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Mechanical Properties of M 25 Grade Concrete Made With Pumice as A Partial Replacement Of Coarse Aggregate

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Abstract:*Light weight concrete has become more popular in recent years owing to the tremendous advantages it offers over the conventional concrete. Even light concrete but at the same time strong enough to be used for the structural purpose. Lightweight concrete has been successfully used since the ancient roman times and it has gained its popularity due to its lower density and superior thermal insulation properties. Compared with normal weight concrete, lightweight concrete can significantly reduce the dead load of structural elements, which makes it especially attractive in multi-story buildings. The most important characteristic of light weight concrete beside its light weight is its low thermal conductivity. The adaptation of certain class of light weight concretes gives an outlet for industrial wastes and dismantled wastes which would otherwise create problems for disposal. The aim of the research is to study the attitude of the conventional mix has been designed for M 25 grade concrete and coarse aggregate replaced with pumice aggregate in volume percentages of 10, 20, 30 and 40% further cement replaced with the Ground Granulated Blast Furnace Slag (GGBFS) and Fly Ash (FA) in weight percentages of 10, 20 and 30% study in the present investigation. The properties like compressive strength, split tensile strength, flexural strength and young's modulus of above combinations were studied and compared with conventional design mix concrete. Hence we can infer that 30% replacement of cement by fly ash is optimum proportion among the proportions tested.*

Keywords:*Pumice, Fly Ash, Ground Granulated Blast Furnace Slag, Compressive Strength, Split Tensile Strength, Flexural Strength and Modulus of Elasticity*

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I. Introduction

1.1 Introduction

Light weight concrete has become most popular in recent years outstanding to the very great advantages it offers over the predictable concrete but at the same time strong enough to be used for the structural purpose.

The most important characteristic of light weight concrete is its low thermal conductivity. This properties improves with decreasing density. Concrete with a density between 1350 and 1900 kg/m3 and a minimum compressive strength of 17MPa is defined as structural lightweight concrete (ACI 213R-87, 1998). Structural lightweight aggregate concretes were measured as unconventional to concretes made with dense natural aggregate because of the relatively high strength to unit weight ratio that can be achieved.

Other reasons for choosing lightweight concrete as a construction material is more attention is being paid to energy saving and to the usage of waste materials to provide exhaustible natural sources.

Lightweight aggregate, because of their cellular structure, can absorb more water than normal weight aggregate. In a 24-hour absorption test, they generally absorb 5 to 20% by mass of dry aggregate, which is depending on the pore structure of the aggregate. In general, under circumstances of outdoor storage in stockpiles, total moisture content does not exceed two-thirds of this value. This means that lightweight aggregate frequently absorb water when placed in a concrete mixture, and the resulting rate of absorption is important in proportioning lightweight concrete.

Due to this more absorption of water of light weight aggregate, internal curing shall be maintained for a long period. Increasing exploitation of lightweight materials in civil structuring applications is making pumice stone a very important raw material as a lightweight rock.

1.2 Classification Of Light Weight Concrete

Various types of light weight concrete can be classified by their method of production in to three groups

i) No-fines concrete: By omitting the fine aggregate from the mix so that a large number of interstitial voids present; normal weight coarse aggregate is generally used. This concrete as no-fines concrete.
ii) Lightweight aggregate concrete: By using porous lightweight aggregate of low apparent specific gravity instead of normal coarse aggregate. This type of concrete is known as lightweight aggregate concrete.
iii) Aerated/Foamed concrete: Aerated concrete does not contain coarse aggregate, and can be regarded as an aerated mortar. Typically, aerated concrete is made by introducing air or other gas into a cement slurry and fine sand.

Since the lightness of these aggregates derives from the air trapped in each individual particle, the more air that is trapped per particle unit, the lighter the weight and the better but conversely, lower the strength.

