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EXPERIMENTAL STUDY ON LIGHT WEIGHT FIBER CONCRETE USING PUMICE STONE AS PARTIAL REPLACEMENT OF COARSE AGGREGATE

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Abstract - *Light weight concrete has many applications in construction industry nowadays. It has many advantages such as dead load reduction, high thermal reduction and it also increases the life of building and reduces the handling cost. This can relate to both serviceability and structural integrity. The new source of structural aggregate which is produced from environmental wastes is natural aggregate. The use of structural light weight concrete reduces the weight of structure and helps to construct heavy precast elements. In this experimental work an attempt has been made to study and compare the structural properties of light weight concrete of M40 grade using the light weight aggregate Pumice stone as a partial replacement to natural coarse aggregate and mineral admixture materials like GGBFS and with some percent of Recron 3s. This study has been done by varying 10% - 50% pumice stone on partial replacement. Compressive strength, flexural strength and split tensile strength were evaluated for this study and comparison was made with that of conventional concrete. All these concrete specimens were cured for 7 days and 28 days in water tank on normal 27 ± 2 ^{0}C atmospheric temperatures.*

Key Words: light weight concrete, mix design, GGBFS, Recron 3s fiber, compressive strength, tensile strength, flexural strength.

1. INTRODUCTION

Mostly the aggregates of normal concrete are natural stone that we obtain from different resources such as lime stone, granite, etc. As the use of concrete is increasing day by day natural resources and environment is being excessively exploited. The use of light weight concrete is permitting greater design flexibility and substantial cost reduction, reduced dead load, improved tolerance to cyclic loading, longer span, thinner sections, smaller size structural members and lower foundation costs. Light weight concrete can be also defined as concrete which contains an expanding agent in it that increases the volume of the mixture while reducing the dead load. The main specialty of light weight concrete is its low density, low thermal conductivity and good serviceability.

Nowadays we need a concrete which is light weighted and performs good strength. This concrete will possess high strength and lesser weight. In this work pumice stone has been added as partial replacement of coarse aggregate to achieve light weight concrete and GGBFS with Recron fiber is used to achieve high strength.

1.1 Light Weight Concrete

Light weight concrete may be defined as a concrete of substantially lower density than made from gravel or crushed stones and it is usually obtained by using light weight aggregate or by injecting air or gas into the mortar. Following materials can be used to develop light weight concrete:-

Light weight aggregates:
Replacement of usual mineral aggregates by cellular porous or light weight aggregates reduces the density of concrete. Light weight aggregate are of two types- natural light weight aggregates and artificial light weight aggregate listed as under-

Natural Light Weight Aggregates	**Artificial Light Weight Aggregates**
a) Pumice stone	a) Artificial cinders
b) Diatomite stone	b) Coke breeze
c) Scoria stone	c) Foamed blast furnace slag
d) Volcanic cinders	d) Bloated clay
e) Sawdust	e) Expanded shale and slate
f) Rice husk	f) Sintered ash
	g) Exfoliated vermiculite crystal
	h) Granulated Blast furnace slag

1.2 Objectives

1. Natural coarse aggregates are partially replaced with pumice stone with different percentage to reduce the weight of concrete.
2. Evaluate effective use of pozzalanic materials with fiber to achieve the desired strength.

3. Take the optimum dosage of Recron 3s fibers to get maximum strength for the M40 grade concrete.
4. Obtaining the optimum replacement % of pozzalanic material with cement with a constant dosage of fiber.
5. Comparison of results.

2. EXPERIMENTAL PROGRAMS

2.1 Materials

2.1.1 Aggregates

In this experiment two types of aggregates are used with coarse aggregate (size more than 4.75mm) and fine aggregate (size less than 4.75mm). In this work coarse aggregates used are of sizes 10mm and 20mm. The properties of coarse and fine aggregate are given in table 1 and table 2 respectively.

