International Journal of Scientific & Engineering Research Volume 9, Issue 1, January-2018
ISSN 2229-5518

Structural Concrete Using Oil Palm Shell As Lightweight Aggregate

Manasmita paikaray[1] , Ankit Jena

Abstract— This paper represents the experimental results to produce structural Lightweight concrete (LWC) using oil palm shell (OPS). It has been widely used in buildings as masonry blocks, wall panels, roof decks and precast concrete units. For low-cost housing construction and also for use in earthquake prone areas. Structures were constructed on the c ampus, which is located near the coastal area. When OPS blended with cement, it makes the most eco-friendly versatile supplementary cementing material to concrete. Reported in the paper are compressive strength, workability and density of oil palm shell concrete.

Index Terms — Compressive strength, Density, Eco-friendly, Light weight aggregate,Oil palm shell, Slump height, Workability.

———————————— ◆ ————————————

1 INTRODUCTION

1.1 There were many experimental work conducted to improve the property of the concrete by putting new materials, whether it is natural material or recycled materials or synthetic materials in the concrete mix. A large number of agricultural wastes were disposed in most of tropical countries especially in Asia for countries like Thailand, Philippines and Malaysia. If the waste cannot be disposed properly it will lead to social and environmental problems. The high cost of conventional building material is a major factor affecting housing delivery in Malaysia. This has necessitated research into alternative materials of construction.The present investigation deals with the various characteristics of the basic ingredients of concrete e.g. cement, OPS fine aggregate and coarse aggregate.

1.2 Lightweight concrete

Lightweight concrete, similar to normal weight concrete, is a mixture of water, Portland cement or Ordinary Portland Cement (OPC), and aggregate. Lightweight aggregate concrete uses a variety of aggregates with lower density than normal weight concrete.LWA can be divided into two categories

A. Those occurring naturally and are ready to use only with mechanical treatment, i.e., crushing and sieving.

B. Those produced by thermal treatment from either naturally occurring materials or from industrial by-products, waste materials, etc

In this study, oil palm shell is used as light weight aggregate Production of lightweight concrete is a technology aimed at reducing dead load on structures and to reduce the overall cost of the structure. Nearly all LWACs are fire resistant. In addition, depending upon the densities and strength, the concrete can be easily cut, nailed, drilled, and chiseled with ordinary wood working tools. The use of agricultural waste as aggregates can provide an alternative to conventional methods for production of lightweight aggregates. Structural concrete with densities from 1000 to 2000 kg/m3 can be prepared. Compressive strength up to 80MPa can be achieved.FIG.1 shows the sample of OPS.

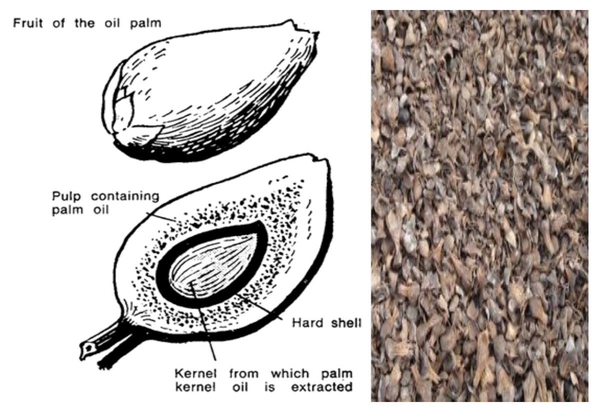

FIG.1 Sample of OPS

[1]Manasmita paikaray
Assistant professor.St. Martin's engineering college
SyNo.98, DulapallyRoad, Dhulapally, NearKompally, Hyderabad, Telangana-500014 Email: manasmitapaikaray@gmail.com

ISSN 2229-5518

2 OBJECTIVES

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 study the mechanical properties of the oil palm shell concrete and compare it with the properties of the normal weight concrete of similar grade

3 MATERIALS

3.1 Cement

The cement selected for the present work is Ordinary Portland cement (OPC). Ramco Cement, OPC 43-grade is used in the present study. . It conforms to the requirements of Indian Standard IS: 12269-1987.The chemical composition of it ,is in Table 1

