An Experimental Study on Partial Replacement of Cement with Groundnut Shell Ash in a Concrete Mix for Rigid Pavements

Malugu Ravi Prasanth[1], Dr. NC Anil[2], P Sanyasi Naidu[3]

[1]PG Student, [2]Associate Professor, [3]Assistant Professor
Civil Engineering Department
Sanketika Institute of Technology and Management

Abstract: **Concrete is the most popular binding material that is being used for many years and is serving the purpose of binding very effectively. Concrete doesn't represent a single material. It is the combination of binding material, aggregates, and water. Concrete has many applications in design and construction industries. It has become indispensable and very popular because of its accessibility and ease of manufacturing. Even though numerous binding materials have been invented in the construction industry, the usage of this wonderful material has not decreased but has been increasing every day. But in the recent days, the manufacture of concrete ingredients is posing many problems. For example, the manufacturing of cement1 on a huge scale is increasing the environmental pollution. The concrete industry is trying constantly to find the alternate materials for cement. Fly ash has been used as the alternate material for their placement of cement for many years. Apart from these materials, for replacement, many innovative materials are also being used as replacement materials in the recent construction works. Some of the replacement materials are the rice-husk ash, silica fume, Ground Granulated Blast Furnace Slag (GGBS) etc., These replacement materials are being used in case of high strength concrete also. In my study, I have used Groundnut Shell Ash (GNSA) as a partial replacement of cement. The use of agricultural waste products such as groundnut shells as a replacement for cement could reduce the cost of construction and helps take care of energy and disposal problems.**

Experimental studies were performed on Conventional concrete with replacement of cement with groundnut shell ash is done. The Compressive Strength Test, Split Tensile test and Flexural Strength of concrete with 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% replacement of cement with ground nut shell ash cured in normal water for 3,7, 14, 28, 56 and 91days are done. From Compressive strength test and the Split tensile strength tests, it is observed that up to 10% replacement there is increase in strength and after 10% after replacement there is decrease in strength shows that 10% replacement of cement shows better results and the flexural strength of concrete is increased when the replacement of Cement with groundnut shell ash up to 15% replaces by weight of Cement.

***Keywords*: Concrete, Cement Groundnut shell ash, Compressive strength, Flexural strength**

I. INTRODUCTION

A. *General*

Concrete is the most popular binding material that is being used for many years Band is serving the purpose of binding very effectively. Concrete doesn't represent a single material. It is the combination of binding material, aggregates, and water. Concrete has many applications in design and construction industries. It has become indispensable and very popular because of its accessibility and ease of manufacturing. Even though numerous binding materials have been invented in the construction industry, the usage of this wonderful material has not decreased but has been increasing every day. But in the recent days, the manufacture of concrete ingredients is posing many problems. For example, the manufacturing of cement1 on a huge scale is increasing the environmental pollution. The concrete industry is trying constantly to find the alternate materials for cement. Fly ash has been used as the alternate material for their placement of cement for many years. Apart from these materials, for replacement, many innovative materials are also being used as replacement materials in the recent construction works. Some of the replacement materials are the rice-husk ash, silica fume, Ground Granulated Blast Furnace Slag (GGBS) etc., These replacement materials are being used in case of high strength concrete also. In my study, I have used Groundnut Shell Ash (GNSA) as a partial replacement of cement. The use of agricultural waste products such as groundnut shells as a replacement for cement could reduce the cost of construction and helps take care of energy and disposal problems.

B. *About Ground Nut*

Groundnut botanically belongs to Araches hypo Gaea Linn of a leguminous family. Groundnut is a self-pollinated; annual and herbaceous legume crop. The complete seed of groundnut is called pod and contains one to five kermis which develops underground in a needle like structure called peg which grows into the soil and then converts into a pod. Groundnut has tap root system which has many nodules, present in root and lateral roots. These nodules contain Rhizobium bacteria, which are symbiotic in nature and focus atmospheric nitrogen. The outer layer of groundnut is called groundnut shell: The shell constitutes about 25- 35% of the pod. The seed accounts for the remaining portion (65-75%).

C. *Test Data for Materials*

- Type of cement or grade of cement- OPC 53 grade
- Specific gravity of cement = 3.12
- Specific gravity of coarse aggregates = 2.527
- Specific gravity of fine aggregates = 2.62

D. *Design of concrete mix*

- Target mean strength(f)- Fck+1.65(s)= 15+1.65(3.5) =20.775N/mm2
- Water cement ratio=0.6
- Water content =186litres
- Cement content per m3 of concrete -310 kg
- Percentage of entrapped air -2%
- Fine aggregates required-620 kg/m3
- Coarse aggregate required – 1240kg/m3

E. *Mix proportions by weight*

Cement	Fine aggregate	Coarse aggregate	w/c ratio
310	620	1240	186
1	2	4	0.6

TABLE -1 Mix ratio for plain cement concrete

Research Objectives:

The objectives of the study are:

- To recognize and assess various supplementary materials obtained as by- products for partial replacement of cement.
- To develop a green and economical substitute to cement by using groundnut shell ash
- To minimize the overall environmental effects of cement production using these resources as partial replacement

Need of the Project

Cement is the costliest rand energy intensive component of concrete. The unit cost of concrete can be reduced by partial replacement of cement with groundnut shell ash. Concrete making with conventional material is becoming costlier day by day.

