A STUDY ON PARTIAL REPLACEMENT OF CEMENT WITH GGBS IN CONCRETE

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Abstract

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure Viz., buildings, industrial structures, bridges and highways etc., leading to utilization of large quantity of concrete. On the other side, cost of concrete is attributed to the cost of its ingredients which is scarce and expensive, this leading to usage of economically alternative materials in its production. This requirement is drawn the attention of investigators to explore new replacements of ingredients of concrete. The present technical report focuses on investigating characteristics of concrete with partial replacement of cement with Ground Granulated Blast furnace Slag (GGBS). The topic deals with the usage of GGBS and advantages as well as disadvantages in using it in concrete. This usage of GGBS serves as replacement to already depleting conventional building materials and the recent years and also as being a byproduct it serves as an Eco Friendly way of utilizing the product without dumping it on ground.

I.INTRODUCTION

1.1 GENERAL

Concrete has been the major instrument for providing stable and reliable infrastructure since the days of Greek and roman civilization. Concrete is the most world widely used construction material. The increase in demand of concrete more the new method and materials are being developed for production of concrete. Concrete is a mixture of cement, water, and aggregates with or without chemical admixtures.

The most important part of concrete is the cement. Use of cement alone as a binder material produces large heat of hydration. Since the production of this raw material produces lot of CO_2 emission. The carbon dioxide emission from the cement raw material is very harmful to the environmental changes. Nowadays many researchers have been carried out to reduce the CO_2.

The effective way of reducing CO_2 emission from the cement industry is to use the industrial by products or use of supplementary cementing material such as Ground Granulated Blast Furnace Slag (GGBS), Fly Ash (FA), and Silica Fume (SF) and Meta kaolin (MK).

In this present experimental work an attempt is made to replace cement by GGBS to overcome these problems. River sand has been used as a major building material component. Its well-graded and that all sizes grains are well distributed in a given sample.

River sand is mainly used for all kinds of civil engineering construction. River sand has been the most important choice for the fine aggregate component of concrete in the early periods.

Overuse of the material have been led to environmental concerns, the depleting of securable river sand due to this the material cost also increases. Nowadays the natural river sand becomes scarce and very costly.

To overcome from this crisis, partial replacement of natural sand with quarry sand is economic alternative. Use of quarry dust in concrete increases the strength characteristics.

1.2GROUND GRANULATED BLAST FURNACE SLAG (GGBS):

Ground Granulated Blast Furnace is a byproduct from the blast furnace slag is a solid waste discharged in large quantities by the iron and steel industry in India. These operate at a temperature of about 1500 degree centigrade and are fed with a carefully controlled mixture of iron – ore, coke and limestone. The iron ore is reduced to iron and remaining materials from slag that floats on top of the iron.

It is a granular material formed when molten iron blast furnace slag is rapidly chilled by immersion of water. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS it has been rapidly quenched in large volumes of water. The quenching optimizes the cementations properties and produces granules similar to coarse sand. This granulated slag is then dried and ground to a fine powder.

The re-cycling of these slag's will become an important measure for the environmental protection. Iron and steel are basic materials that underpin modern civilization, and due to many years of research the slag that is generated as a byproduct in iron and steel production is now in use as a material in its own right in various sectors. The primary constituents of slag are lime (CaO) and silica (SiO2). Portland cement also contains these constituents.

The primary constituent of slag is soluble in water and exhibits an alkalinity like that of cement or concrete. Meanwhile, with the development of steel industry, the disposal of such a material as a waste is definitely a problem and it may cause severe environmental hazards.

On its own, GGBS hardens very slowly and for use in concrete, it needs to be activated by combining it with Portland cement, but percentage of GGBS anywhere between 20 and 80 percent are commonly used. The greater the percentage of GGBS, the greater will be the effort on concrete properties.

1.3QUARRY SAND:

Origin as the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregate in different size. Specific gravity depends on the nature of rock from which it is processed. The fine aggregates or sand used is usually obtained from natural sources specially river beds or river banks.

Now-a days due to constant sand mining the natural sand is depleting at an alarming rate. Sand dragging from river beds has led to several environmental issues.

Due to various environmental issues Government has banned the dragging of sand from rivers. This has led to a scarcity and significant increase in the cost of natural sand. There is an urgent need to find an alternative to river sand. The only long term replacement for sand is Quarry sand.

Also it can't be disposed of properly and its disposal is not economically viable but it is blended with other construction materials like clayey soil then it can be used best for various construction purposes like sub grade, foundation base and embankments.

Due to rapid industrialization there is scarcity of land having desirable soil bearing capacities. Soil stabilization is the technique which improves the properties of expansive soil to meet the engineering requirements. For a successful stabilization, a laboratory tests required to determine engineering properties.

1.4 OBJECTIVE:

- To determine the most optimized mix of GGBS- based concrete.
- To optimize strength characteristics of concrete by partially replacement of cement by GGBS.
- To determine the variation of workability of concrete by partially replacing the cement by GGBS.
- To investigate the structural behavior of concrete by adding replacing materials.
- To study the fresh properties of concrete.
- To increase the compressive strength of pavement by using GGBS.
- To improve resistance to attack from fire by using GGBS.
- To decreases the cost of concrete production by using Quarry sand.
- To increases workability by using GGBS and Quarry sand.
- To provide economical construction cost
- To increases the durability by using Quarry sand.