TABLE 1
CHEMICAL COMPOSITION OF CEMENT

Type	OPC%
SiO_2	22.48
Al_2O_3	7.12
Fe_2O_3	3.01
CaO	59.03
MgO	1.77
K_2O	1.33
Na_2O	0.36
TiO_2	0.37
SO_3	4.20
LOI	3.846

The physical property of cement specified by IS 8112:1989 and also the experimental results are listed in table 2

TABLE 2
PHYSICAL 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)
Specific gravity	3.15	3.15
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)

3.2 Coarse Aggregate

The size of coarse aggregate used is 20 mm. It is also tested as per IS: 383-1970 specification. Figure 2 shows the particle size gradation curve of Natural coarse aggregate (NCA)

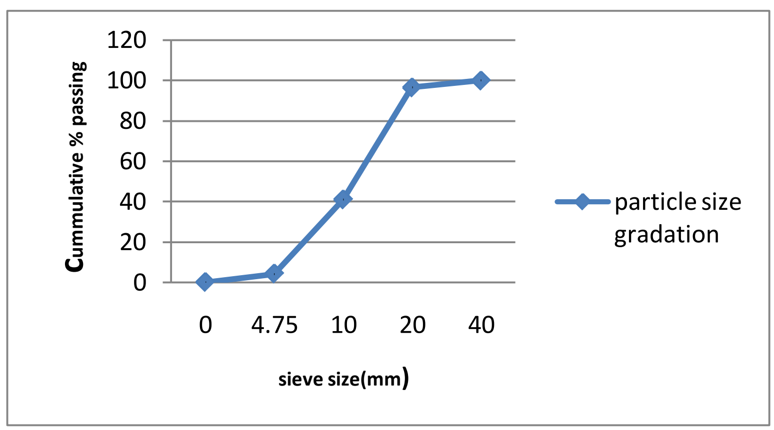

FIG.2 Particle size gradation curve of natural coarse aggregate

The physical Properties of natural coarse aggregate shows in table 3

TABLE 3

PHYSICAL PROPERTIES OF NATURAL COARSE AGGREGATE

CHARACTERISTICS	VALUE OBTAINED EXPERIMENTALLY AS PER IS :383-1970
SPECIFIC GRAVITY	2.84
ABRASION VALUE (%)	27.02
IMPACT VALUE (%)	24.00
CRUSHING VALUE (%)	28.70
WATER ABSORPTION (%)	0.10
FINENESS MODULUS	7.95

3.3 Sand (Natural Fine Aggregate)

Sand is used as fine aggregate which is passing through IS 4.75 mm sieve.By Sieve analysis Fine Aggregate sample conforms to grading Zone III (IS: 383-1970)

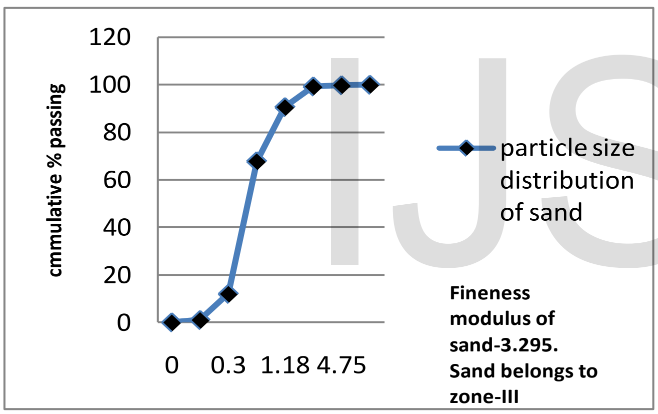

FIG.3 Particle size gradation curve of sand

The physical properties of fine aggregate are listed in Table 4

Table 4

physical properties of fine aggregate

CHARACTERISTICS	VALUE OBTAINED EXPERIMENTALLY AS PER IS 383-1970
FINENESS MODULUS	3.295 (ZONE III)
SPECIFIC GRAVITY	2.63
WATER ABSORPTION	0.9%
BULK DENSITY(KG/M3)	1647

3.4 Oil Palm Shell

OPS is available in various shapes, such as curved, flaky, elongated, roughly parabolic, and other irregular shapes as shown in Figure 4

FIG.4 Irregular shape of OPS

Before the OPS was used as aggregate, it was sieved and only aggregate passing through the 12.5 mm sieve and retained on the 4.75 mm sieve was used.