II. LITERATURE REVIEW

A. *General*

In this following chapter, for our experimental Programme purpose, some important publications were reviewed in order to get a broad idea about using Ground nut shell ash in Concrete mixes and they have been listed in the references at the end of the report.

Alabadan, B. A., et al. (January-June 2005),

This paper studies on partial replacement of ordinary Portland cement (OPC) with Bambara groundnut shell ash (BGSA) in concrete. The ash contained 10.91% CaO, 2.16%, Fe2O3, 4.72% MgO, 33.36% SiO2, 1.75% Al2O3, 16.18% K2O,9.30% Na2O, 6.40% SO3, 6.02% CO3 and 9.20% HCO3. 10%, 20%, 30%, 40%, 50% and 0% ash was used in the mix to replace cement. The strength of cement/ash concrete increased with curing period but decreased with increasing ash percentage. The highest strength was 31.24N/mm2 and 20.68N/mm2 at 28 days for 0% and 10% ash respectively. Substitution of cement with ash in concrete formation was relatively possible not exceeding 10%. Though the strength of OPC/BGSA concrete was lower than that of 100% cement; it can be used for light load bearing elements.

B.A. Alabadan et al. (2006)

Estimates the Potentials of Groundnut Shell Ash as Concrete Admixture, Pozzolanic materials have long demonstrated their effectiveness in producing high-performance concrete. Artificial pozzolanas such as rice husk ash have gained acceptance as supplementary cementing materials in many parts of the World. This work evaluates the potentials of groundnut shell ash (GSA) as a partial replacement for ordinary Portland cement (OPC) in concrete. Chemical analysis of the ash was carried out to ascertain whether it possesses Pozzolanic or cementing properties and the partial replacement of OPC by GSA was varied from 0% to 70% in the concrete.

B.H. Sada, Y.D. Amartey, S. Bako (2013)

Studied Investigation into the use of Groundnut shell as a fine aggregate replacement. The suitability of groundnut shell as a constituent material in concrete was investigated by replacing proportions by volume of fine aggregate (river sand) with groundnut shells. Physical properties of cement, groundnut shells, and aggregates were determined. Concrete cubes measuring 150x150x150mm were cast. Groundnut shells were used to replace fine aggregate at 0, 5, 15, 25, 50 and 75% replacement levels Increase in percentage of groundnut shells in the cubes led to a corresponding reduction in densities of the cubes and compressive strength values. At a replacement value of 25% and above, of fine aggregate with groundnut shells; lightweight concrete was produced which could be used where low stress is required. Hence groundnut shells can be used for the Production of light weight concrete.

