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Comparitive Studies on Sustainable Alternative Materials for Aggregates in Concrete Industry

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Abstract: Concrete industry is one of the largest consumers of natural resources due to which sustainability of concrete industry is under threat. Preventing the exhaustion of natural resources and enhancing the usage of waste materials has now became a significant problem in this modern world. In the present study, an attempt has been made to investigate the strength parameters of concrete made with partial replacement of coarse aggregate with 10%, 20% and 30% of shabath stone waste, coconut shell and partial replacement of fine aggregate with 10%, 20% and 30% of crushed cullet glass, quartz. The main parameter investigated in this study is the replacement of M30 grade concrete with partial replacement of coarse aggregate with 10%, 20% and 30% of shabath stone waste, coconut shell and partial replacement of fine aggregate with 10%, 20% and 30% of crushed cullet glass, quartz. This project presents a detailed experimental study on compressive strength, split tensile strength at age of 3, 7 and 28 days. In this project, out of various percentage of replacement of fine aggregate by crushed glass, quartz and coarse aggregate by shabath stone waste, coconut shell of among 16 mixes.

Keywords: CS, XRF.

I. INTRODUCTION

A. General

Due to the high consumption of raw material by the construction sector results in chronic shortage of building materials. Construction Industry has been conducting various researches on utilization of waste products obtained from domestic & Industrial activities in order to reduce the utilization of precious natural resources. India is pioneer in exploration of commercial rock deposits. Of the 300 varieties of stone being traded in world market nearly half of them are from India. India possesses a wide spectrum of dimensional stones that include granite, marble, kotastone, sandstone, limestone, sate, and quartzite spread out all over the country. In India 0.9% of total urban waste comprises of glass. Glass is an ideal material for recycling as it is non biodegradable. Crushed bottle glass if properly sized show properties similar to that of sand due to its high silica content. The potential of using agricultural wastes in civil engineering and building construction works have been investigated by various researchers in a study, compared concrete made with coconut and palm kernel shells as replacement for coarse aggregates and concluded that coconut shells performed better than palm kernel shells as replacement for conventional aggregates in the concrete. Some mineral species and groups are much more abundant than others; these are termed the rock-forming minerals. The major examples of these are quartz, the feldspars, the micas the amphiboles the pyroxenes, the olivines, and calcite except the last one, all of the minerals are silicates. Overall, around 150 minerals are considered particularly important, whether in terms of their abundance or aesthetic value in terms of collecting. Total of 144 numbers of cubical specimens of size 150mmX150mmX150mm, and 144 number of cylinders of size 150mmX300mm were casted and tested for the compressive strength and tensile strength at the age of 3,7 and 28 days. Each of the compressive strength test data corresponds to the mean value of the compressive strength of three cubes. And each of the tensile strength value corresponds to the mean value of the split tensile value of 3 cylinders.

B. Classification Of Concrete

Concrete of Grade M30 is considered for this project. As per our Indian standard IS 456: 2000 concretes are grouped as ordinary concrete, standard concrete and high strength concrete as given in Table.1.

TABLE I: Group of Concrete as per IS 456: 2000

SL. No	Name of Group of Concrete	Grade Designation
1	Ordinary Concrete	M10 to M20
2	Standard Concrete	M25 to M55
3	High Strength Concrete	M60 to M80
Note: M refers to mix and the number to specified compressive strength of 150mm size cube t 28 days expressed in N/mm^2		

C. Materials Used

Stone Waste: The principle waste coming in the stone industry is stone itself, stone wastes are generated as a waste during the process of cutting and polishing. Stone chips posess ideal physical and chemical properties for partial replacement as coarse aggregate. it is estimated that 175 million tons of quarrying waste are produced each year, for this study shabath waste is replaced for conventional coarse aggregate.

Fig.1. Stone Waste.

Crushed Glass Aggregate: Glass is an ideal material for recycling as it is non biodegradable. Crushed bottle glass if properly sized show properties similar to that of sand due to its high silica content. Attempts have been made for a long time to use waste glasses as an aggregate in concrete but it seems that the concrete with waste glasses always cracks but very limited work has been conducted for the use grounded glass as an partial replacement for fine aggregate.

Fig.2. Crushed Glass.

Coconut Shell: Properties of concrete with coconut shells (CS) as aggregate replacement were studied. Control concrete with normal aggregate and CS concrete with 10-20-30% coarse aggregate replacement with CS were made. Properties like compressive strength, split tensile strength, water absorption and moisture migration were investigated in the laboratory. The results showed that, density of the concretes decreases with increase in CS percent. Workability decreased with increase in CS replacement. Compressive and split tensile strengths of CS concretes were lower than control concrete. Permeable voids, absorption and sorption were higher for CS replaced concretes than control concrete.

Fig.3. Coconut Shell.

Quartz: Quartz is a naturally occurring substance that is solid and inorganic represent table by a chemical formula, usually abiogenic, and has an ordered atomic structure. It is different from a rock on grounding it finely which can be an fine aggregate.

Fig.4. Quartz.

D. Objectives

An agenda of sustainable development and green has penetrated the construction industry at an accelerating rate in recent years. In this regard, the idea of using non biodegradable waste material has given at most prominence.

- To find an effective alternate to reduce the over all cost of concrete.
- To incorporate the maximum utilization of sustainable aggregates.
- To study the sustainable aggregate and concrete interaction.
- To pave way for greener concrete.
- To find the Compressive strength and split tensile strength of all the specimens at age of 3, 7 and 28 days.

II. EXPERIMENTAL STUDIES AND METHODS

A. General

Concrete is an artificial material, which is made up of cement, fine aggregate, coarse aggregate and water. In this study cement was replaced with 10%, 20% and 30% of Class F fly ash and fine aggregate was replaced with 10%, 20% and 30% of crushed cullet glass aggregate in various combinations to arrive at the most suitable mix. The properties of materials used for preparing the different Mixes of concrete M30 will be described in the following sections.

Materials Used: Cement, fine aggregate, coarse aggregate, stone waste, crushed glass aggregate, super plasticizer and water were used in this investigation. The following are the properties of the materials used.

Cement:

Fig.5.

Ordinary Portland cement of grade–53 conforming to Indian standard IS: 12269-1987 has been used in the present study. The specific gravity of cement used is 3.1.