2.1 LITERATURE REVIEW

Pathan V.G, Ghutke V.S and Pathan G have concluded in their project that ground granulated blast furnace slag is better replacement of cement than various other alternatives. The rate of strength gain in slag replaced concrete is slow in early stages but with proper curing the strength goes on increasing tremendously. The compressive strength decreases when the cement replacement is more than 50%. Use of slag or slag cements usually improves workability and decreases the water demand due to the increase in paste volume caused by the lower relative density of slag. From their results they concluded that 45% replacement of cement by GGBS gives the highest amount of compressive strength. They suggested that the replacement of cement with slag should be limited to 40% in India.

Latha K.S, Rao M.V.S and Reddy V.S have concluded from their research that Strength efficiency of GGBS increases by 89% in M20, 41% in M40 and 20% in M60 grade concrete mixes when compared to M20, M40 and M60 grade concrete mixes without any mineral admixture at 28 days respectively. The optimum dosage of percentage of replacement of cement with GGBS was found to be 40%, 40%and 50% in Ordinary (M20), Standard (M40) and High strength grade (M60) grades of concrete respectively. They also concluded that the partial replacement of cement with GGBS in concrete mixes has shown enhanced performance in terms of strength and durability in all grades. This is due to the presence of reactive silica in GGBS which offers good compatibility. It is observed that there is an increase in the compressive strength for different concrete mixes made with GGBS replacement mixes.

Mohammed Moyunddin, Varnitha MS, Sathish YA have concluded from their project that cement can be partially replaced with GGBS and natural sand by M sand gives high strength. Compressive strength of concrete increases with increase of percentage of manufactured sand upto certain limit and also increases in dosage of admixture.M30 grade concrete acquires maximum compressive strength for 60% replacement of natural sand by quarry sand and 1.5 % dosage of mixture. Split tensile strength of concrete, when cement is replaced with 40% of GGBS & 60% of quarry dust for maximum dosage of mixture.Flexural strength will be max, if 30% of cement by GGBS & 60% of quarry sand as constant replacement for fine aggregates. Split tensile strength of concrete is 3.65 & 3.88 N/mm2after 28 days of curing for 1.50% of admixture content.

Chaithra.HL, pramod.K, Dr.Chandrashekar.A from the experimental investigation observed that the workability of concrete was found to be increased with the increase in GGBS in concrete. It further decreases as the percentage of quarry Sand increases. Maximum compressive and flexural strength has been obtained for replacement of cement by 40% GGBS. Maximum flexural strength obtained for replacement of cement by 40% GGBS and 50% GGBS and sand by 40% quarry sand. Maximum spilt tensile strength is achieved for cement replacement by 50% GGBS and 50% of quarry sand. Maximum compressive strength obtained for replacement of cement by GGBS 40% and natural sand by M sand 40%. Maximum flexural strength achieved for cement replacement by GGBS 50% and sand by quarry sand 50%.Increases workability and durability of concrete member.

Dubey A., Chandak R and Yadav R.K from the experimental investigations observed that the optimum replacement of GGBS Powder to cement without changing much the compressive strength is 15%. They observed that 7 days, 14 days and 28 days compressive strength on 30% replacement of cement reduces about 30% that is from 21.03N/mm2 to 15N/mm2, 23.N/mm2 to 16.74N/mm2.and 26.9 N/mm2 to 18.81N/mm2 respectively.

The choice of quarry dust as replacement for sand has been supported in the previous study (Manassa, 2010) showing that up to 20% of sand has been effectively replaced by quarry dust in traditional concrete. Ilangovan et al. (2008) reported that the strength of quarry rock dust concrete was comparably 10-12% more than that of similar mix of conventional concrete.

In another study conducted by Wakchaure et al, (2012) using artificial sand in place of river sand, it was found that for M30 mix using artificial sand, the compressive strength increased by 3.98%, flexural strength by 2.81% and split tensile strength by a marginal value than concrete which used river sand. Seeni et al. (2012) have made an attempt to partially replace fine aggregates with waste material obtained from China Clay industries. Out of the replacement percentages of 10% to 50%, the highest strength was achieved at 30% in compressive, split and flexural strength.

Hameed and Sekar (2009) studied the effect of crushed stone dust as fine dust and found that flexural strength increases than the concrete with natural sand but the values decreases as the percentage of crusher dust increase Divakar et al. (2012) have experimented on the behavior of M20 grade concrete with the use of granite fines as a partial replacement for sand in 5%, 15%, 25%, 35% and 50%; and based on the results obtained for compressive, split-tensile and flexural tests, it was recommended that 35% of sand can be replaced by granite fines.

PROPERTIES OF MATERIALS GENERAL:

The properties of materials depends on the various physical and chemical properties such as particle size, specific gravity etc. Also, the compatibility and performance in the presence of materials need to be established which may help in short listing of the materials when two or more types are available.

MATERIALS USED:

Materials that are used for making concrete for this study where tested before casting the specimen. The preliminary tests used for making concrete for this study where tested before casting the specimen. The preliminary tests were conducted for the following materials.

