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EXPERIMENTAL INVESTIGATION ON LIGHTWEIGHT CONCRETE CONTAINING OIL PALM KERNEL SHELL AS REPLACEMENT OF COARSE AGGREGATE AND BINDING MATERIAL WITH FLYASH

V.MADHAVA
Professor, Dept. of CIVIL, SVIST, Kadapa

ABSTRACT

Humans have a fundamental desire for sanctuary. Unfortunately, enough housing for most people; the impoverished have proven difficult to find throughout time. The public has been concerned about the cost of concrete materials used in building and civil engineering projects. Due to these and other reasons, research has been done on genetic local resources that are dumped into the environment as waste and cause pollution and traffic jams as substitute materials. Therefore, the purpose of this research was to evaluate the use of palm kernel shell in concrete as a partial replacement for coarse aggregate. A biosolid waste from the palm oil industry in tropical areas, oil palm kernel shell (OPKS) may be used as an aggregate in concrete. OPKS has been used as a natural lightweight aggregate (LWC) in research projects since 1984 in order to create lightweight concrete. Grade M30 lightweight concrete, or oil palm kernel shell concrete (OPKSC), is compared to comparable strength normal weight concrete (NWC) in terms of its fresh, mechanical, and bond properties. Oil palm kernel shell (OPKS), an industrial waste, has been used into lightweight aggregates (LWA) by the OPKSC. For each combination of mix proportions of 10%, 20%, 30%, and 40% oil palm kernel shell partial substitution of course aggregate, a constant 5% flyash was employed as a favored replacement of binding material. In comparison with NWC, the OPKSC resulted in a density decrease of around 20%.

I. INTRODUCTION

Even though concrete is now the most widely used building material worldwide, the quest for optional building materials has been prompted by the high cost of important components like concrete, fine and coarse aggregate. The importance of cement in common works and development projects cannot be overstated. Due to the massive need for concrete in development, which makes use of usual weight totals (NWAs) like rock and sand, there has been lasting ecological harm caused by the massive depletion of normally occurring totals. Many of them are suitable for use as lightweight aggregate (LWA) to produce lightweight concrete, which has the advantage of reducing the weight of considerable structures when compared to ordinary cement, which has a high dead load. They may also be used for financial viability, adaptability, and underlying strength. Consequently, using these waste materials will help to reduce the rate at which non-renewable natural resources are used and produce concrete that is more durable. Expanded pelletized fly ash aggregates, sintered fly ash aggregates, expanded slag gravel, and blast furnace slag are examples of waste materials that are utilized to make lightweight aggregates. Waste utilization has really been shown to be effective in industrialized nations. Industrialized countries' contemporary design methodologies reveal a great deal about the caliber of the knowledge, research, and experience at hand. This leads to a faster wide-scale development of new lightweight aggregate kinds. The use of industrial and agricultural wastes as potential building materials has gained more attention, especially in emerging countries with strong agronomic sectors like India. Industrial wastes may be recycled to create ecologically friendly concrete, which is a sustainable substitute.

II. LITERATURE REVIEW

1. The influence of cementitious materials, fine and coarse total substance, on the functionality and compressive strength of palm part shell concrete was stated by U. Johnson Alengaram in his paper influence of Cementitious Materials and Total Substance on Palm Shell Concrete. 10% more silica rage was added to the cementitious material as an additional addition.
2. According to Payam Shafigh, one kind of strong waste used in horticulture in tropical environments is oil palm shell (OPS). OPS may be used as a lightweight total for making underlying lightweight total cement, according to analysis conducted over the last 20 years. OPS concrete has a thickness that is between 20 and 25 percent thinner than regular weight concrete.
3. Johnson Alengaram said in his paper that the mechanical, strength, and utilitarian qualities of OPKS concrete (OPKSC) are summarized along with the physical and mechanical characteristics of OPKS. Utilization of oil palm part shell as lightweight total in concrete - A survey.
4. Muhammad Aslam spoke about how the underlying lightweight cement is produced by the OPBC lightweight total. Because of its surface, OPBC complete has excellent holding strength when mixed with mortar. In his study, OPBC RC radiates exhibit shear and disappointment behavior that is similar to that of standard RC radiates. Side effects of oil palm as a lightweight overall in a significant combination.

III. METHODOLOGY

The project is completed by using the technique that is outlined below, and this chapter provides details on the different material processes.

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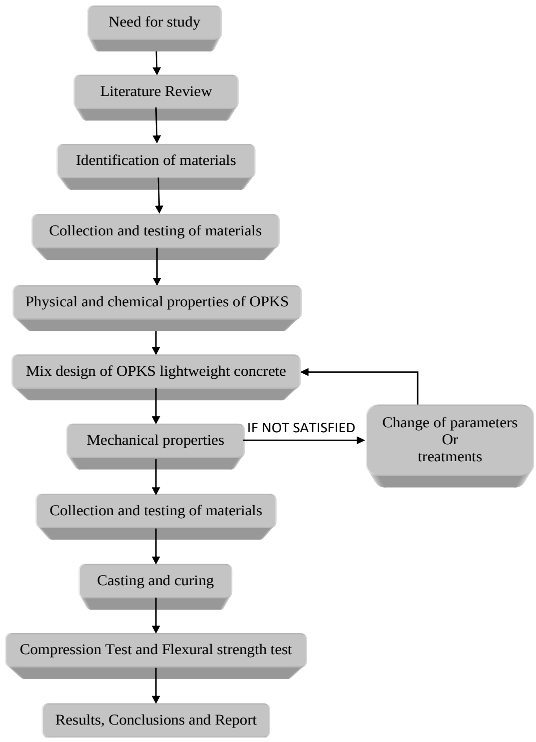