III. METHODOLOGY AND EXPERIMENTAL MATERIALS

A. *Methodology*

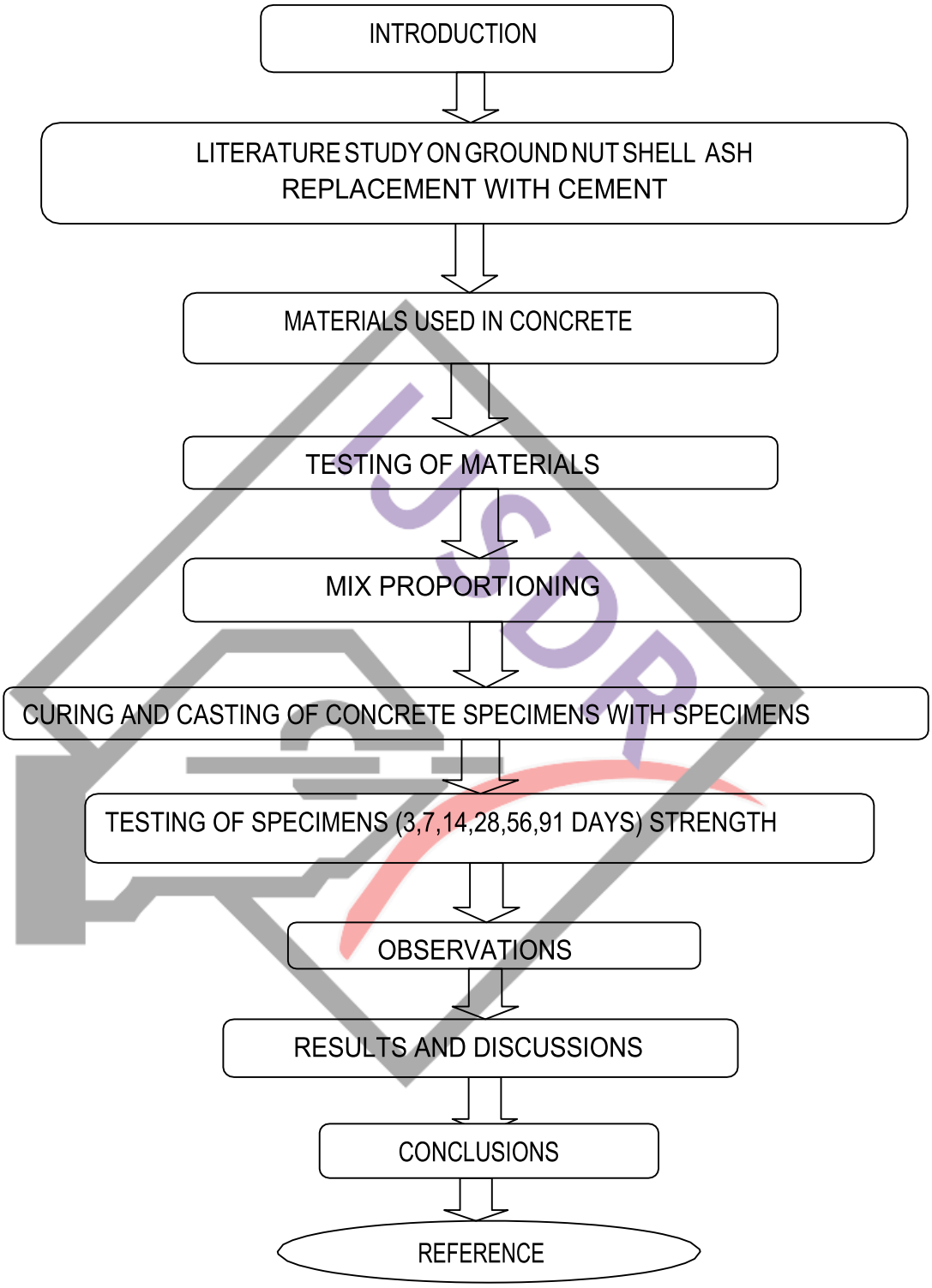


Fig 3.1 Methodology

The above chapter briefly explains the methodology adopted for this experimental work. In the first phase, the physical properties of the ingredients of concrete have been found and also a mix design for concrete was calculated. Then the results of the preliminary test the entire all the specimens, moulds, concrete mixing and curing and testing are made in the future.

B. *Materials Used in the Experimental Work*

The materials used in experimental work are:

- Cement
- Coarse aggregate
- Water
- Groundnut shell ash

1. *Cement:*

The most common cement used in construction is ordinary Portland cement conforming to IS: 12269- 1987.This type of cement is typically used in construction and is readily available from a variety of sources. The cement is fresh and uniform color. The cement is free from lumps and foreign matter.

The fineness is used to quantify the surface area of cement. The surface area provides a direct indication of the cement fineness. The typical fineness of cement ranges from 350 to 500 sq/kg. The type of cement used all throughout the experiment was Ordinary Portland Cement of grade 53 (OPC-53). This is the most common type of cement used in general concrete construction where there is no exposure to sulphates in the soil or in the ground water.

Fig. 3.2.1 Image of cement used

2. *Fine Aggregate:*

The locally available river sand is used as fine aggregate in the present project. The sand is free from clay, silt, and organic impurities. The sand is tested for various properties like specific gravity, bulk density etc…., and accordance with IS 2386-19637. These test results are tabulated in table

Fig 3.2.2: image of sand used

3. *Coarse Aggregate:*

Crushed granular aggregate obtained from the local quarry is used as the coarse aggregate. The aggregate used is free from any of the deleterious substances. The aggregates are found to contain percentage of alkalis within prescribed limits which may otherwise provoke the alkali-aggregate reaction. The aggregates that are used satisfy the properties according to IS 2386-19638.Machine crushed angular granite metal of 20mm nominal size from the local source is used as coarse aggregate in this project. It is free from impurities8 such as dust, clay, particles and organic matter etc…, coarse aggregate is also tested with various properties. The specific gravity, bulk density shown in the table.