1.3 Light Weight Aggregate

The term light weight aggregate is defined as aggregate with a relatively low specific gravity. It is used in this lightweight concrete instead of ordinary aggregate. There are many types of aggregate available that are classed as light weight and their properties cover wide ranges. Elastic properties, compressive and tensile strength, time dependent properties, durability, fire resistance and other properties of light weight aggregate concrete are dependent on the type of lightweight aggregate utilized in the concrete. The light weight aggregate can be natural aggregate such as pumice, scoria and all those of volcanic origin or the artificial aggregate such as expanded blast-furnace slag vermiculite and coal cinder aggregate. The main characteristic of this light weight aggregate is its high porosity which results in a low specific gravity. Light weight aggregate concrete is fully compacted similar to that of the normal reinforced concrete of dense aggregate. It can be used with steel reinforcement as to have a good bond between the steel and the concrete. The light weight aggregate concrete should provide adequate protection against the corrosion of the steel. Light weight aggregate, due to their cellular structure, can absorb more water than normal weight aggregate. In a 24-hour absorption test, they generally absorb 5 to 20% by mass of dry aggregate, depending on the pore structure of the aggregate. Normally, under conditions of outdoor storage in stockpiles, total moisture content does not exceed two-thirds of that value. This means that light weight aggregate usually absorb water when placed in a concrete mixture and the resulting rate of absorption is important in proportioning light weight concrete. Due to this more absorption of water of light weight concrete, internal curing will be maintained for a long period. Light weight aggregates can be divided in to two groups

1. Natural light weight aggregate
- Pumice
- Scoria
- Volcanic cinders
- Palm oil shells

2. Artificial light weight aggregate
- Coal cinders
- Sintered fly ash
- Exfoliated vermiculite
- Expanded perlite
- Foamed slag
- Bloated clay
- Thermo coal beads
- Expanded shale and slate

1.3.1 Pumice Aggregate

Pumice is a natural absorbent substance-like material of volcanic origin collected from molten lava rapidly cooling and trapping millions of small air bubbles. Pumice aggregate are abundant at the outer edge of volcanic mountains, particularly in Mediterranean area, Rocky Mountains in US, and most part of Turkey and Indonesia. The utilization of Light Weight Aggregate Concrete based on natural lightweight aggregate materials such as pumice has been some extent limited, partially due to insufficient amount obtainable in the early years when the material and production know-how is low and partly due to lack of enthusiasm and industrial interests. In recent years, the existing limited research that has been conducted in this area structural concrete with compressive strength up to 25 MPa can be produced with adequate economic benefits using pumice

Pumice is a accepted aggregate of abundant resource around the world and it is ecofriendly. However, pumice is far from being fully utilized in lightweight concrete at the time being. Concrete structures are usually designed to take advantage of its compressive strength. The major structural property of concrete that a concrete designer is generally concerned is the compressive strength of concrete at a specific age. Pumice is the only rock that floats on water, although it ultimately becomes waterlogged and sinks. Since pumice is a volcanic rock, and retains its useful properties only when it is young and unaltered, pumice deposits are found in areas with young volcanic fields. Worldwide, more than 50 countries produce pumice products. The largest producer is Italy, which dominates pozzolana production. Other major pumice producers are Greece, Chile, Spain, Turkey, and the United States. Pumice and pumice are used to make lightweight construction materials. About three-quarters of pumice and pumice are consumed annually for this purpose.

In the present investigation, the light weight aggregate has been replaced in the normal coarse aggregate by an amount 40%. From the literature it is noticed that, due to the decreased unit weight with light weight aggregate, the strength properties may also retard. Hence to overcome the same for these mixes, the replacement of cement by fly ash has been tried. It is observed that the lost properties in the light weight aggregate replaced mixes have regained to certain extent.