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Quarry dust
5. Ground granulated blast furnace slag(GGBS)

3.1 CEMENT

3.1.1SPECIFIC GRAVITY TEST:

PPC cement is used for the laboratory investigation. The cement for the whole work was procured in a single consignment and properly stored.

Fig.3.1.1 Cement

Dry the flask carefully and fill with kerosene or naphtha to a point on the stem between zero and 1 ml. Record the level of the liquid in the flask as initial reading. Put a weighted quantity of cement (about 60gm) into the flask so that level of kerosene rise to about 22ml mark , care being taken to avoid splashing and to see that cement does not adhere to the liquid to the sides of the above the liquid.

After putting all the cement to the flask, roll the flask gently in an inclined position to expel air until no further air bubble rise 3s to the surface of the liquid. Note down the new liquid level as final reading.

$$specific\ gravity = \frac{(w_2 - w_1)}{(w_2 - w_1) - ((w_3 - w_4) \times 0.79}$$

Where, w_1= weight of empty flask
w_2= weight of flask+ cement
w_3= weight of flask+ cement+ kerosene
w_4= weight of flask+ kerosene
0.79 = specific gravity of kerosene

RESULT:
Specific gravity of cement = 3.1

3.1.2CONSISTENCY TEST

1. Weigh about 400gm of cement accurately and placed it in enamel trough.
2. To start with add about 25% of potable water. Care should be taken that the gauging time is not less than three minutes and not more than 5 minutes.
3. Apply thin layer of oil to inner surface of mould. Fill the vicat`s mould with this paste in the mould resting on non-porous plate.
4. Make the surface of cement paste in level with the top of mould with the trowel. The mould should be slightly shaken to the expel air.
5. Place the mould together with the non-porous plate under the rod bearing the plunger so that it touches the surface of the test block.
6. Release quickly the plunger allowing it to sink in the cement paste in the mould. Note down the penetration of the plunger in the paste, when the penetration of plunger becomes stable in the mould.
7. If the penetration of the plunger in the paste is less than the 33 to 35mm from the top of the mould, prepare the trail paste with increasing percentage of water and repeat the above mentioned procedure until the plunger penetrate to a depth of 33to35mm from the top or 5 to 7 mm from the bottom of mould.
8. Expressed this amount of water as a percentage by weight of dry cement.
9. The percentage of water required for obtaining cement paste of standard consistency is = 29%

RESULT:
Normal consistency of cement = 29%

3.1.3INITIAL SETTING TIME

The initial setting time is found by vicat apparatus. The time elapsed between the moments that the water is added to the cement to the time that the paste starts losing its plasticity is called initial setting time usually 30 minutes. About 400g of cement sample was taken and added water to bring it to standard consistency. The sample was placed in vicat mould within 3-5 minutes. The needle was lowered gently and contact with surface of the rest block.

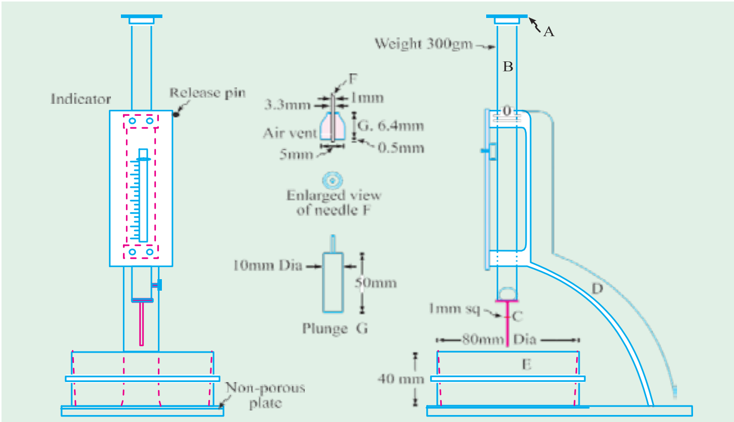


Fig.3.1.3 Vicat apparatus

Then quickly released it. Allow it to penetrate into the test block. In the beginning the needle will completely pierce through the test block .But after some time when the paste starts losing its plasticity, the needle may penetrate only to a depth of 33-35mm from top .The period elapsing between the time when water is added and the time at which needle penetrates to depth equal to 33-35mm is called initial setting time.

RESULT:
Initial setting time of cement = 30 minutes

3.2 GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

On its own , ground furnance slag(GGBS) harderns very slowly and , for use in concrete, its needs to be activated by combining it with portland cement, but percentage of GGBS anywhere between 20 and 80 percent are commomly used. The greater the percentage of GGBS, the greater will be the effect on concrete properties.

SETTING TIME

The setting time of concrete is influenced by many factors, in particular temperature and water/ cement ratio. With GGBS, the setting time will be extended slightly, perhaps by about 30 minutes. The effect will be more pronounced at high levels of GGBS or low temperatures. An extended setting time is advantages in that the concrete will remain workable longer and there will be less risk of cold joints. This is particularly useful in warm weather.

WATER DEMAND

The difference in rheological behavior between GGBS and Portland cement by enable a small reduction in water content to achieve equivalent consistence class.

CONSISTANCE

While concretes containing GGBS have a similar, or slightly improved consistence to equivalent Portland cement concretes, fresh concrete containing GGBS tends to required less energy for movement. This makes it easier to place and compact, especially when pumping or using mechanical vibration. In addition, it will retain its workability for longer.

