressive strength of concrete Cube prepared by using Concrete materials and replacing oil palm shell with different percentage of replacements with coarse aggregate. In fresh state; the workability parameters such as slump cone test was studied. In hardened state; the strength tests such as compressive strength, workability, spilt tensile strength and flexural strength was studied. The study was carried out for mix design of concrete-M15 grade. In this study, concrete cubes casted for testing were of dimensions of 150×150×150 mm.
The study of this project is fully based on the experimental work. In this section of the dissertation, following steps are adopted during experimental work:

- To build a structure first we need to build its base or foundations. Likewise first of all Mix design for M15 grade of concrete is prepared according to the "INDIAN STANDARDS CODE" IS 10262:2009.
- In the preparation of mix design for M15 grade of concrete various physical properties of the materials like specific gravity, nominal size, water absorption capacity, fineness Modulus etc. are required, also some other conditions like type of exposure to sun and water, material mixing technique etc. are to be assumed in accordance with INDIAN STANDARD CODE IS 456:2000.
- After working out the quality of different materials in an appropriate proportion, it's time for the selection of materials.
- Keeping in mind the "INDIAN STANDARDS" materials are selected i.e., aggregates Conforming/full filling the various conditions as per IS 383:1970 and cement 43 grade OPC conforming to IS 12269:1987 are taken.
- Selected materials are mixed in a fixed proportion as per mix design to acquire the desired strength. Sampling & analysis of concrete is done according to IS 1199:1959.
- IS 2386 (Part 1): 1963 is used for the methods of tests for aggregates for concrete Specifically for shape and size of aggregates.
- Two important tests are performed on concrete namely 1) slump cone test and 2) compaction factor test, after preparation of mix for physical properties of concrete.
- Standard moulds of size 150 mm x 150 mm x 150 mm are then cleaned and oiled Concrete is poured in the moulds and different shaped reinforcements are placed in the Moulds.
- After 24 hrs. Concrete cubes are unbolted from moulds and named with water resistant paint and placed in the curing tank filled with normal water at 27 ± 2 0C for 28 days.
- At the end of 28 days curing it's time for the final test which gives the actual strength of concrete i.e., compression strength test in accordance with the "INDIAN STANDARD CODE" IS 516:1959 for the test of concrete.

TEST ON MATERIALS

The ordinary Portland cement was tested for physical properties such as:

- Fineness test
- Standard consistency test
- Setting time test
- Specific gravity
- Compressive strength test

The Fine and Coarse aggregates were tested for physical properties such as:

- Specific gravity
- Particle distribution test
- Water absorption.
- Abrasion test
- Impact value test
- Crushing value test

The fresh concrete was subjected to the following tests.

- Slump test

Properties were tested in the hardened state of the concrete are.

- Compressive strength test
- Flexural strength test
- Split tensile strength test

TESTING OF CEMENT

The physical test results on OPC are as follows.

Fineness of Cement

A sample of cement weighing 1000gm was taken in I.S. sieve no. 9(90 micron) the lump, if any were broken down carefully with the fingers without applying external force. The sample is then sieved continuously for 10 minutes by manually. The residue left on sieve was weighed. Fineness of cement was 2%.

Table:Fineness of Cement

Sr. No.	Weight of cement	Wt. of residue left on sieve	Finer on 90 micron sieve
1.	1000gm	2 %	98%
2.	1000gm	2 %	98%
3.	1000gm	1%	99%

Standard Consistency of Cement

Vicat apparatus with 10mm diameter plunger was used to find standard consistency. For the experiment, a 400g cement sample was obtained, and a paste containing a measured proportion of water was made. The paste was made according to regular procedure, and it took three to five minutes to fill the vicat mould entirely. The mould was then shook to remove any remaining air. A typical 10 mm diameter by 50 mm long plunger is fastened to the vicat equipment, lowered to the top of the cement paste in the test block, and then swiftly released to allow the plunger to sink into the paste due to its own weight. Calculate its quantity by taking into account the plunger's depth of penetration. Until the plunger penetrates between 5 and 7 mm from the bottom, the process is repeated.

Table: Standard consistency test for cement

Wt. of Cement	Quantity of water added (ml)	Penetration from bottom (mm)
400	128(34%)	7
400	132(33%)	6
400	128(33%)	4
Standard Consistency of Cement =34%		

Setting Time of Cement

Initial Setting Time of Cement

Vicat device is also used for time setting. To begin with Then add 0.85 P (standard consistency)% of water to get a fine cement paste. As soon as the water is introduced to the cement, set the stopwatch. After adding water to produce a paste, prepared cement paste is poured into the vicat mould. The mould is stored in the vicat device beneath the needle on a nonporous plate. Gently lower the needle until it makes contact with the test block's surface, then swiftly release it to allow it to pierce the block. After every minute, record the penetration of the needle. Continue reporting the process until the needle, measured from the bottom of the mould, pierces the block after 5 + 0.5 mm. Put the watch away and check the time. That is when it was first set.