II. Literature Review

2.1 Necessity Of Light Weight Concrete

One of the most negative aspect of the conventional concrete is its high self-weight. Because of heavy self-weight of concrete makes it to some extent uneconomical structural material in some particular applications. Attempts have been made in the past to lower the self -weight of concrete and hence to increase its effectiveness as structural materials. Till now, studies on lightweight concrete with pumice aggregate have been scarce. However, considerable research work has been carried out on normal weight concrete. The development and use of lightweight concrete is important to the construction and maintenance of civil engineering structures.

Light weight concrete is that concrete which by one means or the other has been made lighter than the conventional concrete. The DRAFT INTERNATIONAL MODEL CODE for concrete construction classifies light weight concrete as having densities between 1200 and 2000 Kg/m3.

The most and great important quality of light weight concrete is its low density. There are many advantages of having low density. It helps in reduction of dead load, increases the improvement of building and lowers the haulage and handling costs. The use of light weight concrete has made it possible to proceed with the construction of tall structures on soils of low bearing capacities. In framed structures, if floors and walls are made of light weight concrete it will results in considerable economy. Another advantage of light weight concrete is its low thermal conductivity, and by which improves with decreasing density. Hence, in extreme climatic conditions and also in case of building with air-conditioning, the use of light weight concrete not only results in thermal comforts but also helps in declining the power consumption. Further, the use of light weight concrete results in opening an outlet for industrial wastes such as clinker, fly-ash, slag etc., which otherwise create problems of disposal. Keeping in view, the growing construction industry, it is almost necessary to resort to non-conventional and economic building materials, as the conservative materials are becoming more and more rare and costly.

2.2 Methods Of Making Light Weight Concrete

Basically, there is only one means of making concrete light-by including air in its composition. The inculcation of air can however be accomplished by the following three ways

i. By omitting i.e. finer sizes from the aggregate grading, thereby creating the so called 'no-fines concrete'. .
ii. By replacing the gravel or crushed rock by a hollow, cellular or permeable aggregate which includes air in the mix
iii. By creating gas bubbles in a cement slurry - 'Aerated Concrete'.

Natural aggregate confirming to BS 882; blast furnace slag confirming to BS 1047; foamed slag confirming to BS 877 and aggregate covered by BS 3797 are suitable for making no-fines concrete. The grading should be such that not more than 5% is held on a 19 mm sieve and not more than 10% passes through a 9 mm sieve. The aggregate should be free from dust and its Flakiness Index limited to 30%. The water must be satisfactory for all the modules coated with cement grout; more water is undesirable as cement by runoff.

According to Euro Light Con Light-weight aggregate concrete (LWAC) has lower density and higher insulating capacity than NWC (about 6 times). Insulating building blocks are made with low strength aggregate such as pumice. These aggregate have an average compressive strength of 3.5 MPa, but this value can be improved up to 7.0MPa. The average density of a block is 978 kg/m3 and thermal conductivity of these blocks is 0.20W/mK.

G. Campione, N. Miraglia and M. Papia stated that Lightweight concrete exhibits very brittle actions with respect to normal weight concrete having the same compressive strength. Experimental results have shown pumice stone performs well, making it suitable for use even in seismic areas, especially in regions where its cost is low.

The work done by Zhutovsky, S., Kovler, K., and Bentur, A describes how to optimize the size and porosity of lightweight aggregate to get a minimum amount of effective internal curing and also states Light-weight aggregate concrete (LWAC) has lower density and higher insulating capacity than NWC (about 6 times).

Insulating building blocks are made with low strength aggregate such as pumice. These aggregate have an average compressive strength of 3.5 MPa, but this value can be increased up to 7.0MPa. The average density of a block is 978 kg/m3 and thermal conductivity of these blocks is 0.20W/mK.

Chandra S, Berntsson L stated that the aim of conventional concrete technology is its maximized mechanical performance enhancement using raw materials. Alonso E, Martinez L, Martinez W, Villasenor L stated that Low quality lightweight aggregate are widespread in many parts of the world and there is a concern as to the production of high quality lightweight concrete in those regions. With a wide range of that low quality lightweight aggregate offered for concrete, there is need for a better understanding of the properties influence of those aggregate on the compressive strength, splitting tensile strength and elastic modulus of concrete.