B. Vicat Apparatus Of Cement

Vicat apparatus is a device used used to determine the consistency and setting time of cement .Consistency and setting time of cement are significant degrees of consideration for any cement water paste. As these helps in preparing a proper paste of cement which meets all the standard specifications. Vicat apparatus consists of a metallic frame, graduated scale with index, sliding probe of 300g, consistency plunger of 10mm,initial setting time needle of 1mm,an annular needle for final setting time calculation and non porousplate, like glass base plate or stainless plate.

- Prepare a paste of cement 400g with 0.85 times the water required for the consistency.
- The gauging time should be a 3-5 minute.
- After gauging properly filled it in the vicatmould and level it with the help of trowel.

Initial Setting Time:

- For determine the initial setting of cement set the 1mm diameter needle to the lower end of the rod.
- Immediately place the vicat apparatus mould filled with cement paste above the non porous glass plate.
- Lowers the needle and allow it to penetrate into the mould.
- Repeat the procedure till the needle fails to pierce the mould to a point 5.0 + 0.5 mm measured from the bottom of the mould.
- Now record the period between the water is added to the cement and the needle fails to pierce the mould by 5.0 + 0.5 mm measured from the bottom [t2].

Final Setting Time:

Fig.6.

For determine the final setting of cement time set an annular needle to the lower end of the rod.

- Repeat the same procedure for the final setting time as in initial setting time.
- Lowers the needle and allow it until the annular needle makes an impression on the mould.
- Now record the time period between the water is added to the cement and the annular needle fails to make an impression on the mould [t3].

1. Tests On Cement:
Specific Gravity:
Calculations:

$$\text{Specific Gravity} = \frac{\text{Weight of cement}}{\text{Volume of kerosene read from the flask}}$$

$$\text{Specific Gravity, G} = \frac{60}{19} = 3.16$$

Standard Consistency Test:
Consistency Value of Cement = 29%

Initial and Final Setting Time For Cement:
Cement content = 400grams
Water = 0.85 x Standard Consistency value x Cement content
= 0.85 x (29/100) x 400
= 98.6ml

Result:
Initial Setting Time = 160 minutes
Final Setting Time = 297 minutes

TABLE II: Properties of Concrete

Standard Consistency	30%
Initial Setting Time	35mins
Final Setting Time	245mins

Fine Aggregate: Sand that is available in nearby locality has been used as fine aggregate. Other foreign matter present in the sand has been separated before use. The specific gravity of sand used in this investigation is 2.52

2. Tests On Fine Aggregate:
Specific Gravity: The Specific Gravity is calculated from following Equation.

Specific Gravity, G= $\frac{W2-W1}{(W2-W1)-(W3-W4)}$

Where,

- W_1 = Weight of empty pycnometer (g)
- W_2 = Weight of pycnometer + sample (g)
- A = Weight of sample taken (W_2-W_1) (g)
- B = Weight of pycnometer + sample + water (g)
- C = Weight of pycnometer + water (g)
- D = weight of oven dried sample

Tabulation of Observations:

Description	Sample
W1 = Mass of empty, clean pycnometer	460
W2 = Mass of empty pycnometer + dry soil	710
B = Mass of pycnometer + dry soil + water	1407
C = Mass of pycnometer + water	1253
Specific Gravity (GS)	2.60

Calculations:
Specific Gravity, G = D/ A-(B-C)
G = 2.61
Water absorption = 100 x (A-D)/D= 1.64%

Sieve Analysis Of Fine Aggregate:
Tabulation Of Observations:

IS Sieve	Weight Retained (g)	Cumulative Weight Retained	Cumulative % Retained	Cumulative % passing
4.75mm	37	37	1.89	98.11
2.36mm	48	85	5.25	94.75
1.18mm	316	401	22.05	77.95
600µ	820	1221	67.15	32.85
300µ	589	1810	94.50	5.5
150µ	148	1958	97.90	2.1

Calculations:
Fineness Modulus of Sand = £ (Cumulative % retained)/100
= (1.89 + 5.25+22.05+ 67.15 +94.50 +97.90) / 100

= $\frac{295}{100}$ = 2.95

Result:
Fineness Modulus of Sand = 2.95

Bulk Density Of Fine Aggregate:
Calculations:

Bulk Density, = $\frac{\text{Net Weight of Aggregate in Container (kg)}}{\text{Volume of Container (cumec)}}$ kg/m^3

Volume of Container (V) = $\frac{\pi}{2}$ x D^2 x d

= 9.8175 x 10^{-3} m^3

Bulk Density = 1717.02kg/m^3

TABLE III: Properties of Fine Aggregate

Material	Specific gravity	Fineness modulus	Bulk density(Kg/Cum)
River sand	2.52	3.61	2465

Coarse Aggregate: Crushed stone aggregate of maximum size 12.5mm available from local area has been used. Coarse aggregate has been sieved through IS: 150- micron sieve to remove dirt and other foreign materials. The specific gravity of coarse aggregate used is 3.17.

3. Test On Coarse Aggregate
Specific Gravity:
Formula: The Specific Gravity is calculated from following Equation.
Specific Gravity, G = D/ A-(B-C)

Where,

- W_1 = Weight of empty pycnometer (g)
- W_2 = Weight of pycnometer + sample (g)
- A = Weight of sample taken (W_2-W_1) (g)
- B = Weight of pycnometer + sample + water (g)
- C = Weight of pycnometer + water (g)
- D = weight of oven dried sample(g)

Tabulation of Observations:

Description	Sample
W1 = Mass of empty, clean pycnometer	673
W2 = Mass of empty pycnometer + dry sample	1509
B = Mass of pycnometer + dry sample + water	2071
C = Mass of pycnometer + water	1535
D = Weight of oven dried sample	833.5

Calculations:

$$G = \frac{833.5}{836-(2071-1535)}$$

= 2.76

Water absorption = 100 x (A-D)/D

Result:

- Specific Gravity of fine aggregate G = 2.76
- Water absorption = 0.3%

Sieve Analysis Of Coarse Aggregate:

Tabulation Of Observations:

IS Sieve	Weight Retained (g)	Cumulative Weight Retained	Cumulative % Retained	Cumulative % passing
80 mm	0	0	0	100
40 mm	0	0	0	100
20 mm	123	123	6.15	93.85
10 mm	1866	1989	99.45	0.55
4.75mm	10	1999	99.95	0.05
2.36mm	1	2000	100	0
1.18mm	0	2000	100	0
600µ	0	2000	100	0
300µ	0	2000	100	0

Calculations:

Fineness modulus,

Fineness Modulus of Coarse Aggregate = (£Cumulative % retained)/100

$$= \frac{714}{100}$$

= 7.14

Result:

Fineness Modulus of Coarse Aggregate = 7.14

Bulk Density Of Coarse Aggregate:

Calculations:

Bulk Density, $= \frac{\text{Net Weight of Aggregate in Container (kg)}}{\text{Volume of Container (cumec)}}$ kg/m^3

Volume of Container (V), $= \frac{\pi}{4} \times D^2 \times d$

Bulk Density $= \frac{24.6}{15}$

Bulk Density = 1638 kg/m^3

Result:

Bulk Density of coarse aggregate = 1638 kg/m^3.