Fig 3.2.3: image of coarse aggregate use

4. *Ground Nut Shell ASH:*

The ground nut shell ash was obtained from groundnut shells which are a by- product of groundnut processing and it is considered an agricultural waste from groundnut milling process. This particular one was obtained from the groundnut milling machine shed in the small market in Srikakulam. It was sun dried and then burnt. The burnt ash was passed through a BS sieve of 150 microns. The portion passing through the sieve which has the required fineness of 0.063 mm was used for the test while the residue was thrown away. Ground nut shell contains physical and chemical properties as shown in the table:

Fig 3.2.4: ground nut shell ash

5. *Compressive Strength of Concrete Specimens:*

Concrete specimen's cubes are tested to determine the compressive strength by automatic compressive testing machine as per IS: 516-1969. And results are tabulated in the following. The results of the compressive strength test carried out are shown in the table and graph below. It shows that compressive strength increases as the days of cubes curing increase and decreases when the percentage of ground nut shells ash increase. At 0% ash and 100% cement that served as the control, compressive strength increased from 6.27 N/mm2at 3 days to 28.4 N/mm2 at 28days Compressive strength of 90:10% cement /ash increases from 8.24 N/mm2 at 3days to 23.15N/mm2 at 28days

The compressive strength for 35% ash replacement were 2.6 N/mm2,8.2 N/mm2, 7.52 N/mm2, 8.92N/mm2 ,25.2 N/mm2 , and 24.5 N/mm2 for 3,7, 14,28,56 and 91 days respectively. According to BS 8110 a grade 15 concrete of 1:2:4 without any mixing with cement should have acquired strength of 6.27 N/mm2 within 3 days of wet curing 24.5 N/mm2 within 91 days based on the result obtained from this report work, OPC/GASH of 90:10% would be suitable for concrete. The results show that their strength improves with age since pozzolanas react more slowly than cement due to variation in their constituent's composition. The pattern of this study was similar to they reported that cement blended with pozzolanas would produce 65 to 95 % strength of OPC concrete in 91 days. As previous described by, a percentage replacement of 10% with GSA will be adequate for good concrete work

6. *Split Tensile Strength of Conrete Cylinders*

Concrete cylinders of 300 mm height and 150 mm diameter are placed horizontally in automatic compressive testing machine loading is applied until the failure of the cylinder along the vertical diameter. Results of split tensile strength test are tabulated in table. The result below shows that split tensile strength for the 100:0% cement/ground nut shell ash is 0.82 N/mm2, 1.8 N/mm2,2.1N/mm2, 2.7N/mm2, 3.2 N/mm2 and 3.5 N/mm2 for 3,7, 14,28,56 and 91days respectively while it was for 90:10% cement/ground nut shell ash is 0.98N/mm2, 1.6 N/mm2,2N/mm2, 3.2N/mm2, 4.2N/mm2 and 4.3N/mm2 for 3,7, 14,28,56 and 91days. The result shows that 15% of ground nut ash replacement gives the better result when compared to other replacement. The split tensile strength increases as the age of the concrete increase.

IV. RESULTS AND DISCUSSIONS

A. *Test Results*

S.NO	PROPERTIES	TEST RESULTS	REQUIREMENT AS PER IS 12269-1987
1.	Normal consistency	32%	----------
2.	Setting time		
	Initial (minutes)	50	Not less than 30
	Final (minutes)	180	Not more than 600
3.	Specific gravity	3.15	----------
4.	Compressive strength of cement	53Mpa	53 Mpa

	(28 days)		
5.	Specific surface gravity	320 m2/kg	Should not less than 225m2/kg
6.	Soundness mm	7	10 maximum
7.	Fineness, m2/kg	245	225 minimum

TABLE-4.1: PROPERTIES OF CEMENT

S.No	Properties	Test Results
1.	Specific gravity	2.52
2.	Fineness modulus	6.104
3.	Zone	I.
4.	Mean particle size	0.1-0.2µm
5.	Partial size	Spherical

TABLE-4.2: PHYSICAL PROPERTIES OF FINE AGGREGATE

S.NO	PROPERTIES	TEST RESULTS
1.	Specific gravity	2.56
2.	Fineness modulus	2.385
3.	Zone	I.
4.	Mean particle size	0.1-0.2µm
5.	Particle size	Angular

TABLE-4.3: PHYSICAL PROPERTIES OF COARSE AGGREGATE

Constituent	Percentage composition GNSA (%)
Silica(SiO_2)	16.3
ferrous oxide (Fe_2O_3)	1.7
Calcium oxide(CaO)	8.69
Aluminum oxide(Al_2O_3)	6
Magnesium oxide(MgO)	7
Sodium oxide(Na_2O_3)	10
Potassium oxide(K_2O)	16
sulphite(SO_3^{2-})	6.3

TABLE-4.1.1:7 DAYS COMPRESSIVE STRENGTH RESULTS

S.No	SAMPLE DESIGNATION	PERCENTAGE REPLACEMENT OF CEMENT	PERCENTAGE REPLACEMENT OF GROUN NUT SHELL ASH	COMPRESSIVE STRENGTH AFTER 7 DAYS (N/mm^2)
1.	C_9	100%	0%	13.65
2.	C_{10}	95%	5%	13.7
3.	C_{11}	90%	10%	15.6
4.	C_{12}	85%	15%	12.75
5.	C_{13}	80%	20%	11.53
6.	C_{14}	75%	25%	10.34
7.	C_{15}	70%	30%	8.2
8.	C_{16}	65%	35%	5.9