Chi JM, Huang R, Yang CC, Chang JJ, was also stated that commercially produced lightweight aggregate were used in concrete by many researchers to investigate the strength, stiffness and durability of concrete.

O. Kayali, M.N.Haque, B.Zhu reported that By adding some mineral admixtures, using higher prescribed amount of cement and super plasticizer and decreasing the water to cement ratio, make achievable to produce somewhat high strength Light weight concrete from scoria aggregate.

Kiliç A, Ati_ CD, Ya_ar E, ÖzcanF reported that The term “curing” is repeatedly used to describe the process by which hydraulic cement concrete matures and develops hardened properties overtime as a result of the sustained hydration of the cement in the presence of sufficient water and heat. While all concrete cures to varying levels of maturity with time, the rate at which this development takes place depends on the natural environment surrounding the concrete, and the measures taken to modify this environment by limiting the loss of the water, heat or both from the concrete or by superficially providing moisture and heat. The word “curing” is also used to describe the action taken to maintain moisture and temperature conditions in a freshly placed cementition mixture to allow hydraulic- cement hydration and if applicable pozzolanic reactions to occur so that the potential properties of the mixture may develop.

There are several methods that can be used for curing of concrete. These can be separated into three main groups namely, air curing; which includes sealed curing fogging, etc., water curing and steam curing; which includes atmospheric (low pressure) steam curing and autoclave (high pressure) steam curing.

Mindess, S.Young, J.F. and Darwin, D. states that Pumice is a natural material of volcanic origin produced by the discharge of gases during the solidification of lava and it has been used as aggregate in the production of lightweight concrete in many countries of the world. So far, the use of pumice was mainly based on the availability and limited to the countries where it is nearly available or easily imported.

III. Properties Of Materials

3.1 General

The main constituents of the light weight aggregate concrete are Cement, fine aggregate, coarse aggregate, water and Cinder are procured from various places. Fine aggregate and coarse aggregate are procured from local area. Cinder is procured from Barkath enterprises in Hyderabad. Local drinking water is used for mixing and curing. The properties of cement, fine aggregate, coarse aggregate, water, Cinder used in the investigation were obtained based on standard experimental procedures laid down in IS codes.

The experiments conducted on cement are fineness test, specific gravity, normal consistency, initial setting and final setting time. The experiments conducted on fine and coarse aggregates and Cinder are sieve analysis, water absorption, specific gravity, crushing strength.

3.2 Materials

The constituents of the concrete mix are cement, fine aggregate, coarse aggregate, Cinder. The details of each constituents are as follows:

3.2.1 Cement

In the present investigation, Zuari Ordinary Portland Cement (OPC) of 43 grade confirming to IS: 8112-1989 specifications were used. The properties of cement are shown in table 3.1.

Table: 3.1 Physical properties of 43 grade Ordinary Portland Cement

S. No	Property	Results
1.	Fineness	7%
2.	Specific gravity	3.15
3.	Normal Consistency	30.5%
4.	Setting time(min) a) Initial b) Final	 90 min 285 min

3.2.2 Fine Aggregate

The locally available natural sand is procured and is found to be conformed to grading zone-II of IS 383-1970. Various tests have been carried out as per the procedure given in IS 383-1970 from them it is found that,

- Specific Gravity of Fine Aggregate is 2.56
- Fineness Modulus of Fine Aggregate is 2.6

3.2.3 Natural Coarse Aggregate

Machine crushed granite aggregate conforming to IS 383-1970 consisting 20mm and below maximum size of aggregates has been obtained from the local quarry. It has been tested for physical and mechanical properties such as Specific Gravity, Water Absorption and Sieve Analysis and the results are as follows:

- Specific Gravity of Coarse Aggregate is 2.67
- Water Absorption of Coarse Aggregate is 0.4%
- Fineness Modulus of Coarse Aggregate is 7.53