TABLE IV: Properties of Coarse Aggregate

Material	Specific gravity	Fineness modulus	Bulk Density(Kg/Cum)
20mm	3.17	8.14	1497
12.5mm	3	6.07	1490

Stone Waste: stone wastes are generated as a waste during the process of cutting and polishing. The wastes of shabath stone is used as the substitute for coarse aggregate. They have been cut manually into the required size of 12-20mm approximately.

TABLE V: Properties of Shabath Stone Waste

Material	Specific gravity	Bulk density(Kg/Cum)	Water absorption
Shabath Stone Waste	2.3	1.35x10^3	0.003

Crushed Glass Aggregate: Used Dettol bottles from the university campus collected through a period of 6 months were used for this study. The bottle were first broken to pieces using ramming rods. Then fed into a bottle crusher to get the desired size of aggregate. It was then sieved through an IS sieve.

TABLE VI: Properties of Crushed Glass Aggregate

Material	Specific gravity	Bulk density(Kg/Cum)	Water absorption
Crushed Glass Aggregate	2.52	2.03x10^3	0.009

Coconut Shell: Apart from above mentioned waste materials and industrial by products, few studies identified that coconut shells, the agricultural by product can also be used as aggregate in concrete. According to a report, coconut is grown in more than 86 countries worldwide, with a total production of 54 billion nuts per annum. India occupies the premier position in the world with an annual production of 13 billion nuts.

TABLE VII: Properties of Coconut Shell

Material	Specific gravity	Bulk density(Kg/Cum)	Water absorption
Coconut Shell	1.42	1.09x10^3	0.019

Quartz: The silica polymorph that is most stable at the Earth's surface is αquartz. Its counterpart, β-quartz, is present only at high temperatures andpressures. These two polymorphs differ by a "kinking" of bonds this change in structure gives β-quartz greater symmetry than α-quartz, andthey are thus also called high quartz (β) and low quartz (α).

TABLE VIII: Properties of Quartz

Material	Specific gravity	Bulk density(Kg/Cum)	Water absorption
Quartz	3.2	2.6x10^3	0.011

Super Plasticizers: Plasticizers help us to increase the workability of concrete without addition of extra quantity of water. It means that we can use less water without reducing the workability at the same cement content. This is added to avoid formation of flakes, due to less quantity of water. Use of plasticizers is economical as the cost incurred on them is less than the cost of cement saved. Use of super plasticizers becomes essential for designing mix to achieve HPC and also for the preparation of Micro silica in concrete to increase workability. Super plasticizer used in this study was CON PLAST.

Fig.7. Con Plast.

C. Experimental Program

According to the sixteen types of mix design cubes were casted and compression strength test has been found after 3,7 & 28 days. Cylinders were cast to determine the split tensile strength.

TABLE IX: Mix proportion for M30 Grade Concrete

Mix. No.	% Of Crushed Glass Replacement For FA	% Of Quartz Replacement For FA	% Of Shabath Stone Waste Replacement For CA	% Of Coconut Shell Replacement For CA	No. Of Cubes	No. Of Cylinders
1	0	0	0	0	9	3
2	10	0	0	0	9	3
3	20	0	0	0	9	3
4	30	0	0	0	9	3
5	0	10	0	0	9	3
6	0	20	0	0	9	3
7	0	30	0	0	9	3
8	0	0	10	0	9	3
9	0	0	20	0	9	3
10	0	0	30	0	9	3
11	0	0	0	10	9	3
12	0	0	0	20	9	3
13	0	0	0	30	9	3
14	10	10	10	10	9	3
15	20	20	20	20	9	3
16	30	30	30	30	9	3

Mix Ratio:

Cement: Fine Aggregate: Coarse Aggregate = 1: 1.28: 2.85

D. Preparation Of Specimens

Casting: A pan type concrete mixer was used for the preparation of concrete mix. The mixing operation of concrete ingredients is shown in the Fig. 2.6.1. The Micro silica is added slowly and mixed thoroughly to avoid balling and slurry in the concrete. The specimens are cast in five batches, each batch consisting of six cubes for compressive strength, two prisms for flexural trength, two cylinders for split tensile strength, one cylinder for rapid chloride penetration test and sorptivity.

Materials: In this study, high strength concrete was used and it has been designed for proper guidelines. The cement used in the concrete mix was 53 grade Ordinary Portland Cement. The mix was designed with a water-cement ratio of 0.35. Densified form micro silica as pozzolanic material was used for the preparation of high strength concrete. The admixture used is GLENIUM B233 dosage is 0.6

Fig.8. casting specimens.

TABLE X: Mix Details

Mix. No.	Weight Of Crushed Glass (Kg)	Weight Of Quartz(Kg)	Weight Of Shabath Stone Waste(Kg)	Weight Of Coconut Shell(Kg)	FA Weight(Kg)	CA Weight(Kg)
1	0.0	0.0	0.0	0.0	25.9	37.5
2	3.1	0.0	0.0	0.0	23.3	37.5
3	6.1	0.0	0.0	0.0	20.7	37.5
4	9.2	0.0	0.0	0.0	18.1	37.5
5	0.0	3.4	0.0	0.0	23.3	37.5
6	0.0	6.8	0.0	0.0	20.7	37.5
7	0.0	10.2	0.0	0.0	18.1	37.5
8	0.0	0.0	3.4	0.0	25.9	33.7
9	0.0	0.0	6.7	0.0	25.9	30.0
10	0.0	0.0	10.1	0.0	25.9	26.2
11	0.0	0.0	0.0	2.1	25.9	33.7
12	0.0	0.0	0.0	4.2	25.9	30.0
13	0.0	0.0	0.0	6.3	25.9	26.2
14	9.2	10.2	10.1	6.3	62.2	89.9
15	18.4	20.3	20.2	12.5	46.7	67.4
16	27.6	30.5	30.3	18.8	31.1	45.0

Specimen Details: Cubes of 150mm x 150mm x 150mm were used for determining the compressive strength. Cylinders of 100mm x 200mm were used.