TABLE 1: PROPERTIES OF COARSE AGGREGATE 10mm & 20mm

Property	Coarse Aggregate	
	10mm	20mm
Type	Angular	Angular
Density (SSD)	1478kg/m^3	1560kg/m^3
Sp. Gravity (SSD)	2.63	2.63
Fineness Modulus	5.66	7.54
Water Absorption	0.48%	0.48%

TABLE 2: PROPERTIES OF FINE AGGREGATE

Tests	Results
Type	River sand
Density (SSD)	1675 kg/m^3
Specific gravity	2.56
Fineness modulus	3.13
Water absorption	1.20%

2.1.2 Pumice stone as aggregates

Nowadays pumice stone is being utilized in light weight concrete. It is created when super-heated, high pressure rock violently comes out from a volcano. The properties of pumice stone is given in table 3.

TABLE 3: PROPERTIES OF PUMICE STONE

Property	Results
Density(kg/m^3)	770
Specific Gravity	0.82
Fineness Modulus	6.75
Porosity	11-14%
Water Absorption	20.5%
Ph	7.8

2.1.3 Cement

Where there is no sulphate exposure in the environment or groundwater, Ordinary Portland cement (OPC) is the most common cement used in construction work. OPC produces highly durable and sound concrete due to low percentage of alkalis, magnesia, chlorides and free lime in its composition. The properties of cement are given in table 4.

TABLE 4: PROPERTIES OF CEMENT

Property	Results
Specific gravity	3.15
Normal consistency	28%
Fineness of cement	6%

2.1.4 Ground Granulated Blast furnace slag (GGBFS)

Ground Granulated Blast furnace slag (GGBFS) is a by-product from the blast furnaces. The molten slag is produced which is tapped and quenched by water. This rapid quenching of molten slag facilitates formation of "Granulated slag". Ground Granulated Blast furnace Slag is obtained from Granulated slag. Hydraulic property is developed in slag when it undergoes proper processing and then it can be effectively used as a pozzalanic material. The properties of fine GGBFS is given in table 5.

TABLE 5: PROPERTIES OF FINE GGBFS

Tests	Results
Bulk Density	750 kg/m^3
Surface Area (fineness)	9000cm^2/gm
Particle Shape	Irregular
Specific Gravity	2.9

2.1.5 Recron 3s fiber

Recron 3s fiber reinforced concrete has a lot of applications in construction. It prevents the cracks developed due to shrinkage during curing and it makes the structure and plaster stronger. When continuous loads are applied on concrete structure, the failure is observed in the form of cracks. The addition of Recron 3s fiber in concrete or plaster prevents cracking caused by volumetric change due to expansion and contraction. 0.15-0.45% of Recron 3s by cement weight is sufficient for getting the advantages mentioned below (from the literature). It results with reduced labor cost and improved properties. Following are the advantages of Recron 3s fiber:

- Cracks control
- Increase in ductility, compressive, flexural and tensile strength.
- Reduces permeability
- Reduces rebound losses in concrete
- Safe and easy to handle
- Increase abrasion resistance
- Improves durability of concrete
- Reduce shrinkage crack/ Micro cracks

With respect to the advantages of Recron 3s Fibre, it finds its usage in PCC, RCC, plastering, shortcreting and gunniting. It can also be used in Slabs, footings, foundations, walls and tanks Pipes, prestressed beam Concrete blokes, railway sleepers, manhole cover, tiles, pavements, bridges and dams. The properties of Recron 3s fiber is given in table 6:

TABLE 6: SPECIFICATIONS OF RECRON 3S FIBER

Properties	Value
Denier	1.5d
Length	18mm, 24mm
Tensile strength	About 6000 kg/cm2
Melting Point	250 ^{0}C
Dispersion	Excellent
Acid resistance	Excellent
Alkali resistance	good

2.1.6 Control mix and Proportion mix

The concrete mix was prepared as per IS 10262: 2009 whose constituents are given in table 7:

TABLE 7: PROPORTION MIX USING GGBFS AND RECRON 3S FOR M40 GRADE (1cu.m)