Fig 1 Methodology Flow Chart

OBJECTIVES

- To manufacture low density concrete, oil palm kernel shells may be used as a partial substitute for coarse aggregate and fly ash can be used as an alternate binding ingredient.
- Examine if it is feasible to create lightweight concrete by including OPKS as a coarse aggregate.
- To examine the alkali-silicate reaction in OPKS concrete by decreasing the OPKS aggregate's water absorption rate.
- Examine the mechanical characteristics of OPKS concrete.

MATERIALS USED

Typically, the items must be put in a dry atmosphere and allowed to naturally air dry. Below is a thorough explanation of every resource needed for this investigation:

Cement

Ordinary Portland cement in 53 grades was supplied by Ultra Tech Concrete Industrial Facility and used in the test.

Table 1 Properties of cement

PROPERTIES OF CEMENT	
Properties	Values
Specific gravity	3.17
Fineness	95%
Normal consistency	35%
Initial setting time	30mins
Final setting time	more than 30 mins

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Fig 2 Cement

Fine Aggregate

It describes the dimensional security of concrete and represents 60–80% of capacity and 70–80% of cement weight. Table 2 shows the actual parameters of the soil.

Table 2 Properties of Sand

PROPERTIES OF FINE AGGREGATE	
Properties	Values
Specific gravity of FA	2.55
Fineness modulus	2.58
Zone	III

The sieve analysis table & graph of fine aggregate is given in Table 3 & Fig. 7

Fineness Modulus FM $=\sum F/100$

$=258/100$

$= 2.58$

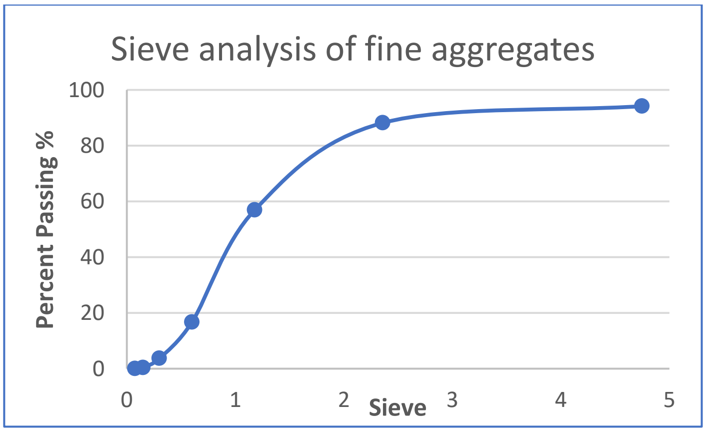

Fig 3 Sieve analysis of fine aggregates

Coarse Aggregate

Properties of totals have a significant impact on cement's toughness, strength, utility, and economy. Table 3 lists the real characteristics of the soil. Characteristics of the coarse aggregate

Table 3 Table Properties of Coarse Aggregate

PROPERTIES OF COARSE AGGREGATE	
Properties	Values
Explicit gravity	2.40

Oil Palm KernelShell

Oil Palm Portion Shells (OPKS), also known as Oil Palm Shells, are the by product of the production of palm oil and palm bit oil. They are the portions of shells that remain after the nuts are separated. After crushing palm kernels to remove the seed, which is used to make palm kernel oil, OPKS is produced as crushed bits of varying sizes, ranging from fine aggregates to coarse aggregates (Olutoge, 2010). Shells from oil palms are hard, brittle, and asymmetrical (Oti and Kinuthia, 2015). The palm kernel shell may be referred to by no particular kind of structure. The precedence of breaking during the nut shattering determines the structure. It often consists of a variety of forms, including flaky, quasi-circular, and nearly parabolical shapes, as well as other irregular shapes (Okafor, 1988). Because OPKS are solid by nature and do not readily break down when utilized in concrete, they do not get contaminated or leak to generate harmful materials (Basri et al., 1999). Depending on how the nut was cracked, 65–70% of the medium-sized particles in the 5–10 mm range may make up OPKS (Alengaram et al., 2010).

Fig 4 : Crushed oil palm kernel shells of different sizes

OPK's mechanical and physical characteristics make it ideal for a wide range of uses. For the purpose of creating concrete, it may be used as an aggregate (Okafor, 1988; Okpala, 1990; Osei and Jackson, 2012). OPKS was used as a sorbent material for industrial water treatment by Okoroigwe et al. (2014), who claimed that the material's chemical and physical characteristics made it appropriate for the job. OPKS is equally applicable to the building of roads. On the other hand, it is advised to replace bitumen and stone dust aggregate on intensively used roads with OPKS in a 10% asphalt mix (Ndoke, 2006). Additionally, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, has produced pozzolana, a cement alternative material, using OPKS (FAO Rome, 2002). Furthermore, Oti and Kinuthia (2015) used OPKS ash in the production of concrete and reported that it is more practical to utilize OPKS ash burned at 750°C in lieu of up to 509a Portland cement. Furthermore, OPKS may be used in part place of sand in the manufacturing of sandcrete blocks, according to a recent research. When the OPKS aggregate content is less than 109c, the blocks made from OPKS aggregates are denser, heavier, and stronger than those made from standard sandcrete (Dadzie and Yankah, 2015).