- Total No. of Mixes = 16 Nos
- No. of Cubes per Mix = 9 Nos
  - (150x150x150)
- No. of Cylinders per Mix = 3 Nos
  - (150x300)
- Total No. of specimen per Mix = 12 Nos

Curing: Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration. It may be either after it has been placed in position (or during the manufacture of concrete products), thereby providing time for the hydration of the cement to occur. Since the hydration of cement does take time – days, and even weeks rather than hours – curing must be undertaken for a reasonable period of time if the concrete is to achieve its potential strength and durability. Curing may also encompass the control of temperature since this affects the rate at which cement hydrates. The curing period may depend on the properties required of the concrete, the purpose for which it is to be used, and the ambient conditions, the temperature and relative humidity of the surrounding atmosphere. Curing is designed primarily to keep the concrete moist, by preventing the loss of moisture from the concrete during the period in which it is gaining strength. Curing may be applied in a number of ways and the most appropriate means of curing may be dictated by the site or the construction method. After 24 hours, demoulding of the specimens were carried out, the specimens were given identification marks and transformed to the curing tank for 3, 7, and 28 days as required [Fig: 2.5].

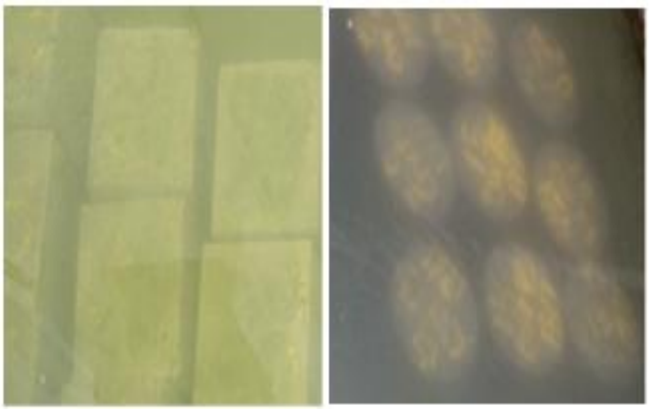

Fig.9. Cube Specimens&Cylinder Specimens.

E. Testing Procedure

The testing of cubes and cylinder shave been done after 3, 7 & 28 days. The following tests were performed in the present research work:

- Compression test on concrete cubes
- Split tensile test on cylinders
- Rapid chloride penetration test on cylinders

Compressive Strength Test: Compressive strength measurements are primarily concerned in testing the strength of concrete. Cube specimens were tested using the 2000 kN capacity Compression Testing Machine. This machine fulfills the entire requirement for compression testing as per IS: 516-1959.

Split Tensile Strength Test: This test method covers the determination of the splitting tensile strength of cylindrical concrete specimens, such as molded cylinders and drilled cores. The values stated in inch-pound units are to be regarded as the standard. This standard does not purport to address all of the safety concerns, if any associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determines the applicability of regulatory limitations period to use.

XRF Analysis Test: X-ray fluorescence analysis (XRF) – one of the best analytical techniques to perform elemental analysis in all kinds of samples, no matter if liquids, solids or loose powders must be analyzed.XRF combines highest accuracy and precision with simple and fast sample preparation for the analysis of elements from Beryllium (Be) to Uranium (U) in the concentration range from 100 % down to the sub-ppm-level.

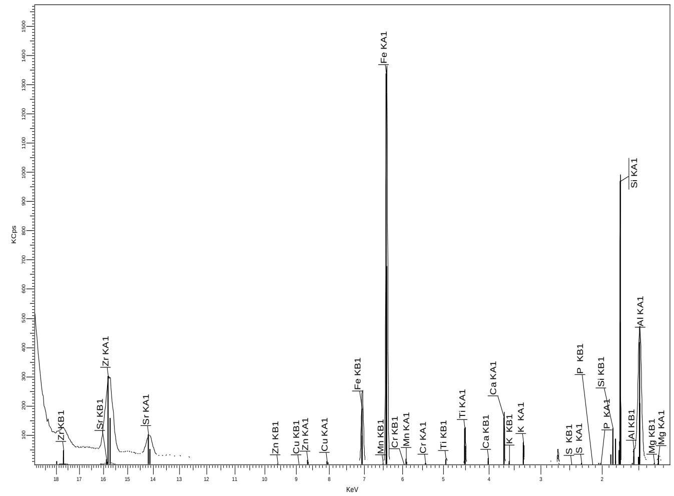

Fig.10. XRF Report for Natural Sand.

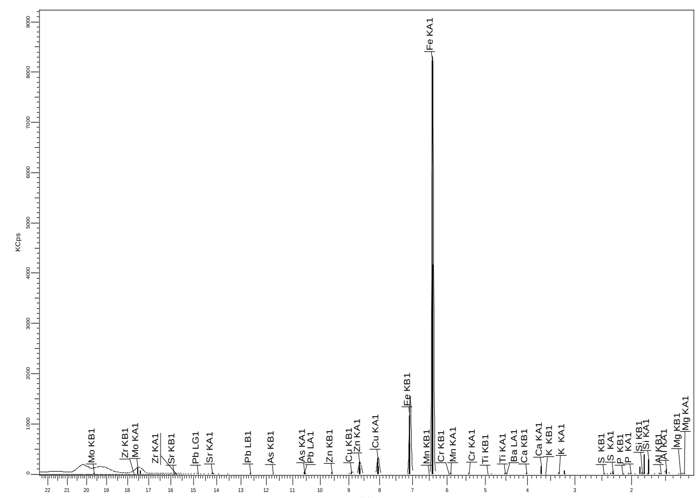

Fig.11. XRF Report for Crushed Glass.