3.2.4 Light Weight Aggregate (Pumice)

Fig: 3.1 Light weight Aggregate (Pumice)

a. Specific Gravity for coarse aggregate is 1.14.
b. Specific Gravity of LWA -25%-2.1
c. Specific Gravity of LWA- is 33.33%- 2.3
d. Fully compacted density of Lightweight coarse aggregate is 85kg/m^3
e. Loose density of Light weight coarse aggregate is 140kg/m^3

3.2.5 FLY ASH

Table: 3.2Chemical Composition of Fly Ash

Oxide Composition	Percentage (%)
SiO_2	18.95
Al_2O_3	7.53
Fe_2O_3	3.85
CaO	51.29
MgO	1.58
SO_3	12.06
K_2O	1.51
Na_2O	0.32
Loi	1.94

3.2.6 GROUND GRANULATED BLAST FURNACE SLAG

Table: 3.2 Physical Property GGBFS

Properties	GGBFS
Specific Gravity	2.8
Fineness(m^2/kg)	350 to 450
Appearance/ Colour	Light yellow
Structure	Glassy

3.3 MIX DESIGN

Table: 3.4 Mix Proportions for M 25 Grade Concrete

Cement	Fine Aggregate	Coarse Aggregate	Water
1	**2.2**	**3.6**	**0.5**

IV. Experimental Investigation

4.1 General

The experimental investigation is carried out to obtain the compressive strength, tensile strength, flexural strength and modulus of elasticity tests of M 25 grade of concrete.

In the present investigation concrete specimens were prepared with various combinations i.e. coarse aggregate are replaced with Pumice aggregates (10%, 20%, 30% and 40%) and cement is replaced with Fly Ash (10%, 20% and 30%) and GGBFS (10%, 20% and 30%).

4.2 Compression Strength Test

Compression test is the most common test conducted on hardened concrete, because it is an easy test to perform, and most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. Compression test is carried out on specimen of cubical shape. Compression test is done confirming to IS: 516-1959. All the concrete specimens that are tested in a 2000 tons capacity of the compression testing machine. Concrete cubes of size 150mm x 150mm x 150mm were tested for compressive strength. Compressive strength of concrete is determined by applying load at the rate of 140kg/sq.cm/minute till the specimens failed.

After 3, 7, 28 and 56 days of curing, cube specimens were removed from the curing tank and cleaned to wipe off the surface water. Cubes were tested at the specified age using compression testing machine as shown in Fig 4.1. The maximum load to failure at which the specimen breaks and the pointer starts moving back was noted. The test was repeated for three specimens and the average value was taken as the mean strength.

Fig: 4.1 Cube Compressive Strength Test

4.3 Split Tensile Strength Test

This test is conducted in a 2000 tones capacity of the compression testing machine by placing the cylindrical specimen of the concrete, so that its axis is horizontal between the plates of the testing machine. Experimental setup for Split Tensile Test is shown in fig 4.2 the load was applied uniformly at a constant rate until failure by splitting along the vertical diameter takes place. Load at which the specimen failed is recorded and the splitting tensile stress is obtained using the formula based on IS: 5816-1970.

Fig: 4.2 Split Tensile Test

The following relation is used to find out the split tensile strength of the concrete

F_t = $2P/\pi DL$
P = Compressive load on the cylinder
L = Length of the cylinder
D = Diameter of the cylinder

4.4 Flexural Strength Test

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam to resist failure in bending. The flexural strength can be determine by standard test method of third point of loading or center – point loading.

In this study, three beams of size 100mm x 100mm x 500mm were used to find flexural strength. The system of loading used for finding the flexural strength is shown in figure 5.3. In case of three point loading, the critical crack may appear at any section, of the pure bending zone.

Flexural strength is calculated using the following formula.