Physical properties for treated OPKS

The maximum grain size of the OPKS total used in this analysis is 12 mm, despite the fact that Malaysian OPKS has 13 mm. The 350–480 kg/m3 mass thickness of OPKS provides rationale for the reduced cement thickness. The amount of water used by the OPKS used in this study and Malaysian OPKS is similar. The OPKS thickness used in this investigation is 3 mm, but Malaysian OPKS varies in thickness from 0.3 to 8 mm. For the OPKS totals used in this analysis and Malaysian OPKS, the flakes record and extension list are similar, but they are greater than the usual totals.

Oil Palm Kernel Shell Concrete

Concrete made with oil palm kernel shell (OPKSC) largely replaces coarse material with OPKS. When the 28-day compressive strength is less than 17 MPa, the mix design determines whether the concrete is an Insulating Lightweight Concrete (ILWC) or Structural Light-Weight Concrete (SLWC). The American Concrete Institute (ACI) defines Structural Light Weight Concrete as a substantial through with low thickness total that has a 28-day compressive strength of more than 2,500 psi/17 MPa and an air-parched thickness of not more than 115 lb/ft" (1840 kg/m").SLWC was specified by BS 5328 (1997) as hardened concrete with an oven-dried density of no more than 2000 kg/m3. According to Okafor (1988), OPKS is appropriate for concrete grade 25 and lower but cannot be used in lieu of conventional coarse aggregate in concrete with a compressive strength more than 30 MPa. However, in their most recent investigation, Alengaram et al. (2010) increased the 28-day compressive solidarity to 36–38 MPa by combining silica smolder, and Shafigh et al. (2011) developed an alternative method to produce high-strength OPKS cement with a 28-day compressive strength of 53 MPa by using crushed OPKS. Osei and Jackson (2012) investigated OPKS as Coarse Aggregates in Concrete and found that it could replace coarse total by 100%; nevertheless, they recommended that volume clustering be used for better results.Many scientists have compared the mechanical and fundamental characteristics of OPKSC with ordinary weight concrete (NWC) in order to demonstrate the feasibility of OPKSC (Alengaram et al., 2013).

Physical properties of oil palm kernel shell concrete

The physical characteristics of NWC and OPKSC are identical. The primary physical characteristics of the concrete that OPKSC is concerned with are its workability, density, and water absorption capacity.

Work ability of Palm Kernel Shell Concrete

Workability, which is the ease with which concrete can be mixed, moved, laid, compacted, and completed without segregation, is the most crucial characteristic of new concrete. One common test used to assess whether concrete is workable is the slump test. It is used to measure the consistency of the concrete and compute variations in the uniformity of mix of a particular percentage. The amount of OPKS and the water to cement ratio determine how workable OPKSC is. As shown in Graph 3-2, Danashmand and Saadatian (2011) partially replaced coarse aggregate with OPKSC for varying percentages of OPKS (Oil Palm Shell-OPKS) content at a constant water cement ratio of 0.40. The results demonstrated that the workability of the concrete decreases as OPKS content increases.

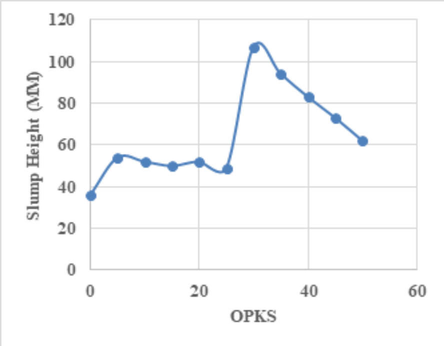

Fig 5: Slump Test for different percentage of OPKS content (Danashmand and Saadatian, 2011).

Workability is increased by a decrease in OPKS content and an increase in fine aggregate content, as shown by the results from many studies that are included in Table 5.

Table 5: Slump of OPKSC by researchers for different mixes

Author	w/c	Mix Proportion	Slump (mm)
Abdullah 1984	0.6	1:1.5:0.5	200
	0.4	1:2:0.6	260
Okafor 1988	0.48	1:1.7:2.08	8
	0.65	1:2.1:1.12	50
Okpala 1990	0.5	1:1:2	30
	0.6	1:1:2	63
	0.7	1:1:2	Collapse
	0.5	1:2:4	3
	0.6	i: 2:4	28
	0.7	1:2:4	55
Mahmud et al. 2009	0.35	1:1:0.8	160

Density of Palm Kernel Shell Concrete

When using light weight concrete (LWC) for structural purposes, mass is often more crucial than strength (Rossignolo et al., 2003). Concrete density is investigated in terms of its bulk, fresh, and dry densities. Okafor (1988) states that the fresh density of OPKSC varies between 1753 and 1763 kg/m', depending on the mix percentage, cement to water ratio, and sand use.Based on the mix percentage, Mannan and Ganapathy (2001) also reported the fresh density of OPKSC in the 1910–1958 kg/m' range. According to Alengaram et al. (2008), OPKSC's fresh density was around 1880 kg/m' after 0.7o silica fume and 5to fly ash were added by weight, with a cement: sand: aggregate: water ratio of 1.2:0.8:0.35. According to Alengaram et al. (2013), the freshing density of OPKSC is typically between one hundred and twenty kg/m3 less than the saturated density of LWC. Osei and Jackson (2015) demonstrated, as Graph 3-3 illustrates, that the dry density of OPKSC rises with curing time but decreases with an increase in OPKS concentration.