MIX (M+P)%	CEMENT (KG)	GGBFS (KG)	RECRON 3S (KG)	COARSE AGG. (KG)	FINE AGG. (KG)	WATER (KG)	ADMIXTURE (KG)
100+0	420	0	0	1135	635	168	5.04
90+10	336	84	0.84	1021.5+ 113.5	635	168	5.04
80+20	336	84	0.84	908.0 + 227.0	635	168	5.04
70+30	336	84	0.84	794.5 + 340.5	635	168	5.04
60+40	336	84	0.84	681.0 + 454.0	635	168	5.04
50+50	336	84	0.84	567.5 + 567.5	635	168	5.04

3. RESULTS

The replacement of aggregates with different proportions of pumice stone in order to achieve the light weight concrete which is 0%-50% for concrete mix of M40 and In cement GGBFS and Recron fiber is used with different proportions which is 20% GGBFS and 0.2% Recron 3s. Tests had been conducted for result of slump, density, compressive strength, flexural strength and Split tensile strength.

3.1 Workability

TABLE 8: SLUMP VALUE FOR M40 GRADE WITH PUMICE STONE

SN.	M40 + % Pumice	Slump Value (mm)
1	M40 + 0% (P)	107
2	M40 + 10% (P)	96
3	M40 + 20% (P)	91
4	M40 + 30% (P)	86
5	M40 + 40% (P)	82
6	M40 + 50% (P)	78

TABLE 9: SLUMP VALUE FOR MODIFIED M40 GRADE WITH GGBFS AND RECRON 3S

SN.	M40 + % Pumice + GGBFS + RECRON 3S	Slump Value (mm)
1	M40 + 0% (P)	107
2	M40 + 10% (P)	100
3	M40 + 20% (P)	95
4	M40 + 30% (P)	90
5	M40 + 40% (P)	86
6	M40 + 50% (P)	81

3.2 Density

TABLE 10: DENSITY OF SPECIMEN AFTER 28 DAYS ON PARTIAL REPLACEMENT WITH PUMICE STONE

SN.	M40 + % Pumice	Density (kg/m^3)
1	M40 + 0% (P)	2451.85
2	M40 + 10% (P)	2241.48
3	M40 + 20% (P)	2042.96
4	M40 + 30% (P)	1851.85
5	M40 + 40% (P)	1666.67
6	M40 + 50% (P)	1485.03

TABLE 11: DENSITY OF SPECIMEN AFTER 28 DAYS WITH GGBFS AND RECRON FIBRE

SN.	M40 + % Pumice+ GGBFS+RECRON 3S	Density (kg/m³)
1	M40 + 0% (P)	2451.85
2	M40 + 10% (P)	2258.47
3	M40 + 20% (P)	2059.74
4	M40 + 30% (P)	1868.55
5	M40 + 40% (P)	1683.47
6	M40 + 50% (P)	1501.53

3.3 Compressive Strength

TABLE 12: COMPRESSIVE STRENGTH OF CUBE ON PARTIAL REPLACEMENT WITH PUMICE STONE FOR M40 GRADE CONCRETE.

SN.	M40 + % Pumice	7 days (N/mm²)	28 days (N/mm²)
1	M40 + 0% (P)	34.85	49.68
2	M40 + 10% (P)	32.66	47.98
3	M40 + 20% (P)	29.17	45.72
4	M40 + 30% (P)	26.84	42.80
5	M40 + 40% (P)	23.38	37.50
6	M40 + 50% (P)	20.11	32.89

TABLE 13: COMPRESSIVE STRENGTH OF CUBE ON REPLACEMENT WITH GGBFS AND ADDITION OF RECRON 3S FOR M40 GRADE

SN.	M40 + % pumice	7 days (N/mm²)	28 days (N/mm²)
1	M40 + 0% (P)	34.85	49.68
2	M40 + 10% (P)	40.02	56.32
3	M40 + 20% (P)	36.15	53.04
4	M40 + 30% (P)	33.50	50.71
5	M40 + 40% (P)	29.15	44.12
6	M40 + 50% (P)	26.10	39.32