(a) When fracture initiates in the tension surface (i.e., the bottom surface) within the middle third of the beam

$MR = \frac{PL}{bd^2}$

- Where P is the failure load
- l is the span length
- d is the depth of the beam
- b is the width of the beam

All dimensions are in mm.

(b) If fracture initiates in the tension surface (i.e., the bottom surface) outside the middle third of the beam by not more than 5% of the span length.

$MR = \frac{3Pa}{bd^2}$

Fig: 4.3 Flexural Strength Test

4.5 Modulus Of Elasticity

Modulus of elasticity (MOE) test was conducted on the specimens for all the mixes at different curing periods as per IS 516 (1991). Three cylindrical specimens of size 150 mm x 300 mm were cast and tested for each age and each mix. Each specimen was loaded until an average stress of (C+5) kg/cm^2 is reached. Here, C is the one-third of the average equivalent cube compressive strength. The equivalent cube strength has been determined by multiplying the cylinder strength by 5/4. Strains at regular interval of loads till the proportional limit, have been measured. Stress-strain curve has been plotted. The secant modulus is calculated from the slope of the straight line drawn from the origin of axes to the stress-strain curve (IS 516, 1991) and this secant modulus is the required modulus of elasticity of the concrete (E_c).

Fig: 4.4 Modulus of Elasticity Test

V. Results And Discussions

5.1 General

The results and the analysis of experimental investigation is carried out. The properties of concrete mixes are obtained by replacement of coarse aggregate with Pumice Aggregate. The properties like

- Cube Compressive Strength
- Split Tensile Strength
- Flexural Strength
- Modulus of Elasticity

All are studied and the same properties are compared with the conventional control concrete mix M 25.

5.2 Compressive Strength Of Concrete:

The results of the cube compressive strength of M 25 grade concrete for various combinations of Pumice Aggregate (10%, 20%, 30% and 40%) for different curing periods (3, 7, 28 and 56 days) are obtained. Concrete Cubes of size 150 mm × 150 mm × 150 mm which are casted to test the compressive strength at the age of 3, 7, 28, and 56 days. Each value of the cube compressive strength indicates the average of three test results. The variations of compressive strength at 3, 7, 28 and 56 days for different replacements are shown in table 5.1, table 5.2 and table 5.3.

Table: 5.1 Cube Compressive Strengths of M 25 Grade Concrete different Percentages of Pumice and 10% GGBFS, 10% FA

S.No	Type of Mix	Compressive Strength(MPa)			
		3-days	7-days	28-days	56-days
1	control mix	27.54	30.64	34.48	37.92
2	10% Pumice + 10%GGBFS + 10%FA	29.44	32.24	35.88	39.98
3	20% Pumice + 10%GGBFS + 10%FA	33.36	34.24	38.64	42.42
4	30% Pumice + 10%GGBFS + 10%FA	35.25	37.26	40.66	45.35
5	40% Pumice + 10%GGBFS + 10%FA	36.55	39.45	44.56	47.25

Table 5.2: Cube Compressive Strengths of M 25 Grade Concrete different Percentages of Pumice and 20% GGBFS, 20% FA

S.No	Type of Mix	Compressive Strength(MPa)			
		3-days	7-days	28-days	56-days
1	control mix	27.54	30.64	34.48	37.92
2	10% Pumice + 20%GGBFS + 20%FA	32.44	34.24	36.88	40.98
3	20% Pumice + 20%GGBFS + 20%FA	35.36	37.24	41.64	44.42
4	30% Pumice + 20%GGBFS + 20%FA	38.25	39.26	44.66	48.35
5	40% Pumice + 20%GGBFS + 20%FA	44.55	46.45	50.56	54.64

Table 5.3: Cube Compressive Strengths of M 25 Grade Concrete different Percentages of Pumice and 30% GGBFS, 30% FA