Water Absorption of Palm Kernel Shell Concrete

Pore distribution

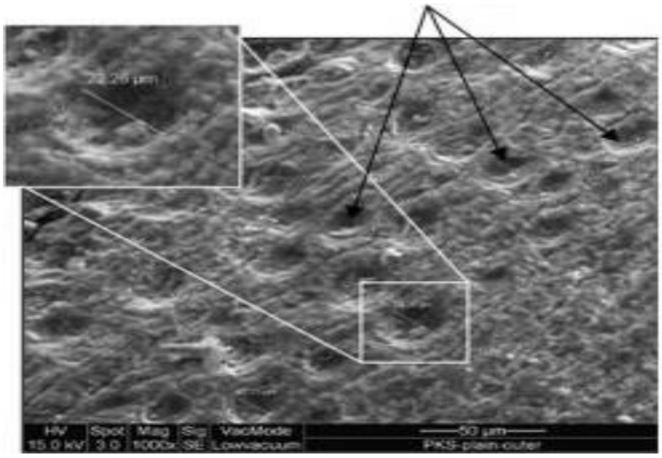

Fig 6: Pores of the outer surface of OPKS (Alengarametal.,2011).

According to Basheer et al. (2001), water assimilation is the ways that surface tension operating in the ducts affects the flow of liquids through porous substances. According to Babu and Babu (2003), the water absorption for LWC, such as expanded polystyrene concrete and pumice stone aggregate concrete, ranges from 369 to 22%, while Guduz and Ugur (2005) report the same range. Teo et al. (2007) demonstrated that the water absorption for OPKSC is 11.23' o for air dry curing and 10.64' o for complete water curing, respectively.

Mechanical properties of oil palm kernel shell concrete

The mixed design used affects the mechanical qualities of OPKSC. Blend plan procedures that work with conventional weight concrete are often difficult to implement with lightweight total cement, as Shetty (2005) points out. According to Abdullah (1996), in order to get a good blend plan for OPKSC, preliminary blends are crucial. Similarly, Osei and Jackson (2012) concluded that grouping by volume yields higher-quality mechanical characteristics than bunching by weight after clustering OPKSC data by volume and weight.

Compressive Strength of Oil Palm Kernel Shell Concrete

The most often used criterion to assess the quality of prepared concrete is its compressive strength (Weigrink et al., 1996). All other mechanical limits, such as modulus of flexibility, parting rigidity, and flexural strength, directly depend on the substantial's compressive strength (Alengaram et al., 2013).Graph 3-5 illustrates the findings of Ikponmwosa et al. (2014), Daneshmand and Saadatian (201 I), and Olutoge et al. (2012), who all stated that the quantity of OPKS aggregate in the concrete determines the compressive strength of OPKSC and that the strength improves with curing age.

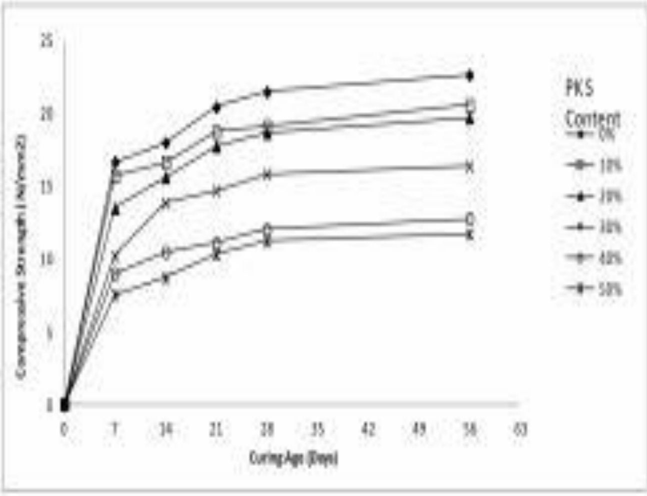

Fig 7: Compressive strength of OPKSC with maturation (Ikponmwosa et al., 2014)

Researchers have reported on varying grades of OPKSC depending on the mix design, proportion of OPKS aggregate, and curing technique. The compression strength of OPKSC by different researches is shown in Table 6. Okpala (1990) used a mix design of 1: 1: 2 (cement: sand: aggregate) with a water to cement ratio of 0.5 and reported a 28-day compressive strength of 22.2 MegaPa. With a water to cement ratio of 0.38 and a design mix of 1: 1.736: 0.72 (cement: sand: aggregate), Shafigh et al. (2011) integrated steel fibers and reported a 28-day compressive strength in the range of 39.34 — 44.95 MegaPa.