The chemical composition and physical properties of OPS are presented in Tables 5 and 6 respectively

TABLE 5

CHEMICAL COMPOSITION OF OPS

ASH	1.53
NITROGEN (AS N)	0.41
SULPHUR (AS S)	0.000783
CALCIUM (AS CAO)	0.0765
MAGNESIUM (AS MGO)	0.0352
SODIUM (AS NA)	0.00156
POTASSIUM (AS K2O)	0.00042
ALUMINIUM (AS AL2O3)	0.130
IRON (AS FE2O3)	0.0333
SILICA (AS SIO2)	0.0146
CHLORIDE ((AS CL-)	0.00072
LOSS ON IGNITION	98.5

TABLE 6

PHYSICAL PROPERTIES OF OPS

PROPERTY	VALUE
BULK DENSITY MG/M3	0.74
DRY DENSITY MG/M3	0.65
VOID RATIO	0.40
POROSITY (%)	28
WATER CONTENT (%)	9
WATER ABSORPTION (%)	14
SPECIFIC GRAVITY	1.62
IMPACT VALUE (%)	4.5

4 EXPERIMENTAL PROGRAM

4.1Mix Proportions

A concrete mixture of M15 was designed as per standard specification IS: 10262-1982 to achieve target mean strength 20.77MPa. The other Four concrete mixtures were made by replacing up to 20% of coarse aggregate with different combination percentage of OPS by mass to perform a light weight aggregate concrete. Five mixes are prepared as P0, P1, P2, P3, P4. P0 indicate concrete mix with 0% OPS. P0 indicate concrete mix with 0% OPS. P1 indicate concrete mix with 5% OPS. P2 indicate concrete mix with 10% OPS. P3 indicate concrete mix with 15% OPS. P4 indicate concrete mix with 20% OPS. The detail mix proportion along with their identification is designated according to replacement of coarse aggregate by different percentage of OPS. Table- 7 represents the different sample with amount of cement, sand, coarse aggregate and ops.

TABLE- 7

DIFFERENTSAMPLES

SAMPLE	%OPS	CEMENT	SAND	AGGREGATE	OPS	TOTAL WEIGHT OF SAMPLE
P0	0	1.114KG	2.051	4.345	0	7.51
P1	5	1.114KG	2.051	4.127	0.217	7.51
P2	10	1.114KG	2.051	3.910	0.434	7.51
P3	15	1.114KG	2.051	3.693	0.651	7.51
P4	20	1.114KG	2.051	3.476	0.869	7.51

As the percentage of OPS increases w/c ratio increases. To increase the w/c ratio we have to decrease the cement content or increase the water content. If we decrease the cement content, the strength of concrete will decrease. So to maintain the strength of concrete the water content was increased in accordance to percentage increase of OPS. Table 8 represents the weight of sample with increased % of water

TABLE- 8

WEIGHT OF SAMPLE WITH INCREASED % OF WATER

Sample	Increase amount of water	Weight of sample	Amount of water (lit)	Total weight of sample
P_0	-	7.51	0.646	8.156
P_1	5% of water	7.51	0.678	8.188
P_2	10% of water	7.51	0.710	8.22
P_3	15% of water	7.51	0.742	8.252
P_4	20% of water	7.51	0.775	8.285

4.2 Mixing, Casting and Curing

The required amount of all dry materials such as coarse aggregate, fine aggregate, cement, ops were weighed (by mass) and placed in the concrete mixer and it was thoroughly mixed. The specified water of required amount for respective mix is then added during mixing. Workability of fresh concrete was measured by slump test immediately after mixing. The test specimens were cast in steel mould and compacted by using table vibrator and demoulded after24 hours.Thereafter the specimen cured for 3, 7 and 28 days in a curing chamber under water. Figure 5 shows the sample of casting of specimen.