TABLE-4.1.1: 7 DAYS COMPRESSIVE STRENGTH RESULT

FOR 28 DAYS, COMPRESSIVE STRENGTH RESULT

S.NO	SAMPLE DESIGN A TIO	PERCENTAGE REPLACEMENT OF CEMENT	PERCENTAGE REPLACEMEN OF GROUND NUT SHELL ASH	COMPRE SSIVE STRENGTH AFTER 28 DAYS (N/mm^2)
1.	C25	100%	0%	17.35
2.	C26	95%	5%	18.13
3.	C27	90%	10 %	23.15
4.	C28	85%	15%	18.26
5.	C29	80%	20%	15.32
6.	C30	75%	25%	13.5
7.	C31	70%	30%	10.81
8.	C32	65%	35%	8.9

TABLE-4.1.2: 28 DAYS COMPRESSIVE STRENGTH RESULT

B. *4.2 Split Tesnile Results With (Gsn) for 7 Days, Split Tensile Strength Results*

S.NO	SAMPLE DESIGNA TION	PERCENTAGE REPLACEMENT OF CEMENT	PERCENTAGE REPLACEMENT OF GROUND NUT SHELL ASH	SPLIT TENSILE STRENGTH AFTER 7 DAYS (N/mm^2)
1.	S9	100%	0%	1.8
2.	S10	95%	5%	1.5
3.	S11	90%	10%	2
4.	S12	85%	15%	1.6
5.	S13	80%	20%	1.3
6.	S14	75%	25%	0.99

TABLE-4.2.1: 7 DAYS SPLIT TENSILE STRENGTH RESULTS

FOR 28 DAYS, SPLIT TENSILE STRENGTH RESULTS

S.NO	SAMPLE DESIGNA TION	PERCENTAGE REPLACEMENT OF CEMEN	PERCENTAGE REPLACEMENT OF GROUND NUT SHELL ASH	SPLIT TENSILE STRENGTH AFTER 28 DAYS (N/mm^2)
1.	S25	100%	0%	2.7
2.	S26	95%	5%	2.5
3.	S27	90%	10%	3
4.	S28	85%	15%	3.2
5.	S29	80%	20%	2.1
6.	S30	75%	25%	1.8
7.	S31	70%	30%	1
8.	S32	65%	35%	0.55

TABLE-4.2.2: 28 DAYS SPLIT TENSILE STRENGTH RESULTS

FOR 7 DAYS, FLEXURAL STRENGTH RESULTS

S.NO	SAMPLE DESIGN TION	PERCENTAGE REPLACEMENT OF CEMENT	PERCENTAGE REPLACEMENT OF GROUND NUT SHELL ASH	FLEXURAL STRENGT AFTER 7 DAYS (N/mm^2)
1.	F9	100%	0%	6
2.	F10	95%	5%	5.7
3.	F11	90%	10%	5.92
4.	F12	85%	15%	6.2
5.	F13	80%	20%	5.7
6.	F14	75%	25%	5.23
7.	F15	70%	30%	4.98
8.	F16	65%	35%	4.5

TABLE-4.3.1: 7 DAYS FLEXURAL STRENGTH RESU

FOR 28 DAYS, FLEXURAL STRENGTH RESULTS

S.NO	SAMPLE DESIGNA TION	PERCENTAGE REPLACEMENT OF CEMENT	PERCENTAGE REPLACEMENT OF GROUND NUT SHELL ASH	FLEXURAL STRENGTH AFTER 28 DAYS (N/mm^2)
1.	F_{25}	100%	0%	7.2
2.	F_{26}	95%	5%	6.88
3.	F_{27}	90%	10%	6.94
4.	F_{28}	85%	15%	7.5
5.	F_{29}	80%	20%	6.85
6.	F_{30}	75%	25%	5.988
7.	F_{31}	70%	30%	5.54
8.	F_{32}	65%	35%	5.12