Table 6: The compressive strength of OPKSC at 28 — day

Author	Water/ Cement Ratio	Mix Proportion	Compressive Strength at 28days (MPa)
Okafor, 1988	0.48	1: 1.7: 2.08	23
Okpala, 1990	0.5	1: 1: 2	22.2
Alengaram et al., 2010	0.35	1: 1.2: 0.8	37.41
Shafigh et al., 2011	0.38	1: 1.736: 0.72 (+steel fibers)	39. 34-44.95

Suitability of oil palm kernel shells in concrete

Since 1984, OPKS has been tested in research as light weight aggregate (LWA) to create low-cost, light-weight concrete (Alengaram et al., 2013). Research conducted over the last 20 years, according to Shafigh et al. (2010), has shown that OPKS may be used as a lightweight component to produce low cost and very lightweight cement.Additionally, Yap et al. (2013) demonstrated that OPKS is a good substitute for coarse aggregate in order to produce high-level strength LWC with a compressive strength of up to 53 Mega Pa after 28 days.

Okafor (1988) examined the compressive, flexural, and malleable parting strengths of the OPKS concrete in addition to the shell's real characteristics. Three mixtures of usually distinct water were used to solidify the proportion, replacing the 1009c coarse total with OPKS. The tested attributes were compared to those of similar large instances that used crushed rock as the coarse aggregate.The material may be used to build concrete that is grade 25 or below, according to the findings. Additionally, Williams et al. (2014) produced some significant work with OPKS at a mix plan of I:2:4 (concrete: sand: coarse total) with a water to solidify percentage of 0.65, replacing the coarse total with 1009c. The results demonstrated that although the compressive and flexural strengths increased throughout the course of the relieving period, they were still lower in the OPKSC than in the NWC. They reasoned that OPKS can be used to supply LWC as it can be used for significant creation as a lightweight total. In any case, OPKS new cement has excellent, totally functional, dependable, and easily positioned qualities.

Consequently, using the information above, the OPKS is appropriate for producing low structural concrete by substituting coarse aggregate.

Fly Ash

Different types of debris are produced when coal ignites at high temperatures and pressures in power plants. The "fine" part of the debris is carried upward by the vent gases and collected before it reaches the climate by highly skilled electrostatic precipitators. We call this stuff fly debris. It resembles concrete and is mostly composed of exceedingly thin, polished circles. The chunk of coarse debris is siphoned to tidal ponds by being mixed with water in the meshes underneath the boilers. This substance, referred to as base debris, has a surface that resembles filthy sand. There has long been a system in place for the use of base and fly debris in development. Applications include adding cement to concrete, using it as a simple filler, and using it as a lightweight total when making squares. Making use of fly debris is a climate-friendly move. Fly ash is used in many applications to replace naturally occurring aggregates and minerals, which may significantly reduce interest in naturally occurring aggregates (stone). In addition, fly ash is part of the process used to create flowable fill, which is used as a self-leveling, self-compacting inlay material instead of granular or compacted earth. Flowable fill is a mixture of Portland concrete and filler material that may also include fly debris or other mineral admixtures. The majority of the time, fine total (sand) makes up filler material. However, some flowable fill mixes may include about equal portions of coarse and fine totals.

Properties of fly ash

Research by KhairulNizar (2007) has shown that climate and soil science have an impact on the physical and chemical characteristics of FLA. Similarly, research conducted in 2014 by Mohd Mustafa Al Bakri Abdullah revealed that waste produced during quarrying may be the reason for differences in FLA's physical and chemical characteristics. Thus, the chemistry, climate, and internal grain structure applied during the cooling of molten lead have a significant influence on the characteristics of FLA.

Chemical Properties of Fly Ash

Table 7 introduces the compound synthetics of FLA from various places. The main components of fly debris include silicon, aluminum, iron, and calcium oxides. Less prominently, magnesium, potassium, sodium, titanium, and sulfur are also found. Depending on the material organization, fly ash is classified as Class C or Class F debris when it is used as a mineral additive in concrete. The content of Class C and Class F fly debris is characterized by American Society for Testing and Materials (ASTM) Specification C 618 and American Association of State Highway Transportation Officials (AASHTO) M 295.

- The majority of Class C remnants are obtained from sub-bituminous coals and mostly consist of calcium alumino-sulfate glass, tricalcium aluminate, quartz, and free lime (CaO). Class C debris, which often includes more than 20% CaO, is also referred to as high calcium fly debris.
- Class F cinders are mostly made of an alumino-silicate glass, while they also include quartz, mullite, and magnetite. They are often obtained from bituminous and anthracite coals. Under 10% CaO is found in Class F, or low calcium fly debris.

Table 7: The Chemical composition of fly ash

Compounds	Fly Ash Class F	Fly Ash Class C	Portland Cement
SiO_2	55	40	23
Al_2O_3	26	17	4
Fe_2O_3	7	6	2
CaO (Lime)	9	24	64
MgO	2	5	2
SO_3	1	3	2

Physical Properties of Fly Ash

Colour

Fly dung may range in color from brown to dark gray, depending on the chemical and mineral components. Light and tan tones are often associated with high lime content. The iron component is often associated with a caramel tone. Elevated unburned carbon concentration is often associated with a dull, dim to dark tone. Normally, fly powdery gray is quite consistent for every force plant and coal supply.

Super Plasticizer

- An industrially accessible sulfonated naphthalene formaldehyde-based superplasticizer

(CONPLAST SP 430) was utilized as a synthetic admixture to upgrade the usefulness of the solid.