3.4 Split Tensile Strength

TABLE 14: SPLIT TENSILE STRENGTH OF CYLINDER ON PARTIAL REPLACEMENT WITH PUMICE STONE FOR M40 GRADE

SN.	M40 + % pumice	28 days (N/mm²)
1	M40 + 0% (P)	4.51
2	M40 + 10% (P)	4.21
3	M40 + 20% (P)	3.77
4	M40 + 30% (P)	3.42
5	M40 + 40% (P)	3.05
6	M40 + 50% (P)	2.82

TABLE 15: SPLIT TENSILE STRENGTH OF CYLINDER ON REPLACEMENT WITH GGBFS AND ADDITION OF RECRON FOR M40 GRADE

SN.	M40 + % pumice	28 days (N/mm²)
1	M40 + 0% (P)	4.51
2	M40 + 10% (P)	5.58
3	M40 + 20% (P)	5.22
4	M40 + 30% (P)	4.88
5	M40 + 40% (P)	4.45
6	M40 + 50% (P)	3.98

3.5 Flexural Strength

TABLE 16: FLEXURAL STRENGTH OF BEAM WITH PARTIAL REPLACEMENT OF PUMICE STONE FOR M40 GRADE

SN.	M40 + % pumice	28 days (N/mm²)
1	M40 + 0% (P)	6.92
2	M40 + 10% (P)	6.69
3	M40 + 20% (P)	6.38
4	M40 + 30% (P)	6.02
5	M40 + 40% (P)	5.65
6	M40 + 50% (P)	5.10

TABLE 17: FLEXURAL STRENGTH OF BEAM ON REPLACEMENT WITH GGBFS AND ADDITION OF RECRON 3S FOR M40 GRADE

SN.	M40 + % pumice	28 days (N/mm²)
1	M40 + 0% (P)	6.92
2	M40 + 10% (P)	8.39
3	M40 + 20% (P)	8.00
4	M40 + 30% (P)	7.58
5	M40 + 40% (P)	7.016
6	M40 + 50% (P)	6.502

4. CONCLUSIONS

- Slump value of M40 grade concrete was found to be 107 mm for conventional concrete and 90 mm for the modified concrete using 20% GGBFS and 0.2% Recron 3s and 30% pumice stone as course aggregate.
- Density for the conventional M40 grade concrete is found to be 2451.85 kg/m³ and for the modified concrete, it was found to be 1868.55 kg/m³ which were 23.8% less from conventional concrete.
- Compressive strength was found to be decreasing on addition of pumice stone as partial replacement of coarse aggregate. After addition of 20% GGBFS

and 0.2% Recron 3s in concrete with various percentage of pumice stone as course aggregate there was an increase in compressive strength of M40 grade modified concrete.

- Flexural strength was found to be decreasing on addition of pumice stone as partial replacement of coarse aggregate and for modified concrete flexural strength increasing on addition of GGBFS and Recron 3s with various percentages of pumice stone in concrete.
- Splitting tensile strength was found to be decreasing on addition of pumice stone as partial replacement of coarse aggregate and for modified concrete flexural strength increased on addition of GGBFS and Recron 3s with various percentages of pumice stone in concrete.
- The mean strength was achieved in modified concrete at 20% GGBFS and 0.2% Recron 3s and 30% pumice stone as coarse aggregate.

5. FUTURE SCOPE

- Light expanded clay aggregate (LECA) can be used in place of pumice stone as it is easily available, cheap and has almost same properties as of pumice stone.
- Pumice stone should not be used in concrete structure as it is costly and not feasible.
- Cementitious materials like silica fumes, fly ash, rice husk etc. can be used in place of GGBFS in different proportion to achieve desired strength.
- Steel fiber can also be used in place of Recron 3s for improving tensile and flexural properties of concrete.

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