An Experimental Study on Light Weight Concrete Using Pumice and Partial replacement of cement using GGBS and Metakaolin

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Abstract **- In Light weight concrete pumice plays a role as coarse aggregate. In our concrete we are using M-sand and partial replacement of cement using GGBS and Metakaolin. The ratio we are (40% Cement ,50% GGBS), (50% Cement, 40% GGBS), (60% Cement,30% GGBS), (70% Cement, 20% GGBS), (80% Cement, 10% GGBS) and 10% Metakaolin is kept constant in our concrete. As we are using this ratio to get the strength and hardness of the concrete. It reduces the permeability. Cement is major constituent material of the concrete which produced by natural raw material like lime and silica. Once situation may occur there will be no lime on earth for production. This situation leads to think all people working in construction industry to do research work on cement replacing material and use of it. Industrial wastes like Ground Granulated Blast Furnace Slag (GGBS) show chemical properties similar to cement. Use of GGBS as cement replacement will simultaneously reduce cost of concrete and help to reduce rate of cement consumption. For these lightweight aggregate concrete mixes when 'cement' was replaced by 'GGBS' it is noticed that there is a marginal improvement in the properties studied. One of the vibrant disadvantages of nominal concrete having high dead load (self-weight). This heavy self-weight will make it to extent an uneconomical structural material. Light weight concrete having low density, reduction of dead load and to increase the thermal insulation. The reduction in density produced by using pumice aggregate as a limited replacement of coarse aggregate in concrete.**

Index Terms **- Pumice, GGBS, Metakaolin, M-Sand, Self-weight.**

I.INTRODUCTION

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time. The cement reacts with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time. Portland cement is the commonly used type of cement for production of concrete. Concrete technology deals with study of properties of concrete and its practical applications. In a building construction, concrete is used for the construction of foundations, columns, beams, slabs, and other load bearing elements. There are different types of binding material is used other than cement such as lime for lime concrete and bitumen for asphalt concrete which is used for road construction. Various types of cements are used for concrete works which have different properties and applications. Some of the types of cement are Portland Pozzolana Cement (PPC), rapid hardening cement, Sulphate resistant cement etc. Materials are mixed in specific proportions to obtain the required strength. Strength of mix is specified as M5, M10, M15, M20, M25, M30 etc., where M signifies Mix and 5, 10, 15 etc. as their strength in kn/m^2. In United States, concrete strength is specified in PSI which is Pounds per Square Inch. Water cement ratio plays an important role which influences various properties such as workability, strength, and durability. Adequate water cement ratio is required for production of workable concrete. When water is mixed with materials, cement reacts with water and hydration reaction starts. This reaction helps ingredients to form a hard matrix that binds the materials together into a durable stone-like material. Concrete can be casted in any shape. Since it is a plastic material in fresh state,

various shapes and sizes of forms or formworks are used to provide different shapes such as rectangular, circular etc. Various structural members such as beams, slabs, footings, columns, lintels etc. are constructed with concrete. Components of concrete are cement, sand, aggregates, and water. Mixture of Portland cement and water is called as paste. So, concrete can be called as a mixture of paste, sand, and aggregates. Sometimes rocks are used instead of aggregates. The cement paste coats the surface of the fine and coarse aggregates when mixed thoroughly and binds them. Soon after mixing the components, hydration reaction starts which provides strength and a rock-solid concrete is obtained. Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as ability and lessened the dead weight. The main specialties of lightweight concrete are its low density and thermal conductivity.

II. MATERIALS

A) PUMICE

Light weight aggregate (Pumice) has been used as a construction material. Light weight concrete is commonly used in precast and prestressed concrete. The light weight used in concrete is pumice. It is one of the oldest light weight concretes. It is formed from volcanic activation. The most important characteristic of light weight concrete is its low thermal conductivity. Pumice is a type of extrusive volcanic rock, produced when lava with a very high content of water and gases is discharged from a volcano. As the gas bubbles escape, the lava becomes frothy. When this lava cools and hardens, the result is a very light rock material filled with tiny bubbles of gas.

Fig 1- Pumice

Table 1- Properties of pumice

S.NO	PROPERTIES	VALUES
1.	Specific gravity	2.75
2.	Water absorption	2.27%

B) Cement

Cement is a finely grey powdered substance made by burning a mixture of clay and lime that sets hard when it is mixed with water. It is used with water and sand to make mortar or mixed with sand, aggregate, and water to form concrete. Cement is a binder material, that is a substance that helps in binding together different material.

Table 2- Properties of Cement

S.NO	PROPERTIES	VALUES
1	Specific gravity	3.125
2	Initial setting time	45min
3	Final setting time	380 min
4	Fineness test	3.4%
5	Bulk density	1440Kg/m^3

C) Fine Aggregate (M-SAND)

Manufactured sand (M-sand) is quarry dust produced from rock quarry; it is the replacement of river sand. M-Sand less damage to the environment as compared to natural sand. Manufactured sand (M sand) is artificial sand produced from crushing hard stones into small sand sized angular shaped particles, washed and finely graded to be used as construction aggregate. M- sand is a substitute of river sand used in construction industries mainly for concrete production and mortar mix. It is an eco-friendly material which made from rock pieces by artificial processes. The specific gravity and bulk density were found to be 2.70 and 1736kg/m^3 respectively. M-Sand has balanced physical and chemical properties that can withstand any aggressive environmental and climatic conditions as it has enhanced durability, greater strength and overall economy. M- sand is free from silt and clay particles which offer better abrasion resistance, higher unit weight and lower permeability.