- To give astounding quickening of solidarity acquire at early ages and significant expansion in strength at all ages by altogether diminishing water interest in the solid blend.
- Particularly appropriate for high early strength necessities.
- To essentially improve the functionality of blended and expanding water.
- To give improved toughness by expanding by-expanding extreme strength and lessening solid penetrability.

Dosage

7ml of conplast for 1kg of cement

Fig 8: Conplast

Water

Consumable water utilized for projecting and relieving.

CONCRETE MIX PROPORTION

Stipulations for Proportioning

Grade designation: M30
Type of cement: OPC 53grade
Max nominal size of aggregate: 20mm
Min cement content: 320kg/m^3
Maxw/cratio: 0.40
Workability: 25-50 mm (slump)
Exposure condition: Mild
Degree of supervision: Good
Type of aggregate: Crushed angular
Max cement content: 450kg/m^3
Chemical admixture: Super-plasticizer

Test Data of Materials

Compressive strength	**= 30 N/mm^2**
Aggregate Type	**= Crushed**
Degree of workability	**= 0.90**
Degree of quality control	**= Good**

Type of exposure = Mild
Specific Gravity, Cement = 3.15
Coarse aggregate = 2.6
Fine aggregate = 2.6
Water Absorption, Coarse aggregate = 0.5%
Fine aggregate = 1.0 %

IV. RESULTS

Compressive Strength after 7Day

The deliberate compressive strength esteems are introduced in the accompanying Tables. The outcomes got for different rates of Fly ash and Oil palm kernel shell i.e., 0%, 10%, 20%, 30%, and 40%of Oil palm kernel shell and 5 % of fly ash is arranged. In view of the test outcomes, diagrams are plotted.

Table 8: Compressive Strength after 7 days

S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	LWC-OP0	20.74	20.091
		21.09	
		20.89	
2	LWC-OP10	21.67	21.85
		21.92	
		21.96	
3	LWC-OP20	23.21	23.29
		23.26	
		23.30	
4	LWC-OP30	24.52	24.75
		24.54	
		25.18	
5	LWC-OP40	24.37	23.48
		23.07	
		23.01	

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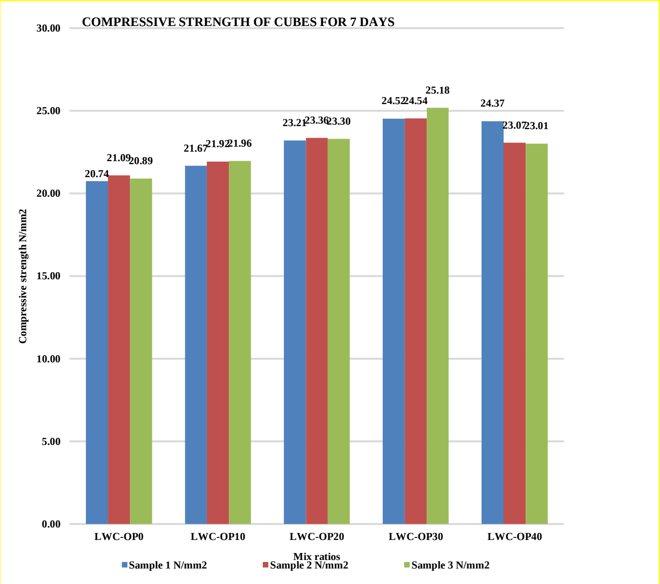

Figure 9: Compressive strength after 7 days

Table 9: Compressive Strength after 14 days

S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	LWC-OP0	30.11	29.95
		30.37	
		29.37	
2	LWC-OP10	28.01	30.26
		31.24	
		31.52	
3	LWC-OP20	32.15	32.25
		32.45	
		32.16	
4	LWC-OP30	34.02	34.26
		34.26	
		34.49	
5	LWC-OP40	32.10	32.52
		32.90	
		32.56	

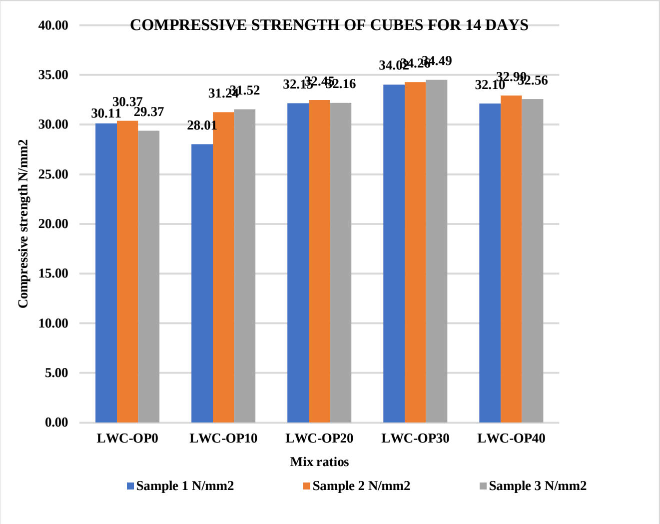

Figure 10: Compressive strength after 14 days

Table 10: Compressive Strength after 28 days

S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	LWC-OP0	30.81	32.17
		33.41	
		32.31	
2	LWC-OP10	33.51	33.62
		33.45	
		33.90	
3	LWC-OP20	35.74	35.83
		35.91	
		35.85	
4	LWC-OP30	38.59	38.07
		37.69	
		37.94	
5	LWC-OP40	35.62	36.13
		36.49	
		36.29	