S.No	Type of Mix	Compressive Strength(MPa)			
		3-days	7-days	28-days	56-days
1	Control mix	27.54	30.64	34.48	37.92
2	10% Pumice + 30%GGBFS+30%FA	36.44	38.24	42.88	43.98
3	20% Pumice + 30%GGBFS+30%FA	38.36	40.24	44.64	46.42
4	30% Pumice + 30%GGBFS+30%FA	39.25	41.26	45.66	50.35
5	40% Pumice + 30%GGBFS+30%FA	45.55	48.45	55.56	58.64

Table 5.4: Split Tensile Strength of M 25 Grade Concrete

S.No	Type of Mix	Split Tensile Strength (MPa)		
		3-days	7-days	28-days
1	Control mix	3.95	4.13	4.22
2	10% Pumice + 30%GGBS+30%FA	3.98	4.24	4.36
3	20% Pumice + 30%GGBS+30%FA	4.12	4.26	4.54
4	30% Pumice + 30%GGBS+30%FA	4.25	4.35	4.63
5	40% Pumice + 30%GGBS+30%FA	4.42	4.62	4.64
6	100% Pumice + 30%GGBS+30%FA	3.74	3.22	3.12

The variation of cube compressive strength with age of M 25 grade concrete for various combinations of Pumice Aggregate, GGBFS and FA for various curing periods is shown in Fig.6.3. The cube compressive strength indicates the average of three test results. The compressive strength of Conventional Control Concrete is 34.48 N/mm^2. Results indicate that as the Pumice Aggregate increases more than 62%. It is observed that the light weight aggregate concrete of 62% Pumice Aggregate, maximum cube compressive strength is 55.58 N/mm^2.

5.3 Split Tensile Strength

The Split Tensile Strength variation for all mixes is shown in Figure 6.2.Concrete Cylinders of size 150 mm Diameter and 300 mm Height are casted to test the Split Tensile strength at the age of 28 days. The variations of Split Tensile strength at 28 days for different replacements are shown in table 6.2. The Split Tensile Strength of Conventional Control Concrete is 3.89MPa. Results indicate that as the Pumice Aggregate increases more than 40%, the tensile strength decreases. It is observed that light weight aggregate concrete at 40% Pumice, the maximum split tensile strength is 4.64 MPa.

5.4 Flexural Strength

The flexural strength variation for all mixes is shown in figure 6.3. Concrete beams of size 500 mm length and 100mm × 100 mm cross-section area are casted to test the flexure strength of concrete at the age of 28 days. The variations of flexural strength at 28 days for different replacements are shown in table 6.3. The flexural strength of Conventional Control Concrete is 3.38MPa. From the results it is observed that light weight aggregate concrete at 40% of Pumice, the maximum flexural strength is 4.22 MPa.

Table 5.5: Flexural Strength of M 25 Grade Concrete

S.No	Type of Mix	Flexural Strength (MPa)		
		3-days	7-days	28-days
1	Control mix	3.38	3.42	3.48
2	10% Pumice + 30%GGBFS + 30%FA	3.51	3.64	3.72
3	20% Pumice + 30%GGBFS + 30%FA	3.62	3.84	3.92
4	30% Pumice + 30%GGBFS + 30%FA	3.74	3.91	4.02
5	40% Pumice + 30%GGBFS + 30%FA	3.94	4.13	4.22
6	100% Pumice + 30%GGBFS + 30%FA	3.26	3.22	3.15

Fig 5.6. Variation of Flexural Strength of M25 Grade Concrete with different Percentages of Pumice Aggregate and 30%GGBS, 30% FA

5.4. Modulus Of Elasticity

In this present investigation would based on the Compressive strength results obtained for 40% of light weight aggregate with different proportions as of the GGBS and fly ash replacements in cement. It could be noticed that the maximum compressive strength is obtained for 30% cement replaced by GGBS and flyash. Hence the Modulus of Elasticity &Flexural Strength proposing is studied for the grouping of 25% and 30% light weight aggregate, replacement in coarse aggregate and 40% replacement of GGBS and fly ash in cement

The Modulus of Elasticity (MPa) of the concrete at 3, 7 and 28 days for the 30% replacements of GGBS and fly ash with the cement and with 0%,10% 20%, 30% and 40% of light weight aggregates replaced in coarse aggregate are reported in Table.