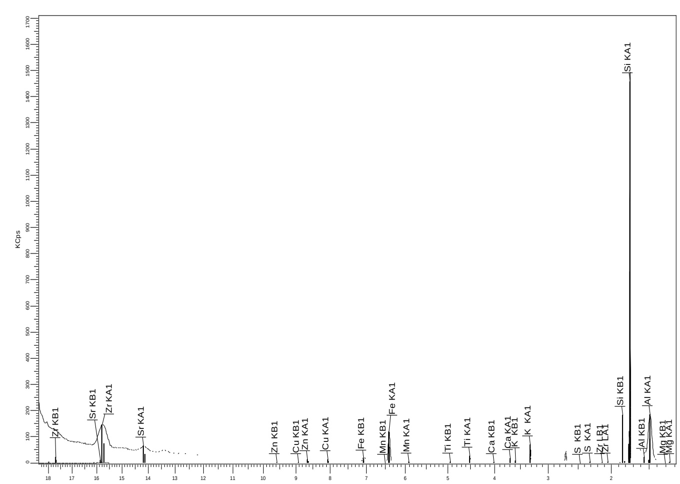

Fig.12. XRF Report for Shabath Stone.

TABLE XI: XRF Analysis Report for different materials.

	Natural Sand	Glass	Shabath Stone waste	Quartz Sand
Formula	Concentration%	Concentration%	Concentration%	Concentration %
Al	10.1400	2.570	3.653	1.760
As	-	0.075	-	-
Ba	-	0.106	-	-
Ca	7.2130	4.224	1.100	1.240
Cr	0.0474	0.036		-
Cu	0.0230	3.447	0.027	0.039
Fe	13.0500	65.080	1.242	0.802
K	3.1780	0.944	4.409	0.816
Mg	1.0400	0.667	0.055	0.078
Mn	0.2100	0.066	0.026	-
Mo	-	0.258	-	-
Na	2.7460	0.341	0.409	0.207
Ni	-	-	-	-
P	0.1030	0.078	-	-
Pb	-	0.226	-	-
S	0.0957	1.948	0.061	0.053
Si	57.6700	17.820	87.770	94.790
Sr	0.1060	0.022	0.021	-
Ti	4.0530	0.294	1.140	0.188
Zn	0.0277	1.782	0.013	0.023
Zr	0.3031	0.016	0.082	-

III. RESULTS AND DISCUSSION

A. Compressive Test On Cubes

Scope: According to IS 516:1959, compression test was carried out on a standard 150x150x150mm cubic specimens. All the cubes were tested in surface dried condition for each mix combination, three cubes were tested at the age of 3, 7 and 28 days using compression testing machine of 2000 ton capacity. The loading was continued till the specimen reaches its ultimate load. The ultimate load divided by the cross sectional area of the specimen is equal to the ultimate compressive strength.

Fig.13. Compression Testing Machine.

Summary of Test Method: This test method consists of applying a compressive axil load to moulded cubes at rate which is within a prescribed range until failure occurs. The compressive strength of the specimen is calculated by dividing the maximum load attained during the test by the cross-sectional area of the specimen.

Calculation:

Formula: Compressive Strength = P/A (Mpa)

Where,

P = Load Applied (N)

A = Area of Cube= 150 x 150 mm

Results:

TABLE XII: Result of Compressive Strength Test

Mix. No	3 Days Compressive Strength			7 Days Compressive Strength			28 Days Compressive Strength		
1	13.3 Mpa	11 Mpa	13.8 Mpa	25 Mpa	25 Mpa	22 Mpa	38 Mpa	37.8 Mpa	37.4 Mpa
2	15.2 Mpa	15.9 Mpa	14 Mpa	28.3 Mpa	28.5 Mpa	25.2 Mpa	41.6 Mpa	40.3 Mpa	40.8 Mpa
3	15.6 Mpa	16.7 Mpa	15.6 Mpa	29 Mpa	31 Mpa	29.3 Mpa	46 Mpa	45 Mpa	46 Mpa
4	16.3 Mpa	16.2 Mpa	15.4 Mpa	27 Mpa	28.7 Mpa	28 Mpa	44 Mpa	43.6 Mpa	43.9 Mpa
5	14 Mpa	15.2 Mpa	14.9 Mpa	24 Mpa	26 Mpa	23 Mpa	39.5 Mpa	38.3 Mpa	39 Mpa
6	14.6 Mpa	14.9 Mpa	14.7 Mpa	24 Mpa	24.9 Mpa	23 Mpa	37 Mpa	36.5 Mpa	36 Mpa
7	14.3 Mpa	14.9 Mpa	14.7 Mpa	24.5 Mpa	25.6 Mpa	23 Mpa	36.5 Mpa	35.3 mpa	36 Mpa
8	13 Mpa	13.5 Mpa	13.6 Mpa	21.5 Mpa	23.7 Mpa	23 Mpa	36 Mpa	35 Mpa	35.3 Mpa
9	12.7 Mpa	13 Mpa	12.9 Mpa	20 Mpa	22 Mpa	21 Mpa	34 Mpa	34 Mpa	33.6 Mpa
10	12 Mpa	12.4 Mpa	11 Mpa	27.6 Mpa	28 MPa	27 Mpa	35 Mpa	34.7 Mpa	35 Mpa
11	12.8 Mpa	13.9 Mpa	12.6 Mpa	21 Mpa	22 Mpa	19 Mpa	36 Mpa	35.2 Mpa	36 Mpa
12	13 MPa	13.6 Mpa	12 Mpa	20 Mpa	23 Mpa	21 Mpa	33 Mpa	32.3 Mpa	32.4 Mpa
13	10.9 Mpa	11.3 Mpa	11 Mpa	19.6 Mpa	20.3 Mpa	19 Mpa	34 Mpa	33.3 Mpa	33.7 Mpa
14	13 Mpa	13.6 Mpa	14.2 MPa	22 Mpa	21 Mpa	23 Mpa	37.6 Mpa	36.6 Mpa	36 Mpa
15	13.1 Mpa	12.6 Mpa	13.3 Mpa	23.6 Mpa	24 MPa	23 Mpa	37.2 Mpa	37 Mpa	36.7 Mpa
16	12.6 Mpa	12.9 Mpa	13.1 Mpa	22 Mpa	21 Mpa	22.6 Mpa	36.5 Mpa	35.7 Mpa	36 Mpa

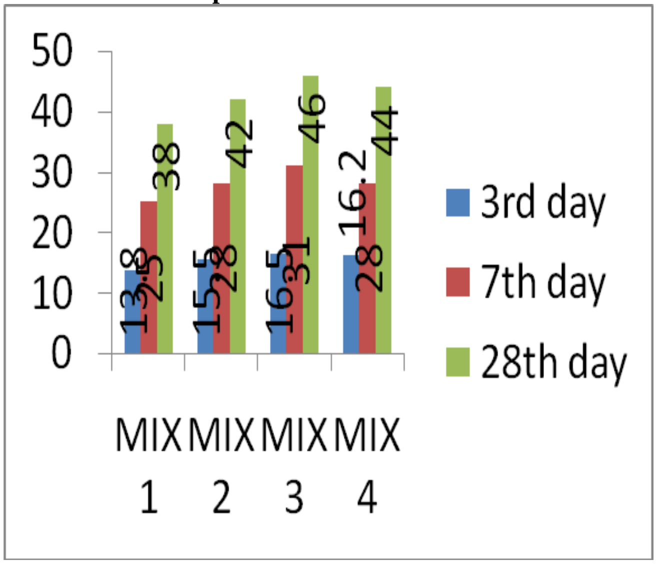

Fig.14. compressive Strength of cube.