EARLY AGE TEMPERATURE RISE

The reaction involved in the setting and hardening of concrete generate significant heat and can produce large temperature rises, particularly in thick section pours. This can result in thermal cracking.

There are a number of factors which determine the rate of heat development and the maximum temperature rise. These include the percentage of GGBS, the total cementations content, the dimensions of the structure, the type of formwork and ambient weather conditions.

The greater the percentage of GGBS, the lower will be the rate at which heat is developed and the smaller the maximum temperature rise.

As well as depressing the peak temperature, the time taken to reach the speak will be extended. For mass concrete structure, it is common to use 70 percent GGBS to control the temperature rise. With thinner sections, significant saving in crack control reinforcement can be achieved even with lower levels of GGBS of 50 percent or loss.

3.2.1 STRENGTH GAIN IN GGBS CONCRETE

With the same content of cementations materials (total weight of Portland cement plus GGBS), similar 28 days strength to Portland cement will normally be achieved when using upto percent GGBS. At higher GGBS percentages the cementations content may need to be increased to achieve equivalent 28 day strength.

GGBS concrete gains strength more steadily the equivalent concrete made with Portlandcement. For the same 28 days strength, a GGBS concrete will have lower strength at early strength will be most noticeable at high GGBS levels and lower temperatures.

Under normal circumstances, concrete with up to 70 percent GGBS will achieve sufficient strength within one day of casting to allow removal of vertical formwork without mechanical damage. At high GGBS percentages, extra care should be taken with thin sections poured during winter conditions when the concrete hardening may been affected by the poured during winter conditions when the concrete hardening may have been affected by the cold ambient air.

3.2.2 CHEMICAL COMPOSITION

GGBS comprises mainly of CaO, SiO2, Al2O3and Mgo.It contains less than 1% crystalline silica and contains less than 1 ppm water soluble chromium .It has the same main chemical consistent as ordinary Portland cement, but in different proportions.

Chemical properties of GGBS and cement

Chemical constituent	Cement	GGBS
CaO	65%	40%
SiO_2	20%	35%
Al_2O_3	5%	10%
MgO	2%	8%

Advantages of GGBS over cement

- Improved workability, compaction characteristics of concrete.
- Reduced permeability
- More chemically stable
- High resistance to chloride penetration
- High resistance to sulphate attack
- Very low heat of hydration

- Improved resistance to attack from fire
- Improved surface finish
- Enhance reflectively for greater visibility and safely
- Eliminate efflorescence
- No emission of SO2,NOX and CO
- Extends life cycle of concrete structures
- Reduces life time construction cost
- Lower maintenance cost

3.2.3 SPECIFIC GRAVITY TEST

Dry the flask carefully and fill with kerosene or naphtha to a point on the stem between zero and 1 ml. Record the level of the liquid in the flask as initial reading. Put a weighted quantity of GGBS (about 60gm) into the flask so that level of kerosene rise to about 22 ml mark, care being taken to avoid splashing and see that GGBS does not adhere to the liquid to sides of the above the liquid. Position to expel air until no futher air bubble rise 3s to the surface of the liquid. Note down the new liquid level as final reading.

Specific gravity= $(w_2 - w_1) / ((w_2 - w_1) - ((w_3 - w_4) \times o.79)))$

Where,

W_1 = weight of empty flask

W_2 = weight of flask + GGBS

W_3 = weight of flask + GGBS + kerosene

W_4 = weight of flask +kerosene

0.79 = specific gravity of kerosene

RESULT

Specific gravity of GGBS = 2.84

3.2.4CONSISTENCY TEST:

Weigh about 400gm of GGBS accurately and plaid it in enamel through.

To start with add about 25% of portable water. Care should be taken that the gauging not less than 3 minutes and not more than 5 minutes.

Apply thin layer of oil to inner surface of mould. Fill the vicat's mould with this paste in the mould resting on non-porous plate.

Make the surface of GGBS paste in level with the top of mould with the trowel. The mould should be slightly shaken to the expel air.

Place the mould together with the non-porous plate under the rod bearing the plunger so that it touches the surface of the test block.

Release quickly the plunger allowing it to sink in the cement paste in the mould. When the penetration of plunger becomes stable in the mould.

If the penetration of plunger in the paste is less than the 33to35mm from the top of the mould, prepare the trail paste with increasing percentage of water and repeat the above mentioned procedure until the plunger penetrate to a depth of 33to35mm from the top or 5to7mm from the bottom of the mould.

Expressed this amount of water as a percentage by weight of dry GGBS.

The percentage of water required for obtaining cement paste of standard consistency is = 34%

RESULT:

Normal consistency of GGBS = 34%

3.2.5 INITIAL SETTIG TIME:

The initial setting time is found by vicat apparatus. The time elapsedbetween the moments that the water is added to the paste starts losing its plasticity is called initial setting time usually 30 minutes. About 400gm of GGBS taken and added water to bring in to standard consistency. The sample was placed in vicat mould within 3-5 minutes. The needle was lowered gently contact and with surface of the rest block.

Then quickly released it. Allow it to penetrate into the rest block. In the beginning the needle will completely through the test block. But after some time when the paste starts losing its plasticity, the needle will penetrate only to a depth of 33-35mm from top. The period elapsing between the time when water is added and the time at which needle penetrates to depth equal to 33-35 mm is called initial setting time.