FIG.5 Sample of casting ofspecimen

4.3 TESTING OF SAMPLE

4.3.1 Fresh Concrete Test

The fresh concrete test was conducted to know the workability of concrete. Slump test was conducted for each batch of mixing. The slump test before lifting is shown in Figures 6

FIG.6 slump test before lifting

4.3.2. Hardened Concrete Test

Compressive strength test

The tests on cubes were carried out using compressive testing machine. The compressive strength was computed by using the expression

fck= P/ B2 for cubes

Where, fck = Compressive strength in MPa

P = maximum applied load in Newton

B = Size of the cube specimen in mm

5 RESULTS AND DISCUSSION

5.1 WORKABILITY

The main variable in the mixtures was aggregate and water content. In these experimental programs the work has been carried out in 4 cycles. In the first cycle, 5% coarse aggregate replaced by OPS. In the second cycle, 10% coarse aggregate replaced by OPS. In the third cycle, 15% coarse aggregate replaced by OPS. Similarly in the fourth cycle,20% coarse aggregate replaced by OPS. The density and compressive strength, test were conducted and results are presented along with the graphical plots and discussions.

The workability of fresh concrete is measured by slump test. Fresh concrete mix was prepared and then slump test was done immediately after the mixing. The variation of slump value is given in Tables 9 for different concrete mix having replacement of OPS by 0%,5%,10%,15%,20%.

TABLE-9

SLUMP VALUE

SAMPLE	% OF OPS	SLUMP HEIGHT (mm)
P_0	0	31.3
P_1	5	51.3
P_2	10	44.6
P_3	15	10.4
P_4	20	0

It is obvious that workability of concrete reduces as the amount percentage of OPS increases except for 5% OPS where it shows a spike in workability, to which from that point, as the percentage of OPS increases, the workability of the concrete reduces. This can be attributed to the fact that since the control aggregate is denser than the OPS aggregate, and the replacement is by weight, the specific surface increases as the OPS content increases.

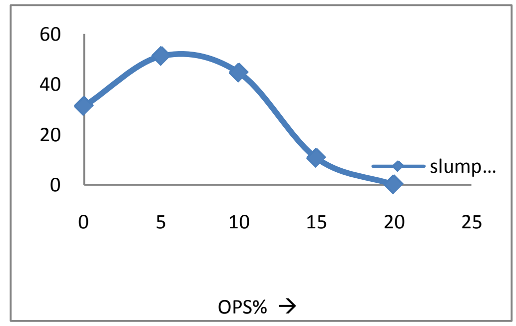

figure 8 shows the graph between slump height and % of OPS

5.2 Density of specimens

The densities of all samples were determined to find the possibility of structural LWC component. Densities of three samples were determined to which the average is taken to determine the actual density of each sample. The density is determined using mass and volume of the sample.

Table 10 shows the average density of samples in 3,7 and 28days

TABLE 10

DENSITY OF SAMPLES

sample	AVERAGE DENSITY		
	3DAYS(kg/m3)	*7DAYS*(kg/m3)	*28DAYS*(kg/m3)
P_0	2529.40	2541.74	2554.07
P_1	2430.88	2447	2464.13
P_2	2299.25	2317.03	2325.92
P_3	2227.17	2247.08	2271.30
P_4	2119.96	2170.61	2171.6

From the hypothesis of this study, it was known that concrete strength will be reduced as the amount of OPS increases. This can be contributed to the generally light weight nature of OPS aggregates having a unit weight of less than 2000 kg/m3, which is approximately 60% lighter compared to the conventional crushed stone aggregate . This consequently results to the production of LWC. With LWC normally having a density of less than 2000 kg/m3,so 25%and 30% OPS aggregate samples are considered as LWC samples.since OPS aggregate is lighter in weight than coarse aggregate, as coarse aggregate is been replaced at different percentages, resulting to a lesser amount of coarse aggregate in the mix, absorption of cement paste is greatly reduced as OPS aggregate do not properly bond with cement, this reduces the overall density of concrete, thus leading to the making of LWC. Figure 9 shows the graph between density of samples with curing age.