TABLE-4.3.2: 28 DAYS FLEXURAL STRENGTH RESULT

C. *Slump Test Values for Concrete*

	0%	5%	10%	15%	20%	25%	30%	35%
slump test	25	24	24.5	23	22	22.5	21	20

TABLE 4.3: SLUMP TEST VALUES FOR CONCR

D. *Discussion:*

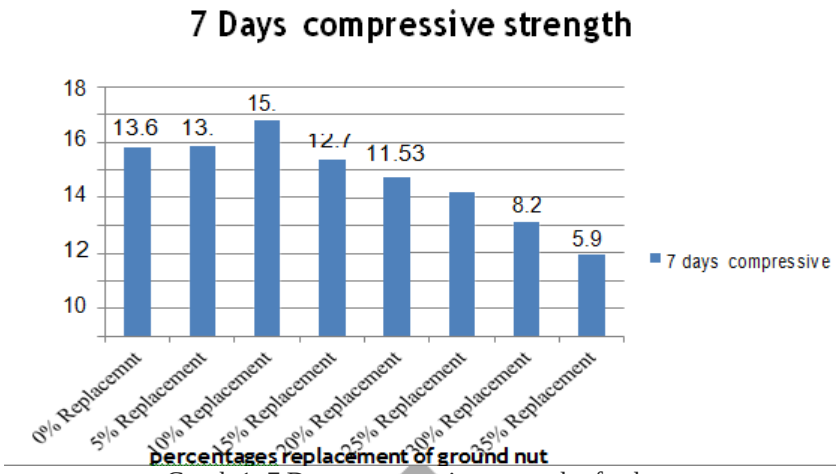
- The physical properties of ordinary Portland cement used in the present investigations are confirming to the IS specifications (Table-). The 28 days compressive strength of cement is 53 M Pa.
- The properties of fine aggregate and coarse aggregate used are given in Table-3, Table-4. The fineness modulus of fine aggregate is 6.104 and confirm zone. The fineness modulus of the 20mm coarse aggregate is 2.385. The mix proportions for M15 grade concrete (by weight) are given in table- 1.
- The compressive strength of concrete with 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% replacement of cement with ground nut shell ash cured in normal water for 3,7, 14, 28, 56 and 91days have reached the target mean strength tables-7,8,9,10,11,12
- The spilt tensile strength of concrete with 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% replacement of cement with ground nut shell ash cured in normal water for 3, 7, 14, 28, 56 and 91days have reached the target mean strength tables-13,14,15,16,7,18
- The flexural strength of concrete with 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% replacement of cement with ground nut shell ash cured in normal water for 3, 7, 14, 28, 56 and 91 days have reached the target mean strength tables-19,20,21,22,23,24
- The compressive strength of concrete with 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% replacement of cement with ground nut shell ash cured in normal water for 3, 7, 14, 28, 56 and 91days indicates that up to 10% replacement there is increase in strength and after 10% after replacement there is decrease in strength from tables this shows that 10% replacement of cement shows better results.
- The split tensile strength of concrete with 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% replacement of cement with ground nut shell ash cured in normal water for 3, 7, 14, 28, 56 and 91days indicates that up to 10% replacement there is increase in strength and after 10% after replacement there is decrease in strength from tables- this shows that 15% replacement of cement shows better results.

V. CONCLUSIONS

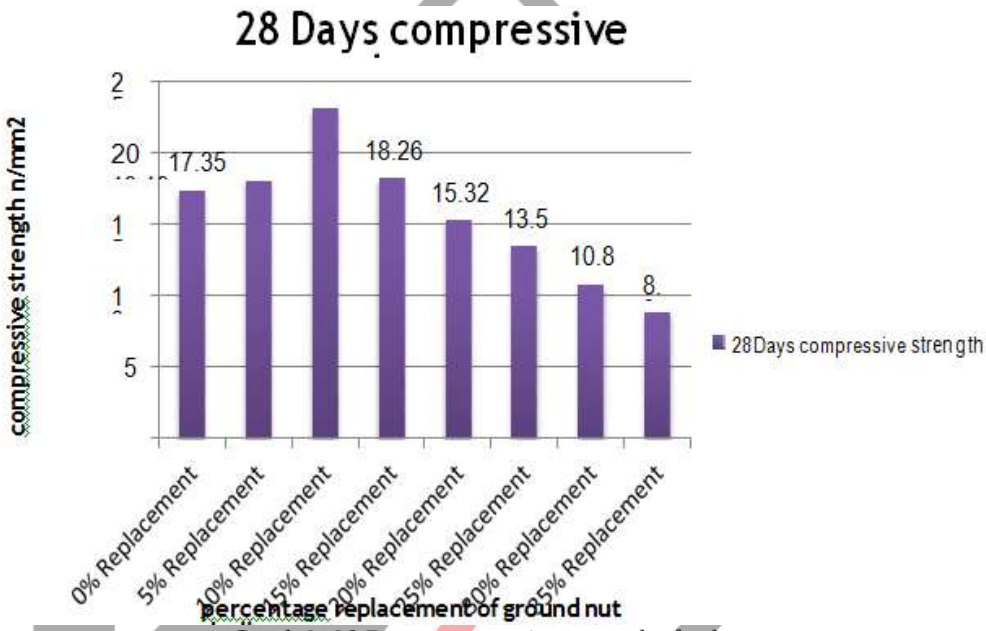
Based on experimental investigations concerning the compressive strength, split tensile strength and flexural strength of Concrete, the following observations are made:

- The Compressive Strength &Split tensile strength of Concrete is increased when the replacement of Cement with groundnut shell ash up to 10% replaces by weight of Cement.
- The Flexural Strength of Concrete is increased when the replacement of Cement with groundnut shell ash up to 15% replaces by weight of Cement.
- When W/C ratio is increased respectively, Compressive Strength, spilt tensile strength and Flexural Strength of Concrete are increased.
- Groundnut shell ash is a better innovative supplementary cementations' construction material which is used in concrete, so it can save the agriculture waste disposal costs and produce a greener" concrete for construction".
- This research concludes that groundnut shell ash can be innovative supplementary cementations' Construction Material in Concrete but judicious decisions are to be taken by engineers.

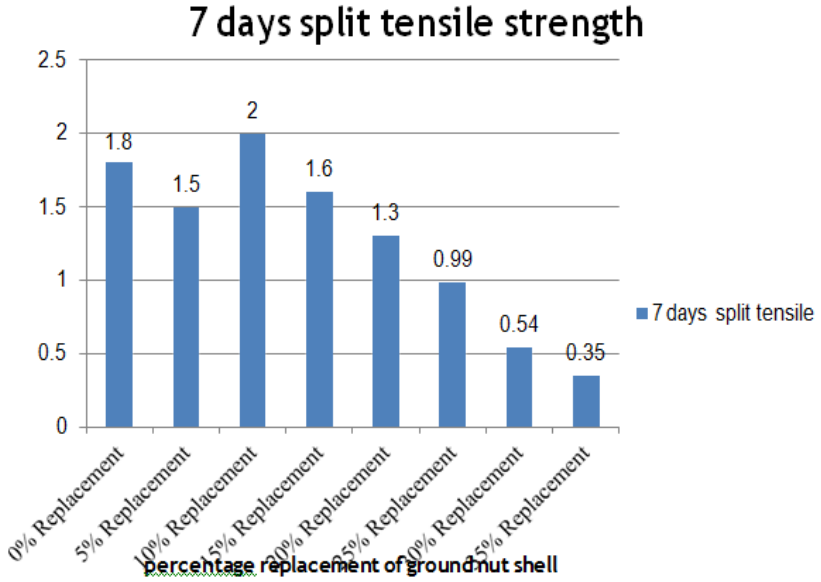
APPENDIX-I- GRAPHS



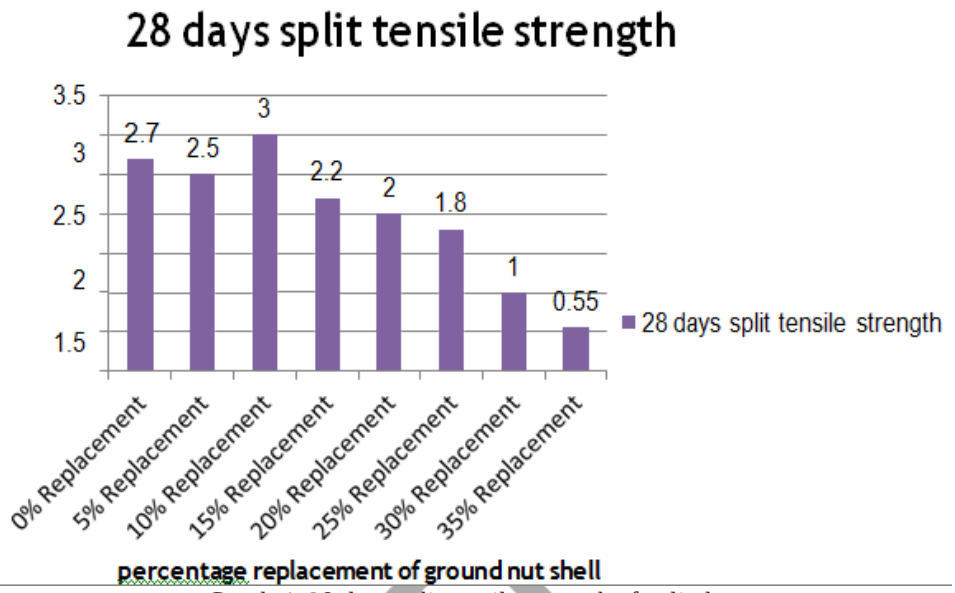
Graph 1: 7 Days compressive strength of cubes