RESULT:

Initial setting time of GGBS = 2 hours

3.3 FINE AGGREGATE

A loose granular material that results from the disintegration of rocks, mortar, glass, abrasives, and foundry mould soil containing 85 percent or more of sand and a maximum of 10 percent of clay, broadly sandy soil.

Fig.3.3. Fine aggregate

3.3.1. SPECIFIC GRAVITY TEST:

Obtain approximately 1000g of the fine aggregate from the sample by use of sample splitter or by quartering. Dry it in a suitable pan or vessel to constant weight at a temperature of 100 to $110^{0}c$. Wash the sample thoroughly on a 71mm sieve.

Fig.3.3.1. Specific gravity test

The process of quartering and the correct use of a sample splitter are discussed in the manual of concrete testing (Annual Book of ASTM Standards, part 14). Allow the sample to cool comfortable handling temperature, cover with water and permit to stand for 24 ± 4 hours. where the absorption and specific gravity values are to be used in proportioning concrete mixtures with aggregates used in their naturally moist condition, the requirement for initial drying to constant weight may be eliminated. Decant excess water with care to avoid loss of fines, spread the sample on a flat surface exposed to a gently moving current of warm air, and stir frequently to secure uniform drying.

Continue this operation until the test specimen approaches a free – flowing condition. then ,place a portion of the partially dried fine aggregate loosely in to the mould , held firmly on a smooth non-absorbent surface with the large diameter down ,lightly tamp the surface 25 times with the tamper and lift the mould vertically. If surface moisture is still present, the fine aggregate will retain the mould shape.

Continue drying with constant stirring and test at frequent intervals until the tamped fine aggregate slumps slightly up on removal of the mould. This indicate that it has reaches a surface – dry condition.

Roll, invert and agitate the pycnometer to eliminate all air bubbles. Adjust its temperature to 23 ± 1.7^{0}C, if necessary by immersion in circulating water and bring the water level in the pycnometer to its calibrated capacity. Leave pycnometer in circulating water or water bath for 30±5 minutes to ensure constant temperature. Continue to agitate every 10 minutes to ensure all air bubbles are eliminated.

Dry of pycnometer and weight. Record this and all other weights to the nearest 0.1g. Remove the fine aggregate from the pycnometer, dry to constant weight at a temperature 100 to 〖 110〗 ^0C, cool in air at room temperature for ½ to 1½ hours and weight.

CALCULATION:

Weight of pycnometer

W_1 = 0.605 Kg

Weight of pycnometer+ Sand

W_2 = 1.790 Kg

Weight of pycnometer+ Sand + Water

W_3 = 2.205 Kg

Weight of pycnometer+ Water

W_4 = 1.440 Kg

Specific gravity

$$G = \frac{(w_2 - w_1)}{((w_4 - w_1) - (w_3 - w_2))}$$

= 2.820

RESULT:

Specific gravity of sand =2.820

3.3.2. SIEVE ANALYSIS TEST:

Sieve analysis test aims at grading or separating sand particles into different ranges of size. In practice this is done by passing the materials through a set of sieves. Prepare a stack of sieves. Sieves having larger opening sizes (i.e. lower numbers) are placed above the ones having smaller opening sizes (i.e. higher numbers).

The very fast sieve is 200 mm dia and a pan is placed under it to collect the portion of soil passing 200 mm dia sieve. Here is a set of sieves. (Dia of 4 and 200 mm are included)Make sure sieves are clean, if many soil particles are stuck in the openings try to poke them out using brush.

S.NO	SIEVE SIZE	RETAINED WEIGHT IN (Kg)	CUMULATIVE PERCENTAGE	CUMULATIVE PERCENTAGE OF RETAINED
1	4.75 mm	0.020	2%	2%
2	2.36 mm	0.040	4%	6%
3S	1.7 mm	0.070	7%	13%
4	1.18 mm	0.130	13%	26%
5	600micron	0.300	30%	56%
6	300micron	0.260	26%	82%
7	150micron	0.100	10%	92%
8	Pan	0.080	8%	100%
				4.23

Weigh all sieves and the pan separately. Pour the soil into the stack of sieves from the top and place the cover, put the stack in the sieve shaker and fix the clamps, adjust the time on 10 to 15 minutes and get the shaker going.

Fineness modulus = 4.23

3.4COARSE AGGREGATE

Usually the aggregates occupy 70% to 80% of the volume of concrete and have an important influence on its properties. They are granular materials, derived generally from natural rock and sands.

3.4.1 IMPACT TEST:

The apparatus consists of a steel test mould with a falling hammer. The hammer slides freely between vertical guides so arranged that the lower part of the hammer is above and concentric with the mould. The material used is aggregate passing a 12.70 mm sieve and retained on a 9.52 mm sieve. It shall be clean and dry (washed if necessary) but it must not be dried for longer than 4 hours nor at a temperature higher than 110OC may otherwise certain aggregates be damaged. The whole of the test sample (mass A) is placed in the steel mould and compacted by a single tamping of 25 strokes of the tamping rod.. The test sample is subjected to 15 blows of the hammer dropping 381 mm, each being delivered at an interval not less than one second.. The crushed aggregate is sieved over a 2.36 mm sieve. The fraction passing 2.36 mm is weighed to the nearest 0.1 g (mass B). The fraction retained on the sieve is also weighed (mass C). If {A-(B+C)}>1 gram, the result shall be discarded and a fresh test made. The aggregate impact value (AIV) is

AIV = (B/A) x100

CALCULATION

Aggregate impact value= (B/A) x100

Weight of fraction passing 2.36mm sieve B = 115 gm.