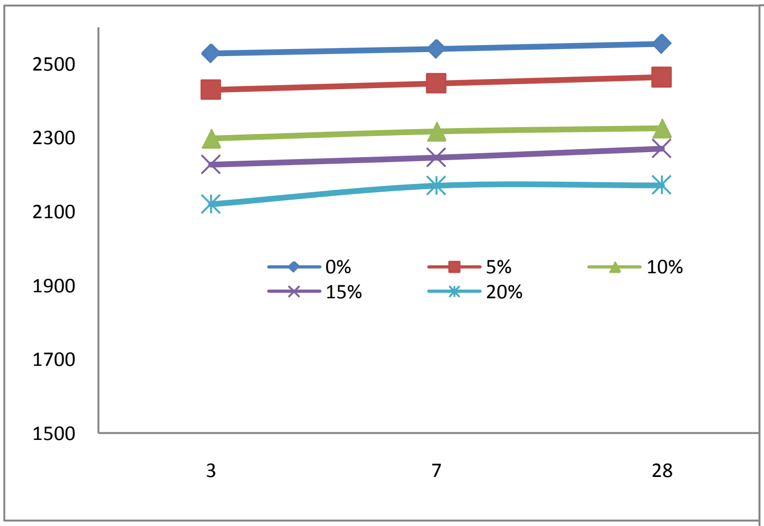

FIG 9 GRAPH BETWEEN DENSITY OF SAMPLES WITH CURING AGE.

5.3 Compressive strength

The test results of cubes for three cycles. And summary of compressive strength are presented in a table-11

TABLE 11
COMPRESSIVE STRENGTH OF SAMPLE

sample	Compressive strength		
	3DAYS(N/mm^2)	*7DAYS*(N/mm^2)	*28DAYS*(N/mm^2)
P_0	17.10	23.90	25.86
P_1	12.16	23.6	25.50
P_2	11.69	15.54	22.96
P_3	12.30	18.86	22.57
P_4	14.08	20.61	21.72

Figure 10 and Table 11 show the development of compressive strength of concrete with age. It indicates the different amount of OPS that were added, as it affects the strength of the concrete. The rate of strength gained was substantial as the curing day's increases, while on the other hand, the strength of the concrete decreases as the percentage of OPS increases. The compressive strength of the concrete specimens is reciprocal to the percentage of OPS added.

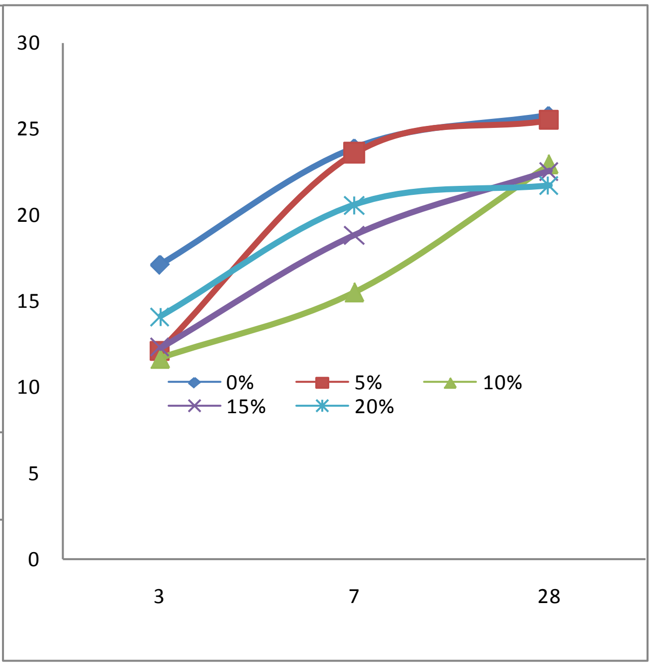

FIG .10 GRAPH BETWEEN COMPRESIVE STRENGTH OF SAMPLES WITH CURING AGE.