Final Setting Time of Cement

Replace the needle of Vicat apparatus by needle with annular attachment. Go on releasing the needle till it makes an impression. The time that elapsed between the moment the water is added to cement and when the needle only makes impression is considered as final setting time.

Table:Initial and final Setting Time of Cement

Cement (gm)	400
Water (ml)	109
Initial Setting Time (min)	125
Final Setting Time (min)	420

Initial setting time = 125 minutes

Final setting time = 420 minutes [7 hours]

Figure: Vicat apparatus used for consistency test

Specific gravity of cement

Specific gravity bottle is used for specific gravity of cement. First of all Weight the dry specific gravity bottle (w1) then fill the bottle with distilled water and weight the bottle (w2). After that dry the specific gravity bottle and fill it with kerosene free from water and weight (w3). Pour some of the kerosene out and introduce a weighed quantity of cement (say about 65 gm.) into the bottle and with kerosene and weigh it (w).

Table: Specific Gravity of cement

Observations	Sample1	Sample2
Weight of empty dry bottle, w_1	50	50
Weight of bottle + water filled, w_2	150	150
Weight of bottle + kerosene filled, w_3	129	129
Weight of bottle + cement + kerosene, w_4	166	166
Weight of cement, w_5	50	40
Specific gravity($\frac{w5(w3 - w1)}{(w5 + w3 - w4)(w2 - w1)}$)	3.15	3.15
Mean Specific Gravity	3.15	

Figure: Specific gravity bottle uses for cement

Compressive strength of cement:

1. Clean the apparatus with the dry cloth and ensure that the room temperature for conducting this test should be 27 ± 2°C
2. Mix the cement and sand with the trowel for the period of 1 min on Non – porous plate. Ensure that the cement should not have any lumps in it
3. Now add water and mix for 3 minutes until the paste is of uniform colour. The quantity of water mixed with the cement, the sand mixture should be (P/4 + 3) % where P is the percentage of water required to produce the Standard consistency
4. Clean the mould with the dry cloth and apply the mould oil for easy removal of mortar cube after drying.
5. Now pour the mortar in steel cube mould. Prod the mortar for 20 times in 8 sec with the help of rod to eliminate the entrained air.
6. You can also use vibrator instead of a rod. The vibrator is played for the period of 2 mins with the speed 12000±400 vibrations /minute to eliminate the entrained air in mortar mix.
7. Once the vibration completes, immediately remove the mould from the vibration machine and place it in room temperature for 24 hrs.
8. Once mortar cube sets, After 24 hours dismantle the steel mould from mortar cube.
9. Keep the test specimens submerged underwater for the stipulated time. This process is called curing.
10. As previously stated, the specimen must be kept in water for seven, fourteen, or twenty-eight days, with a seven-day water change in between.
11. Test the three cubes on the seventh, fourteenth, and twenty-eighth days.
12. In the gap between the compressive strength machine's bearing surfaces, testing specimens (mortar cubes) are positioned.
13. The metal plates of the machine or specimen block must be kept free of any loose particles or grit.
14. The specimen must be loaded axially without any shock, and the loading must be raised at a rate of 35 N/mm2/min until the specimen collapses.
15. Due to the constant application of load on the face of the cube, the mortar cube starts cracking and fails at a point.
16. Note down the reading from Compressive testing machine where the specimen starts failing
17. Compressive strength of cement =max. load carried by specimen/top surface area of specimen

Table:Compressive Strength of Cement

C.S. of 3days	C.S. of 7days	C.S. of 28days
30.05 Mpa	45.75 Mpa	52.39 Mpa

CONCLUSION

The last findings are provided. These are based on a strength comparison using different OPS combinations. The following conclusions can be made in light of the previously given findings: In terms of recycling waste materials as well as strength and workability, OPS aggregate was generally determined to be a good substitute for coarse aggregate for creating concrete.The general strength of the 10%, 20%, and 30% OPS concrete samples met the requirements for light weight concrete, producing light weight concrete with a compressive strength of up to 21.72N/mm2 over a period of 28 days.

Concrete with 5% and 20% OPS content had the best and lowest compressive strengths, respectively. This implies that the compressive strength of OPS concrete samples is influenced by the quantity of OPS aggregate present in the sample. The quantity of OPS and the duration of the curing period were the two variables that determined the strength of the samples, yet the least desirable structural requirements for light weight concrete were satisfied. The study's initial findings on the workability of the concrete indicate poor workability; when the percentage of OPS increases, the workability rate of the concrete shows a relatively medium to low workability range, from 50 to zero slump height.

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