Total weight of sample A= 640 gm.

Aggregate impact value= 17.9%

3.4.2. SPECIFIC GRAVITY TEST:

Obtain approximately 1000g of the coarse aggregate from the sample by use of sample splitter or by quartering. Dry it in a suitable pan or vessel to constant weight at a temperature of 100 to 〖110〗^0 c . Wash the sample thoroughly on a 71mm sieve. The process of quartering and the correct use of a sample splitter are discussed in the manual of concrete testing (Annual Book of ASTM Standards, part 14). Allow the sample to cool comfortable handling temperature, cover with water and permit to stand for 24 ± 4 hours. Where the absorption and specific gravity values are to be used in proportioning concrete mixtures with aggregates used in their naturally moist condition, the requirement for initial drying to constant weight may be eliminated.

Decant excess water with care to avoid loss of fines, spread the sample on a flat surface exposed to a gently moving current of warm air, and stir frequently to secure uniform drying. Continue this operation until the test specimen approaches a free – flowing condition. then ,place a portion of the partially dried fine aggregate loosely in to the mould , held firmly on a smooth non-absorbent surface with the large diameter down ,lightly tamp the surface 25 times with the tamper and lift the mould vertically.

If surface moisture is still present, the fine aggregate will retain the mould shape. Continue drying with constant stirring and test at frequent intervals until the tamped fine aggregate slumps slightly up on removal of the mould. This indicate that it has reaches a surface – dry condition.

Roll, invert and agitate the pycnometer to eliminate all air bubbles. Adjust its temperature to 23± 〖1.7〗^0C, if necessary by immersion in circulating water and bring the water level in the pycnometer to its calibrated capacity.

Leave pycnometer in circulating water or water bath for 30±5 minutes to ensure constant temperature. Continue to agitate every 10 minutes to ensure all air bubbles are eliminated.

Dry of pycnometer and weight. Record this and all other weights to the nearest 0.1g. Remove the fine aggregate from the pycnometer, dry to constant weight at a temperature 100 to 〖 110〗^0C, cool in air at room temperature for ½ to 1½ hours and weight.

CALCULATION

Weight of pycnometer W_1=0.605 Kg

Weight of pycnometer+ aggregate

W_2 = 1.890 Kg

Weight of pycnometer+ aggregate + Water

W_3 = 2.230 Kg

Weight of pycnometer+ Water

W_4 = 1.440 Kg

Specific gravity of Aggregate

$$G = \frac{(w_2 - w_1)}{((w_4 - w_1) - (w_3 - w_2))}$$

G = 2.59

3.4.3. SIEVE ANALYSIS TEST:

Sieve analysis test aims at grading or separating sand particles into different ranges of size. In practice this is done by passing the materials through a set of sieves. Prepare a stack of sieves. Sieves having larger opening sizes (i.e. lower numbers) are placed above the ones having smaller opening sizes (i.e. higher numbers). The very fast sieve is 200 mm dia and a pan is placed under it to collect the portion of soil passing 200 mm dia sieve. Here is a set of sieves. (Dia of 4 and 200 mm are included).Make sure sieves are clean, if many soil particles are stuck in the openings try to poke them out using brush. Weigh all sieves and the pan separately. Pour the soil into the stack of sieves from the top and place the cover, put the stack in the sieve shaker and fix the clamps, adjust the time on 10 to 15 minutes and get the shaker going.

Fineness modulus = 3.85

S.NO	SIEVE SIZE	RETAINED WEIGHT IN (Kg)	CUMULATIVE PERCENTAGE	CUMULATIVE PERCENTAGE OF RETAINED
1	19 mm	Nil	0%	0%
2	12.5 mm	Nil	0%	0%
3	9.5 mm	0.240	24%	24%
4	4.75 mm	0.600	60%	84%
5	2.36 mm	0.060	6%	90%
6	1.18 mm	0.040	4%	94%
7	0.6 mm	0.050	5%	99%
8	0.3 mm	0.010	1%	100%
9	Pan	Nil	nil	100%
				3.85

3.5 QUARRY DUST

The most widely used fine aggregate for making of concrete is the natural sand mined from the riverbeds. However, the availability of river sand for the preparation of concrete is becoming scarce due to the excessive non-scientific methods of mining from the riverbeds, lowering of water table, sinking of bridges piers, etc. Are becoming common problems. The present scenario demands identification of substitute materials for the river sand for making concrete.

Quarry dust as a by-product from crushing process during quarrying actives is one of those materials that have recently gained attention to be used as concreting aggregates, especially as fine aggregate. In concrete production it could be used as a partial or full replacement of natural sand. Besides, the utilization of quarry waste, which itself is a waste material, will reduce the cost of concrete production.