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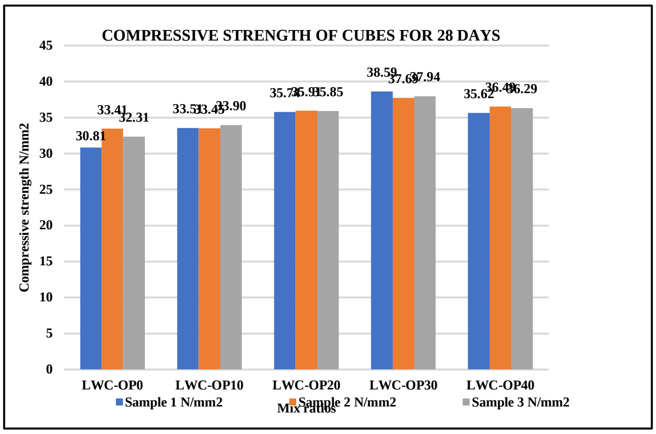

Figure 11 : Compressive strength after 28 days

Table 11: Comparison of Compressive Strength between 7,14, 28 days

S.No.	Mix	7 days	14 days	28 days
1	**OPKSC0**	20.91	28.95	32.17
2	**OPKSC10**	21.85	30.26	33.62
3	**OPKSC20**	23.29	32.25	35.83
4	**OPKSC30**	24.75	34.26	38.07
5	**OPKSC40**	23.48	32.52	36.13

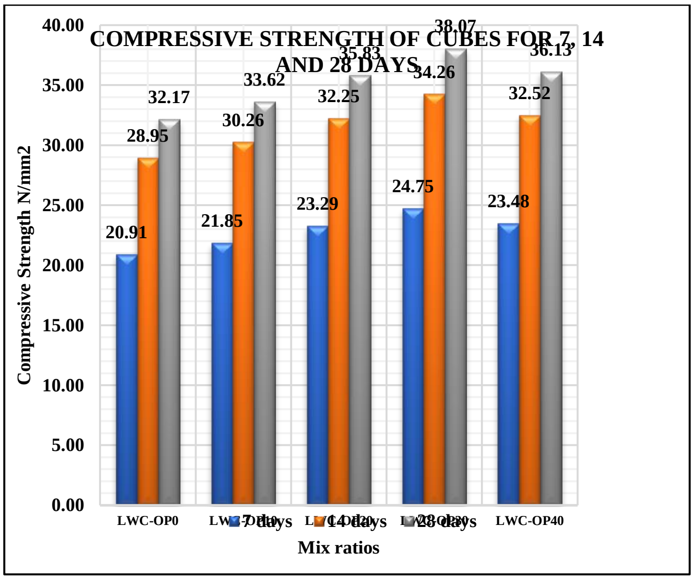

Figure 12 : Compressive strength after 7, 14, 28 days

Table 12: Flexural Strength after 7 days

S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	LWC-OP0	20.74	20.091
		21.09	
		20.89	
2	LWC-OP10	21.67	21.85
		21.92	
		21.96	
3	LWC-OP20	23.21	23.29
		23.26	
		23.30	
4	LWC-OP30	24.52	24.75
		24.54	
		25.18	
5	LWC-OP40	24.37	23.48
		23.07	
		23.01	

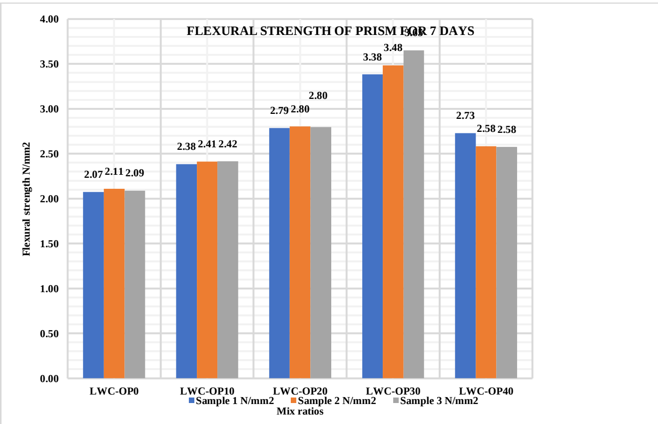

Figure 13 : Flexural strength after 7 days

Table 13: Flexural Strength after 14 days

S. No.	Percentage of Replacement	Compressive strength (N/mm2)	Average compressive strength (N/mm2)
1	LWC-OP0	20.74	20.091
		21.09	
		20.89	
2	LWC-OP10	21.67	21.85

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		21.92	
		21.96	
3	LWC-OP20	23.21	23.29
		23.26	
		23.30	
4	LWC-OP30	24.52	24.75
		24.54	
		25.18	
5	LWC-OP40	24.37	23.48
		23.07	
		23.01	