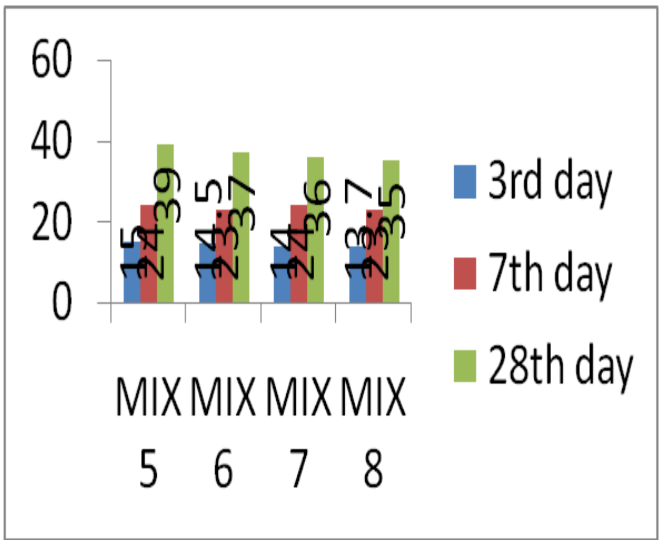

Fig.15. compressive Strength of cube.

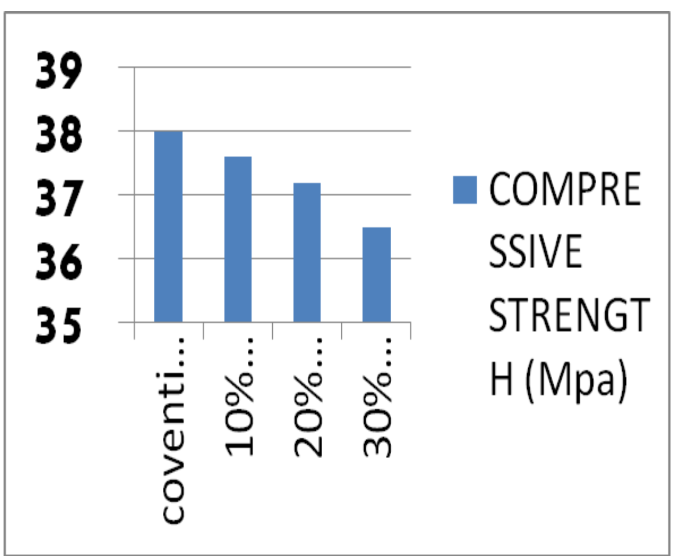

Fig.16. compressive Strength of cube.

B. Split Tensile Strength

Scope: This test method covers the determination of the splitting tensile strength of cylindrical concrete specimens, such as molded cylinders and drilled cores. The values stated in inch-pound units are to be regarded as the standard. This standard does not purport to address all of the safety concerns, if any associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determines the applicability of regulatory limitations period to use.

Summary of Test Method: The cylinders were tested in saturated surface dried condition. For each mix combination, three cylinders were tested at the age of 3, 7 and 28 days using compression testing machine of 2000 tone capacity. The tests were carried out at a uniform stress rate, after the specimen was centered in the testing machine. The loading was continued till the specimen reaches its ultimate load. The split tensile strength is calculated by using the formula given in IS 5816:1999, splitting tensile strength of concrete-method of tests.

Significance and Use: Splitting tensile strength is simpler to determine the direct tensile strength and splitting tensile strength is used to evaluate the shear resistance provided by concrete in reinforced light weight aggregate concrete members.

Calculation: It is used to find the tensile strength of the concrete specimens.

Formula, $\mathbf{T = 2P/ \pi DL}$

Where,
P = Load Applied (N)
D = diameter of the specimen
L = length of the specimen

Fig.17. Splitting of cylinder.

Results:

TABLE XIII: Result of Split Tensile Strength Test

Mix .No.	3 Days	7 Days	28 Days
1	2.3	3.71	4.2
2	2.6	4.05	4.58
3	2.8	4.2	4.89
4	2.89	4.3	4.95
5	2.25	3.55	4.15
6	2.43	3.89	4.3
7	2.7	4.00	4.7
8	1.9	3.23	3.76
9	2.1.	3.56	3.9
10	2.4	3.73	4.2
11	2.89	4.3	4.75
12	3	4.26	4.89
13	3.15	4.35	4.9
14	2.2	3.6	3.9
15	2.1	3.5	3.8
16	1.95	3.23	3.6

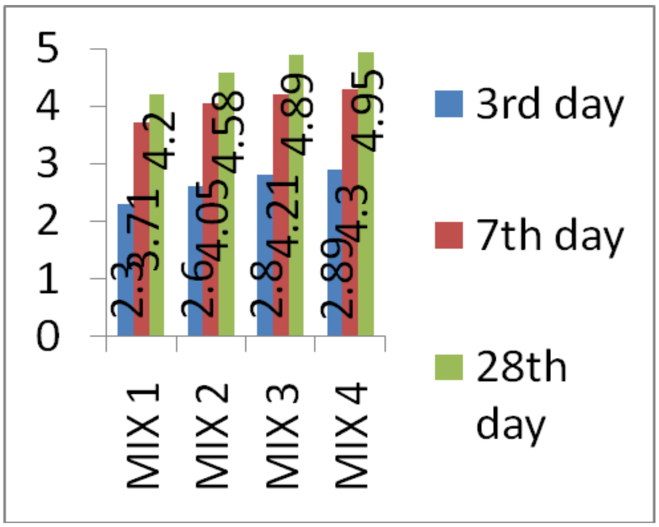

Fig.18. Split Tensile Strength of cylinders.