As it is clear, 0% OPS attained the maximum strength, as OPS gradually replaces the coarse aggregate, so the concrete strength is gradually dropped. These phenomena could be explained from the fact that OPS are organic materials that happen to be lighter and less strong than the usual coarse aggregate. Furthermore, the reduction in strength of concrete strength as a result of increment in the added percentage of OPS aggregate could be attributed as a result of the highly irregular shapes of the OPS, which prevent full compaction with usual coarse aggregate, there by affecting the strength of the concrete. More also, the bonds between OPS and cement paste were not as strong as that of control concrete because of the smoothness of the sample .Taking 28 days as the reference curing day, 0%, 10%, 20% certified the condition of high strength concrete. Even at least curing days of 3, 7days, when concrete strength is at its least, some samples attained a very high strength. The compressive strength developed for 50% OPS in 28 days, which has the most amount of OPS is quite above the range of 20.10 – 24.20 N/mm2 requirement for structural LWC components.

6 CONCLUSIONS

The concluding remarks are obtained from the comparative study of strength using different combination of OPS is presentedBased on the above results the following conclusions may be drawn:

In general OPS aggregate was founded to be a good replacer of coarse aggregate in concrete production from strength and workability point of view and according to recycle of waste material.The general strength of 10%, 20% and 30% OPS concrete samples produced light weight concrete with compressive strength reaching up to 21.72N/mm2 for 28 days, which satisfies the requirement for light weight concrete.Concrete with 5% OPS and 20% OPS had the highest and least compressive strength respectively, which indicates that the compressive strength of OPS concrete samples is dependent on the amount of OPS aggregate in the sample. However, even though the strength of the samples have been dependant on those two variables, i.e. amount of OPS and curing period, the least desirable structural requirement for light weight concrete was achieved. The fresh concrete results of this research indicate the low workability ,as the % of OPS increases the rate of workability of concrete shows a relatively medium to low workability ranging from 50 to zero slump height.As age of curing increases, compressive strength, of concrete increases.The effect of water and OPS enhance the compressive strength of concrete at all ages.From the result we conclude that 5%,10%,15%,20% OPS samples could be considered as partial light weight concrete, but not fully light weight concrete due to density more than 2000kg/m3.Finally, 30% OPS is the ideal percentage of OPS which is in the boundary limit of the production of light weight concrete. In addition further more study, it can be recommended to use of additional admixtures and to look through influence of aging in long term study

7 REFERENCES

[1] Alengaram U.J., Hilmi Mahmud and Mohd Zamin Jumaat, Comparison of Mechanical and Bond Properties of Oil Palm Kernel Shell Concrete with Normal Weight Concrete, International Journal of Physical Science, Vol. 5(8), pp.1231-1239, 2010.

[2] Basri H.B , Mannan M.A. , Zain M.F.M., Concrete Using Waste Oil Palm Shells as Aggregate, Cement and Concrete Research Vol-29, pp. 619-622, 1999

[3] Teo D.C.L., Man.nan, and V.J. Kurian , Structural Concrete Using Oil Palm Shell (OPS) as Lightweigh Aggragate, Turkish J. Eng. Env. Sci, Vol 30, pp. 1-7, 2006

[4] Mannan M.A., Ganapathy C. 2004, Concrete from an agricultural waste-Oil Palm shell, Building and Environment Vol-39, Issue (2004), pp. 441-448

[5] Payam Shafigh, Mohd Zamin Jumaat and Hilmi Mahmud, Mix Design and Mechanical Properties of Oil Palm Shell Light Weight Aggregate Cocrete: A Review Paper, International Journal of the Physical Science, Vol. 5, No. 14, pp. 2127-2134, 2010