Table 3 – Properties of M-Sand

S.NO	PROPERTIES	VALUES
1	Specific Gravity	2.68
2	Water Absorption	2.08%
3	Bulk Density	1860 Kg/m^3

D) Ground Granular Blast Furnace Slag

Ground Granulated Blast Furnace Slag (GGBS) is a byproduct from the blast furnaces used to make iron. Ground Granulated Blast Furnace Slag (GGBS) show chemical properties similar to cement. Use of GGBS as cement replacement will simultaneously reduce cost of concrete and help to reduce rate of cement consumption. Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steelmaking) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder

Fig 2- GGBS

Table 4 – Properties of GGBS

S.NO	PROPERTIES	VALUES
1	Specific gravity	2.9
2	Bulk Density	1100Kg/m^3

E) METAKAOLIN

Metakaolin is a cementitious material used as admixture to produce high strength concrete. Metakaolin is produced by burning kaolin at a temperature of 600°C-800°C. Metakaolin is a cementitious material used as admixture to produce high strength concrete. Metakaolin is produced by burning kaolin at a temperature of 600°C-800°C.

Fig 3 – Metakaolin

Table 5 – Properties of Metakaolin

S.NO	PROPERTIES	VALUES
1	Specific gravity	2.6
2	Bulk density	1005Kg/m^3

III. METHODOLOGY

- The used materials are taken preliminary test for Cement, Fine Aggregate, Coarse Aggregate, GGBS, Metakaolin. The cement we used is Portland Pozzolana Cement.
- And we have calculated slump value. The type of slump we got is True slump. The value is 40mm.
- The design we calculated is M25 mix design.
- We have casted conventional concrete for comparing it with our concrete.
- And then we have made 4 different ratio cubes.
- The calculated materials are taken as per mix design.
- We are using Pumice, M-Sand, cement, GGBS, Metakaolin.
- In our specimen we are partially replacing (i.e.) 10% Metakaolin constant is shown in Table 5.
- We have molded cube size 10cm x 10cm x 10cm. And we have mixed the concrete and placed in the mould. Later we casted the cube.
- After Casting we kept it in the vibration.
- The specimens were kept in laboratory ambient temperature for 24hrs.
- And then specimen was placed in water for curing for about 7 Days ,14Days, 28Day.
- The specimen taken out from curing, corresponding to the days.
- And test is taken for that specimen reading is noted.
- The specimens were broken, and reading are noted.

Table 6 – Trail

MIX	CEMENT	GGBS	METAKAOLIN
MIX 1	40%	50%	10%
MIX 2	50%	40%	10%
MIX 3	60%	30%	10%
MIX 4	70%	20%	10%
MIX 5	80%	10%	10%

Fig 4 – Curing

Fig 5 – Compression Testing Machine

MIX DESIGN (as per IS 10262:2009)

The following specification were considered for Mix design.

Type of cement	PPC
Maximum aggregate size	20mm
Minimum cement content kg/m^3	320
Maximum Water cement Ratio	0.45
Workability	25-50mm(slump)
Exposure condition	Mild
Degree of Supervision	Good
Type of Aggregate	Angular
Types of Fine Aggregate	M-Sand

IV. RESULT AND DISCUSSION

The compressive strength for all mix 7days,14days, 28days are presented. The values are plotted in the chart The compressive strength of the mix is taken after 28 days. The comparison between the compressive strength of 28 days of water curing of light weight concrete and conventional concrete. The weight are also taken after the 28 days of curing it is found to be less when compared to conventional concrete. The attempt of different proportions has improved the compressive strength of the concrete. We find that the compressive strength increases at the ratio of (40% cement, 50% GGBS),10 %Metakaolin) was found to be high. The result shows the higher replacement of GGBS gives the higher strength.

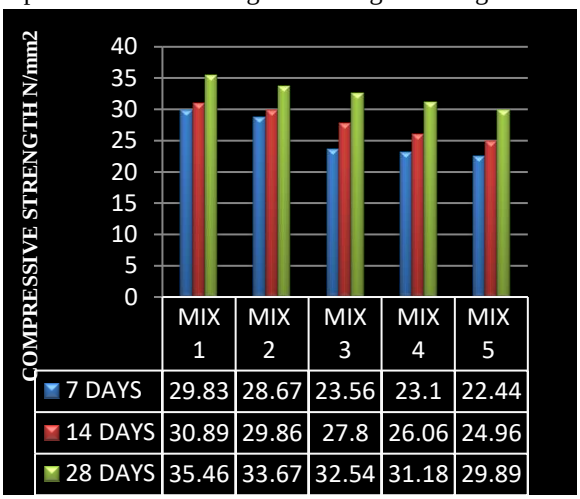

Chart 1- Compressive strength value

V. CONCLUSION

The main objective of our project is the partial replacement of cement with Ground Granulated Blast Furnace Slag and met kaolin for increasing compressive strength. To compare the strength between conventional concrete and light weight concrete. Based on the experimental study and results found from the study following conclusions are made.

- When compared to normal concrete the weight is reduced to 2066.5g.
- Compressive strength values using GGBS, Metakaolin as partial replacement of cement was found to be increased.
- The value was increased by adding pumice fully instead of normal coarse aggregate, and M-Sand replacement for fine aggregate.

- The ratio we used are (40% cement, 50% GGBS), (50% cement, 40% GGBS), (60% cement, 30% GGBS), (70% cement, 20% GGBS), (80% cement, 10% GGBS) and 10% Metakaolin is kept constant in our concrete in our concrete.
- From the comparison of the compressive strength test results at 7day,14days, 28days it was observed that (40% cement, 50% GGBS) shows the maximum strength compared to the other replacement percentage.
- From the result it is concluded that maximum compressive strength was found at (40% cement, 50% GGBS) for partial replacement of cement.

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