Fig.3.5 Quarry dust

Common river sand is expensive due to excessive cost of transportation from natural sources. Also large-scale depletion of these sources creates environmental problems. As environmental transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete industry needs to be found.

In such a situation the quarry rock dust can be defined as residue, tailing or other non-valuable waste material after the extraction and progressive of rocks to form fine particles less then 4.75mm. Use of quarry rock dust as a fine aggregate in concrete draws serious attention of researches and investigators.

The dust is selected from the nearest sources as raw materials without any processing of the dust from quarry.

3.5.1. ORIGIN OF QUARRY DUST

The quarry dust is the by-product which is formed in the processing of the granite stones which broken downs into the coarse aggregate of different size. Quarry dust is crusher, kundrathur (near Chennai), Tamil Nadu, India was made of use. Quarry dust is collected from local stone crushing units of chowdavaram village, Guntur, Andhra Pradesh. It was initially drying condition when collected and was sieved by IS: 90 micron sieve before mixing in concrete.

3.5.2 PROPERTIES OF QUARRY DUST

The dust is black glassy particle and granular materials in nature and has a similar particle size range like sand. The specific gravity of the quarry dust is 3.02 and specific gravity of fine aggregate is 2.69. The bulk density of granulated quarry dust is 1.358g/cc which is almost similar to bulk density of conventional fine aggregate.

The fineness modulus of quarry dust is 4.09 and fineness modulus quarry dust is 4.46. The hardness of the slag lies is almost equal to the hardness of gypsum. The PH of aqueous solution of aqueous extract as per IS: 11127 vary from 6.6 to 7.2. The free moisture content presenting quarry dust was found to less than 0.5%. The following table 1 and table 2 show the physical and chemical properties of quarry dust.

Table 3.5.2 Physical Properties of Quarry Dust

Physical Properties	**Quarry Dust**
Particle shape	Irregular
Appearance	Grey
Type	Air cooled
Specific gravity	2.24
Percentage of voids	43.20%
Bulk density	1.358%
Fineness modulus of copper slag	4.46

Bulking of quarry dust	41.17%
Hardness	6-7mohs
Water absorption	0.4% to 0.6%
Unit weight	1695kg/m^3
Clay & cement	4.34%

Table 3.5.2 Chemical Properties of Quarry Dust

Parameters	Quarry dust
Loss of ignition	0.28
Sand and silica	88.22
Calcium oxide(CaO)	0.12
Magnesium oxide (MgO)	Nil
Iron oxide (Fe_2O_3)	3.46
Aluminum oxide (Al_2O_3)	2.59

Advantages of Quarry dust over natural sand

- ❖ Decreases the cost of concrete production
- ❖ It will solve the problem of disposal of the dust
- ❖ Increases workability
- ❖ Making more flexible
- ❖ Easy to use
- ❖ Increase the reuse of materials
- ❖ Increases durability
- ❖ Increases compressive test

3.5.3. Specific gravity test

Obtain approximately 1000g of the quarry dust from the sample by use of sample splitter or by quartering. Dry it in a suitable pan or vessel to constant weight at a temperature of 100 to 〖110〗^0 c . Wash the sample thoroughly on a 71mm sieve. The process of quartering and the correct use of a sample splitter are discussed in the manual of concrete testing (Annual Book of ASTM Standards, part 14). Allow the sample to cool comfortable handling temperature, cover with water and permit to stand for 24 ± 4 hours.

Where the absorption and specific gravity values are to be used in proportioning concrete mixtures with aggregates used in their naturally moist condition, the requirement for initial drying to constant weight may be eliminated.

Decant excess water with care to avoid loss of fines, spread the sample on a flat surface exposed to a gently moving current of warm air, and stir frequently to secure uniform drying.

Continue this operation until the test specimen approaches a free – flowing condition. then ,place a portion of the partially dried fine aggregate loosely in to the mould , held firmly on a smooth non-absorbent surface with the large diameter down ,lightly tamp the surface 25 times with the tamper and lift the mould vertically. If surface moisture is still present, the fine aggregate will retain the mould shape.

Continue drying with constant stirring and test at frequent intervals until the tamped fine aggregate slumps slightly up on removal of the mould. This indicate that it has reaches a surface – dry condition. Roll, invert and agitate the pycnometer to eliminate all air bubbles. Adjust its temperature to 23± 〖1.7〗^0C, if necessary by immersion in circulating water and bring the water level in the pycnometer to its calibrated capacity.Leave pycnometer in circulating water or water bath for 30±5 minutes to ensure constant temperature. Continue to agitate every 10 minutes to ensure all air bubbles are eliminated.

Dry of pycnometer and weight. Record this and all other weights to the nearest 0.1g. Remove the quarry dust from the pycnometer, dry to constant weight at a temperature 100 to 〖110〗^0C, cool in air at room temperature for ½ to 1½ hours and weight.

CALCULATION

Weight of pycnometerW_1 = 0.605 Kg

Weight of pycnometer + quarry dust

W_2= 1.990 Kg

Weight of pycnometer + quarry dust + Water

W_3 = 2.430 Kg

Weight of pycnometer+ Water

W_4 = 1.440 Kg

Specific gravity of Aggregate

$$G = \frac{(w_2 - w_1)}{((w_4 - w_1) - (w_3 - w_2))}$$

G = 2.69

MIX DESIGN

4.1 GENERAL:

Mix design is the process of selecting suitable ingredients if concrete and determines their relative proportions with the object of certain minimum strength and durability as economically possible.