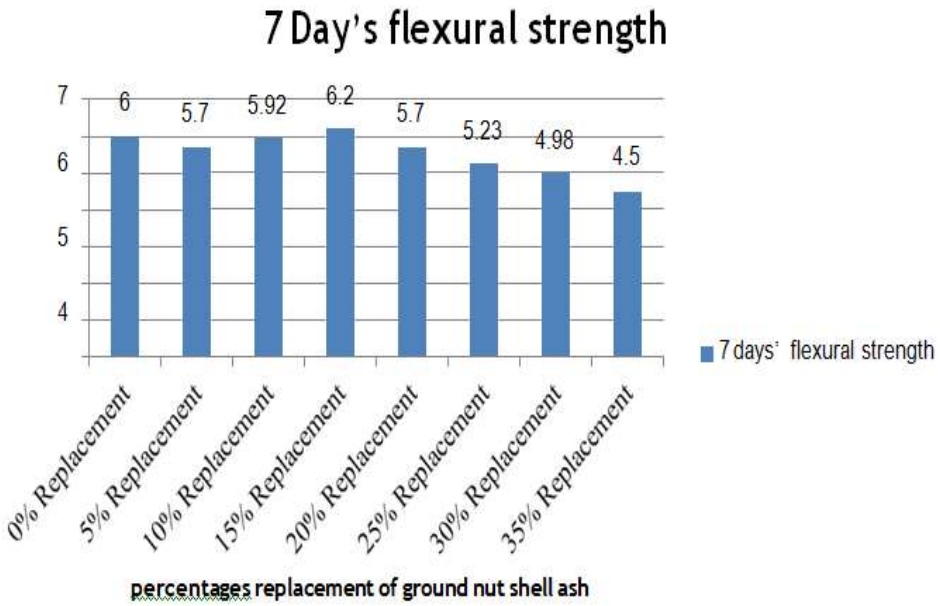
Graph 2: 28 Days compressive strength of cubes



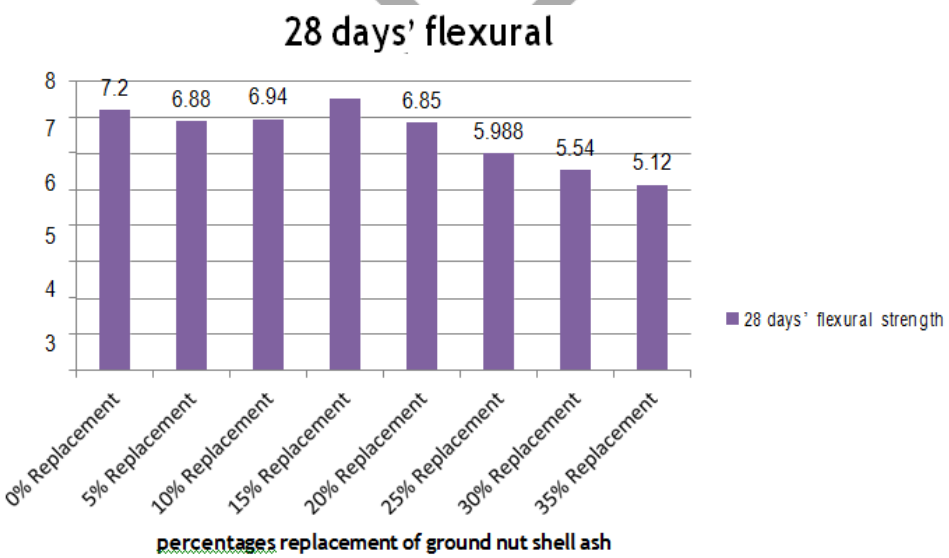
Graph 3: 7 days split tensile strength of cylinder



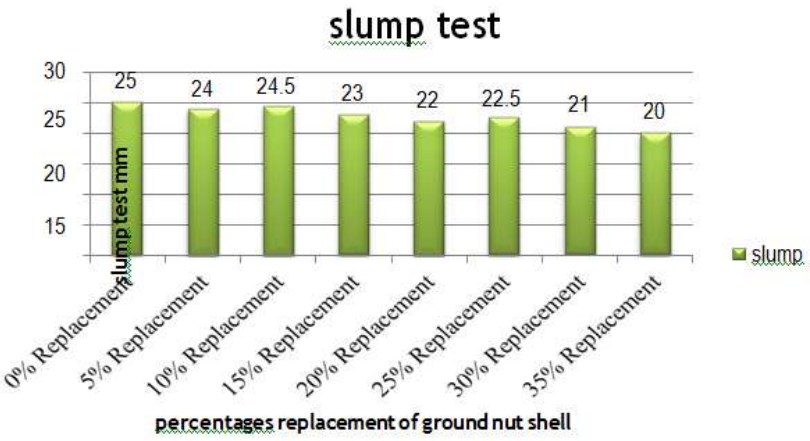
Graph 4: 28 days split tensile strength of cylinder



Graph 5: 7 days' flexural strength of prisms



Graph 6: 28 days' flexural strength of prisms



Graph 7: slump cone test for different

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