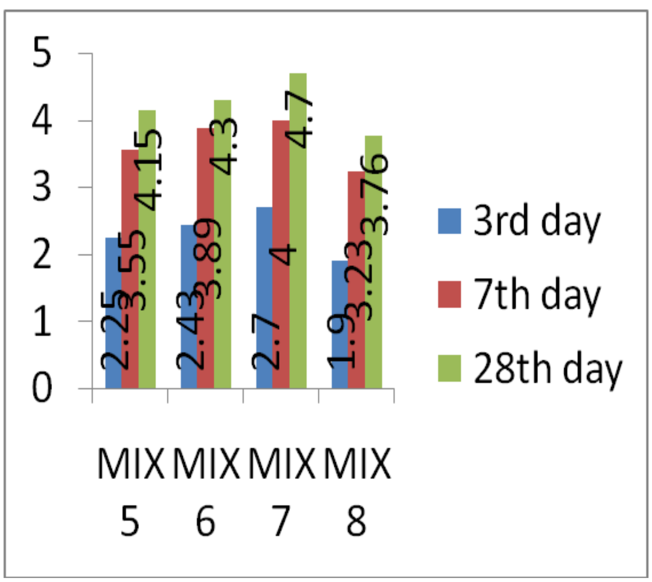

Fig.19. Split Tensile Strength of cylinders.

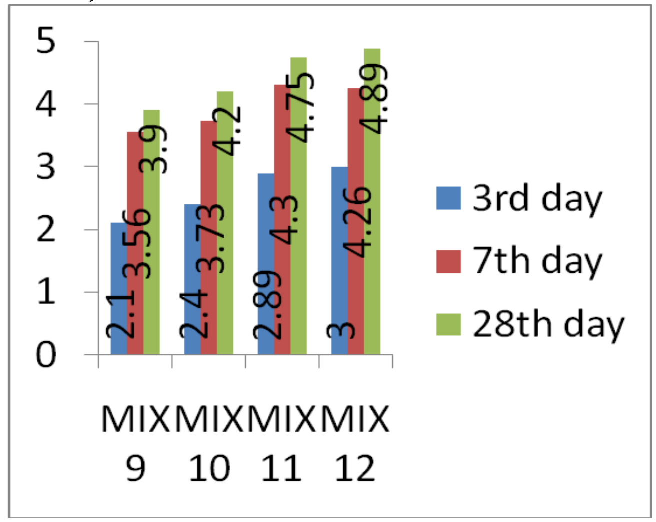

Fig.20. Split Tensile Strength of cylinders.

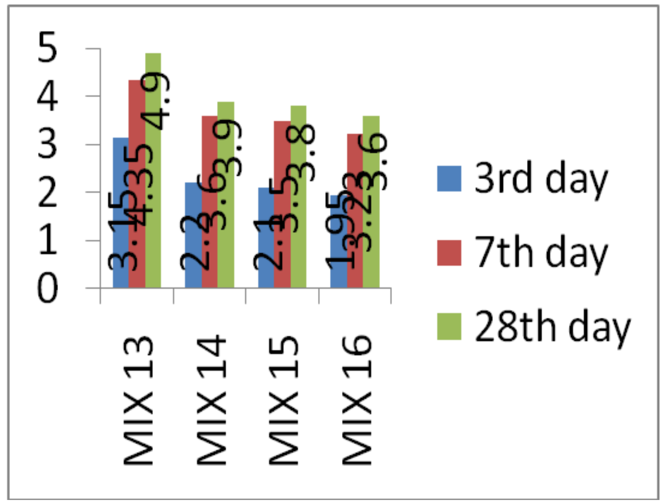

Fig.21. Split Tensile Strength of cylinders.

TABLE XIV: Total Cost Of Materials For M30 Graded Concrete (1:1.28:2.5) PER m3

Mix. No	Cost Of Fine Aggregate Per Cubic Meter			Cost Of Coarse Aggregate Per Cubic Meter			Total Cost Of Aggregates Per Cubic Meter
	Sand	Waste Glass	Quartz	Gravel	Coconut Shell	Shabath Stone Waste	
1	670	0	0	433	0	0	1103
2	603	15	0	433	0	0	1051
3	536	30	0	433	0	0	999
4	469	45	0	433	0	0	947
5	603	0	19	433	0	0	1055
6	536	0	38	433	0	0	1007
7	469	0	57	433	0	0	959
8	670	0	0	400	0	7	1077
9	670	0	0	357	0	14	1041
10	670	0	0	313	0	21	1004
11	670	0	0	400	4	0	1073
12	670	0	0	357	8	0	1035
13	670	0	0	313	12	0	995
14	536	15	19	357	4	7	938
15	400	30	38	260	8	14	750
16	320	45	57	210	12	21	665

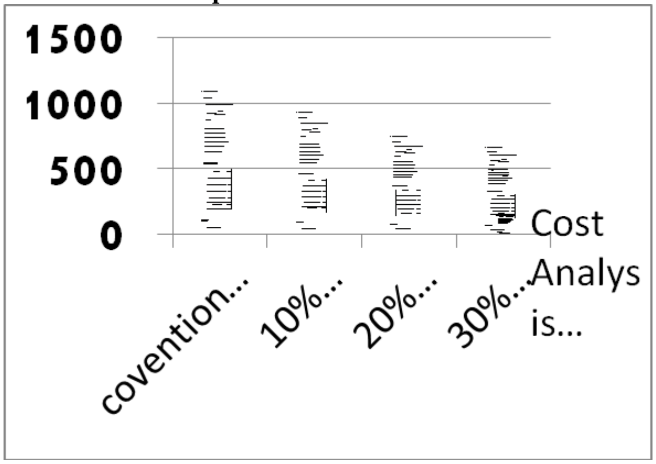

Fig.22. Split Tensile Strength of cylinders.

TABLE XV: Water Absorbtion Test

Mix. No	Avg Dry Weight Of Cube Before Curing (G)	Avg Wet Weight Of Cube After 28 Days Of Curing	Water Absorbed (G)	% Of Water Absorbed
1	8300	8429	129	1.544
14	8230	8339	109	1.32
15	8105	8196	91	1.12
16	8079	8130	51	0.631

Moreover, low permeability of concrete can improve resistance to the penetration of water, sulphate ions, chloride ions, alkali ions, and other harmful substances which caused chemical attack. Concrete permeability had a close relationship with the characteristics of its pore structure in the cement paste and the intensity of microcracks at the aggregate-cement paste interface as well as within the paste itself. Here, pore structure mainly involved volume and size of the interconnected capillary pores. As we know, the hydration reaction of cement results in a product consisting of solid and pore systems.