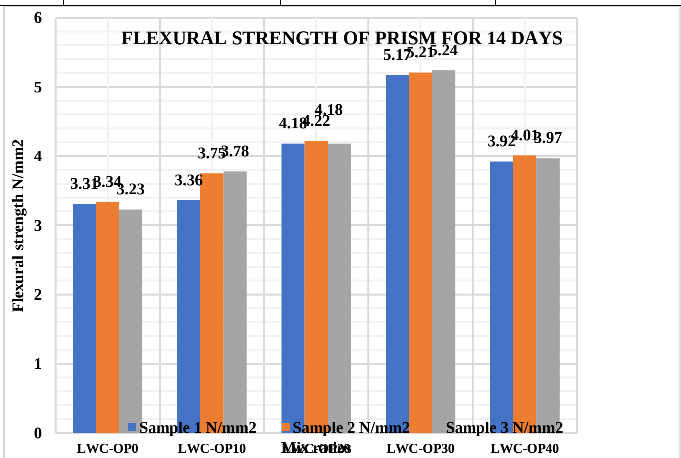

Figure 14 : Flexural strength after 14 days

Table 10: Flexural Strength after 28 days

S. No.	**Percentage of Replacement**	**Compressive strength (N/mm2)**	**Average compressive strength (N/mm2)**
1	LWC-OP0	20.74	20.091
		21.09	
		20.89	
2	LWC-OP10	21.67	21.85
		21.92	
		21.96	
3	LWC-OP20	23.21	23.29
		23.26	
		23.30	
4	LWC-OP30	24.52	24.75
		24.54	
		25.18	

5	LWC-OP40	24.37	23.48
		23.07	
		23.01	

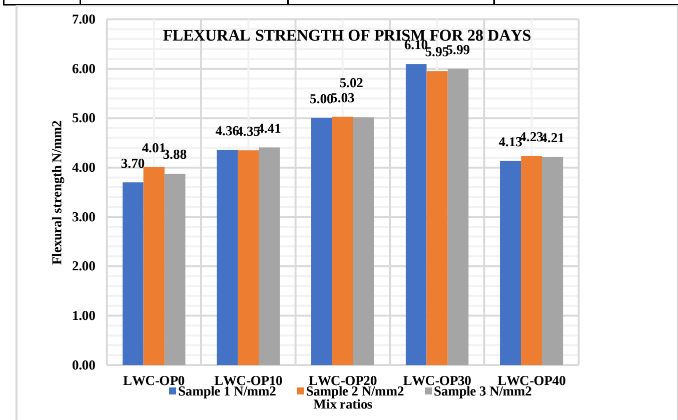

Figure 15 : Flexural strength after 28 days

Table 10: Flexural Strength after 7,14, 28 days

S.No.	Mix	7 days	14 days	28 days
1	**LWC-OP0**	4.18	6.59	7.72
2	**LWC-OP10**	4.81	7.26	8.74
3	**LWC-OP20**	5.59	8.39	10.03
4	**LWC-OP30**	7.01	10.41	12.03
5	**LWC-OP40**	5.26	7.93	8.38

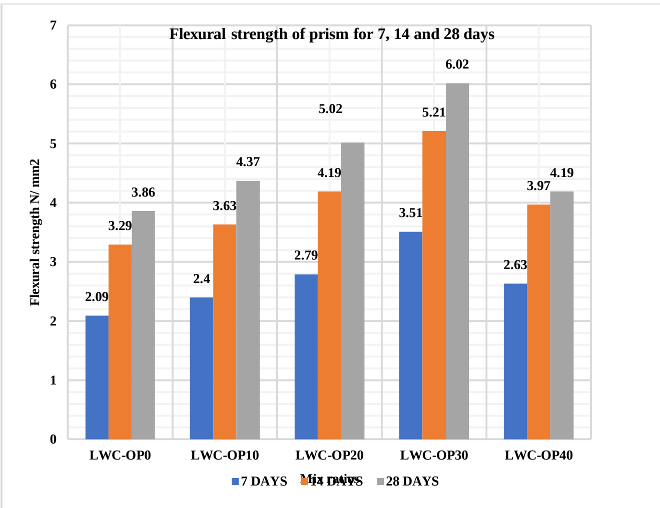

Figure 16 : Flexural strength after 7,14,28 days

CONCLUSION

The final observations stem from a comparison analysis of strength with varying replacement percentages in OPKS. One may make the following assumptions in light of the data mentioned above.

✓ Generally speaking, OPKS total was designed to be a good substitute for coarse total while making frivolous cement, which has a 24-to 25% water absorption rate. As a result, Operations have a coating that repels water. This helps maintain the 6% water assimilation rate.

✓ The NTOPKS concrete's utility and toughness are affected by the greater water concrete percentage, which is around 20% higher when more mineral water is used overall. Given that the compressive strength of NTOPKS concrete is forty-five percent lower than that of TOPKS concrete, the functional impact is evident.

✓ Tests on 10%, 20%, 30%, and 40% OPKS concrete with 5% fly debris added to all blend proportions produced lightweight cement with a compressive strength of at least 33.62 N/mm2 for 28 days and up to 38.07 N/mm2, meeting the requirement for underlying light weight concrete.

✓ The concrete that has a 30% replacement delivers the highest results in all tests, including the flexural and pressure tests. 40% replacement results in the lowest flexural, flexible, and compressive strength along with a greater reduction in cement load. Either way, the two factors—the relieving duration and the OPKS measure—determine the strength of the significant.

✓ Finally, given that the results of the 10% replacement test indicate a density of more than 2000 kg/m3, fractional lightweight cement is what we may infer from them.

✓ Forty percent of the cases also take into account fully lightweight concrete, but since the results are unsatisfactory, they are regarded as non-primary lightweight concrete.

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