Table 5.6: Modulus of elasticityof M25 Grade Concrete

S. No	Age in Days	Modulus of elasticity (MPa)				
		Control mix	10% Pumice+30%GGBS+ 30%FA	20% Pumice+30 %GGBS+30 %FA	30% Pumice+30% GGBS+30%FA	40% Pumice+30% GGBS+30% FA
1	3	$2.5x10^4$	$2.35x10^4$	$2.6x10^4$	$2.2x10^4$	$2.602x10^4$
2	7	$2.6x10^4$	$2.45x10^4$	$3.45x10^4$	$2.4x10^4$	$3.12x10^4$
3	28	$2.85x10^4$	$2.58x10^4$	$3.663x10^4$	$2.6x10^4$	$3.52x10^4$

VI. Conclusions

From the limited experimental study, the following conclusions are seem to be valid:

It can be concluded that strength of light weight aggregate concrete is increased by using Pumice Aggregate. Compared to Conventional Control Concrete, the Cube Compressive Strength, Split Tensile Strength, Flexure Strength up to replacement of 40% Pumice Aggregate in natural coarse aggregate . This is due to the bond strength between the aggregate and the matrix is stronger in the case of light weight aggregate concrete using Pumice than in normal weight concrete, it is attributed due to mainly two reasons.

- The compressive strength at 28, 56 days for the M25 design mix concrete using normal coarse aggregate and cement is obtained as 35MPa and 37MPa. Further the compressive at 28, 56 days for 30% replacement of cement by GGBS and fly ash and 40% light weight aggregate replacement in normal aggregate it is observed as 56 MPa and 59Mpa.
- The Split Tensile Strength at 28days for the M25 design mix concrete using normal coarse aggregate and cement is obtained as 4.22Mpa. Further the Split Tensile Strength at 28days for 30% replacement of cement by GGBS and fly ash and 40% light weight aggregate replacement in normal aggregate it is observed as 4.66 MPa and 100% light weight aggregate replacement in normal aggregate it is observed as decrease in 3.74Mpa.
- The Flexural Strength at 28days for the M25 design mix concrete using normal coarse aggregate and cement is obtained as 3.48Mpa. Further the Flexural Strength at 28days for 30% replacement of cement by GGBS and fly ash and 40% light weight aggregate replacement in normal aggregate it is observed as 4.22 MPa and 100% light weight aggregate replacement in normal aggregate it is observed as decrease in 2.66 MPa.
- The young's modules at 28 days for 30% replacement of cement by GGBS and fly ash and 40% light weight aggregate replacement in normal coarse aggregate it is observed as $3.52 x10^4$ MPa
- Finally, it can conclude that though the permeability is reducing even up to 30% replacement of cement with GGBS, Keeping the workability and compressive strength in mind ,40% replacement of Pumice Aggregate in normal aggregate and 30% replacement of cement with GGBS is recommended for use in M25 grade concrete

6.2 Scope for future study

- The similarly studies could be carried for different replacements of light weight aggregate.
- The similarly studied can be carried for different design mixes.
- An investigation can be made on pre-wetting of the light weight natural pumice aggregate for different mixes.
- Studies on fibrous (metallic, nonmetallic and natural) light weight aggregate (Pumice) concretes can be evaluated.
- The studies on SSC with light weight aggregate (pumice) can be evaluated.
- Behavior of the pumice aggregate concrete mixes with different mineral admixtures can be made.

- Durability studies can be conceded out by exposing to chloride sulphate and acidic environments.
- Elevated temperature studies, freezing, thawing and chloride permeability tests on this particular type of concrete can be studied.
- Studies on Rice husk and GGBS with light weight aggregate (pumice concrete can be evaluated

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