IV. SUMMARY AND CONCLUSIONS

Based on the experimental results, the following conclusions are drawn

- In this project, out of various percentage of replacement of fine aggregate by crushed glass, quartz and coarse aggregate by shabath stone waste, coconut shell of among 16 mixes. The mix 3 has resulted in highest compressive strength as well as tensile too when compared to conventional cube.
- Among 16 mixes precisely mix 14,15&16 clearly states thattarget mean strength can be achieved on replacing natural fine and coarse aggregate with sustainable aggregate.
- The cost analysis has clearly stated that compared to conventional concrete the replaced aggregate concrete can be produced with lesser cost, the analysis report also states that replaced aggregate concrete can be produced with 50% of cost of production of conventional concrete.
- Water absorbtion test states that the replaced aggregate concrete cube is of lesser weight when compared to convention concrete cube here by we can claim that the aggregate replaced concrete is an light weight concrete.
- We can conclude that obtained replaced aggregate concrete is Economic, Durable & Greener.

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Journal Papers:

IQBAL MIRZA.M IOSR Journal of Engineering (IOSRJEN) e-ISSN: 2250-3021, p-ISSN: 2278-8719 Vol. 3, Issue 7 (July. 2013), ||V6 || PP 08-13 Addressed by the use of

waste glass as partial replacement of fine aggregates in concrete. Fine aggregates were replaced by waste glass powder as 10%, 20%, 30% and 40% by weight for M-25 mix. The concrete specimens were tested for compressive strength, splitting tensile strength, durability (water absorption) and density at 28 days of age and the results obtained were compared with those of normal concrete. The results concluded the permissibility of using waste glass powder as partial replacement of fine aggregates up to 30% by weight for particle size of range 0-1.18mm.

VEDIVELLI.B The Open Civil Engineering Journal, 2010, 4, 65-71. This paper examines the possibility of using SGP as a replacement in fine aggregate for a new concrete. Naturalsand was partially replaced (10%, 20%, 30%, 40% and 50%) with SGP. Compressive strength, Tensile strength (cubesand cylinders) and Flexural strength up to 180 days of age were compared with those of concrete made with natural fine aggregates. Fineness modulus, specific gravity, moisture content, water absorption, bulk density, %voids, % porosity(loose and compact) state for sand (S) and SDA were also studied.

HAIDER.K.AMMASH University of Al-Qadisyia , Al-Qadisiya Journal For Engineering Science Saudi. Investigation was carried out to study the possibility of using waste glass of size up to 5mm as a fine aggregate in concrete and mortar. The waste glass was used as a partial weight replacement of sand with percentages of 10, 20, 30 and 40 %. The results have indicated that increasing the fractions of sand replacement by waste glass leads to reduce the compressive and tensile strength for both mortar and concrete. Up to 20 % replacement, the 28 days compressive strength of concrete and mortar is about 92 and 95 percent from the reference strengths,respectively. Also, it was found that the expansion of mortar specimens increase with increasing the waste glass content in the mix.

JAYESH KUMAR PITRODA International Journal of Latest Trends in Engineering and Technology (IJLTET) The waste generated from the industries cause environmental problems. Hence the reuse of this waste material can be emphasized. To produce low cost concrete by replacing cement with stone waste & to reduce disposal and pollution problems due to the use of stone waste. It is most essential to develop low cost building materials from stone waste.

RANIA HAMZA 2011 International Conference on Environment and Civil Engineering IPCBEE vol.21 (2011) © (2011) IACSIT Press, Singapore The objective of this paper is to utilize marble and granite waste of different sizes in the manufacturing of with full replacement of conventional coarse and fine aggregates with marble waste scrapes and slurry powder of content up to 40%. The produced concrete are tested for physical and mechanical properties according to the requirements of the American Standards for Testing Materials (ASTM) and the Egyptian Code.

DANIEL YAW OSEI International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org Volume 2 Issue 5 ǁ May. 2013 ǁ PP.07-11 coconut shells were used to replace crushed granite by volume. Seventy two cubes were produced and the densities and compressive strengths were evaluated at 7 days, 14 days, 21 days and 28 days. The density and compressive strength of concrete reduced as the percentage replacement increased. Concrete produced by 20%, 30%, 40% and 50% and 100% replacement attained 28-day compressive strengths of 19.7 Nmm-2, 18.68 Nmm-2, 17.57 Nmm-2, 16.65 Nmm-2and9.29Nmm-2;correspondingto94%, 89%,, 85%,79.6% and 44.4% of the compressive strength of the control concrete.

Er. MURALI.G International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 2,Mar-Apr 2012, pp.322-327 The effects of shabath (a variety of cudappah) stone and the chemical admixture (supaflo) on concrete were investigated.Natural aggregate had been replaced with the waste shabath stone in four different percentages namely 10, 20, 30 &40 %. A comparison was made between the specimens of partially replaced coarse aggregate and the same set of specimens admixed with supaflo. The effects on compressive strength, split tensile strength and modulus of rupture were reported. Test results indicated that the replacement of coarse aggregate by 30% had attained a good strength in the two cases mentioned above.

RAM CHANDRUDU International Journal of Engineering Inventions ISSN: 2278-7461, www.ijeijournal.com Volume 1, Issue 6 (October2012) PP: 21-31 Properties of concrete with coconut shells (CS) as aggregate replacement were studied. Control concrete with normal aggregate and CS concrete with 10 - 20% coarse aggregate replacement with CS were made. Two mixes with CS and fly ash were also made to investigate fly ash effect on CS replaced concretes. Constant water to cementitious ratio of 0.6 was maintained for all the concretes. Properties like compressive strength, split tensile strength, water absorption and moisture migration were investigated in the laboratory. The results showed that, density of the concretes decreases with increase in CS percent. Workability decreased with increase in CS replacement. Compressive and split tensile strengths of CS concretes were lower than control concrete.

MEGHE International Journal of Civil Engineering Research. ISSN 2278-3652 Volume 5, © Research India Publications http://www.ripublication.com/ijcer.htm coconut shell as partial replacement for coarse aggregate in concrete is studied. The concrete with ground coconut shell was found to be durable in terms of its resistance in water, acidic, alkaline and salty. Density of coconut shell is in the range of 550-650Kg/m3 and these are within the specified limits for lightweight aggregate.