- ❖ The first objective is to achieve the stipulated minimum strength
- ❖ The second objective is to make the concrete in the most economical manner. Cost wise all concrete's depend primarily on two factors, batching, mixing transporting and curing is namely same for good concrete.
- ❖ The attention is mainly directed to the cost of materials. Since cost of cement is many times more than the cost of their ingredients, optimum usage of cement is sought for by designing the mix.

4.1 MIX DESIGN AS PER IS: 10262-1982

1. The following basic data are required of a concrete mix:

a. Characteristics compressive strength of concrete

b. Degree of workability desired

c. Max water cement ratio of coarse aggregate

d. Type and max size of coarse aggregate

e. Standard deviation – based on concrete control

f. Statistical constant – accepted

g. Grade of cement used

2. Target mean strength is determined as

$F_{ck} = f_{ck} + (t \times s)$

3. The water/cement ratio for the target mean strength is obtained from IS: 10262-1982 and is limited as per IS: 456-2000.

4. The air content is estimated as per IS10262-1982.

5. Approximate quarry dust water content per m3 of concrete are selected as per IS:456-2000

6. Adjustment in sand percentage and water content are made as per IS: 456-2000.

7. Collected water quality is computed and hence from W/C ratio.

8. The quantity of fine aggregate and coarse aggregate per unit volume of concrete can be calculated from the following equations

$V = [Ww_s+(Wc/Sc)+(1/P)\{W_{fa}/S_{fa}\} s]\ 1/1000$

The mix proportions by weight are computed by keeping the cement as one unit.

4.2 MIX DESIGN CALCULATION

Grade = M20

Type = OPC 43 grade

Size of aggregate= 20mm

Maximum water cement ratio =0.5(by IS456)

Type of aggregate=crushed angular aggregate

Degree of workability =0.8(100mm)

Specific gravity of cement=3.10

Specific gravity of GGBS=2.90

Specific gravity of C.A= 2.60

Specific gravity of F.A= 2.82

Specific gravity of quarry dust= 2.58

Exposure condition = severe

Minimum cement content = 250 kg/m3.

Step1: Target mean strength

$F_{ck} = f_{ck} + (t.s)$

$= 20 + (1.65 \times 4)$

$= 20 + 6.6$

$= 27.6\ N/mm^2$.

Step2: To find w/c ratio:

From IS456

Max w/c ratio = 0.5

Step3: Selection of water content:

From IS10262

Maximum water content = 186 lit (for 25-30mm slump range)

= 186+ ((3/100) x200)

= 192 liters

Step4: Calculation of cement content:

Water cement ratio = 0.5

Cement content = 192/0.5

= $384 kg/m^3$

From IS456

Minimum cement content = $240 kg/m^3$

$384 kg/m^3 > 240\ kg/m^3$

Hence ok.

Step5: Volume of aggregate:

From 0.5 of w/c= 0.62+0.01(added)

= 0.64(from IS10262)

Volume of coarse aggregate = 0.64
Volume of fine aggregate = 1-0.64
= 0.36

Step6: Mix calculation:

a) Volume of concrete= $1m^3$
b) Volume of cement = Mass of cement/S.G of cement x (1/1000)
= 384/3.1x (1/1000)
=$0.123\ m^3$

a) Volume of water =Mass of water/ S.G of water x (1/1000)
= 192/1 x (1/1000)
= $0.192\ m^3$

c) Volume of all in aggregate=
1 (0.123+0.192)= $0.685\ m^3$

Mass of coarse aggregate=Volume of all aggregate x Volume of C.A x S.G of C.A x 1000
= 0.685 x 0.64 x 2.60 x 1000
= 1139.84 Kg

a) Mass of fine aggregate = Volume of all aggregate x Volume of F.A x S.G of F.A x 1000
= 0.685 x 0.34 x 2.82 x 1000
= 656.78 Kg

Step7: Mix proportions:

Cement = 384 Kg
Water = 192 lit
F.A = 656.78 Kg
C.A = 1139.84 Kg
W/c ratio = 0.5

Step8: Mix ratio:

Cement	F.A	C.A	Water
384 Kg	**656.78 Kg**	**1139.84Kg**	**192 lit**
1	**1.71**	**2.97**	**0.5**

EXPERIMENTAL WORK

GENERAL

The main experimental investigation of this project was to study the strength characteristics of GGBS and quarry dust and compare into normal concrete mixers. A total of 36 concrete mould (cubes) of size (150mmX150mmX150mm) are tested. In that 9 moulds are casted for conventional concrete and 27 moulds are casted for GGBS of different percentages.

For finding the partial replacement percentage in the concrete was fixed based on the optimum value study results. Compressive test is to be selected for this study. Cubes are to be used for Compressive test.

5.1 HARDEN CONCRETE TESTINGS

5.1.1 Compressive strength test

The test was carried out for finding the percentage of replacement of GGBS. Cubes of size 150 mm X 150 mm X 150 mm are to be selected for casting as per the recommendations of IS: 0516 (1959). The concrete cubes casted with different GGBS percentages. The samples are taken out at the end of 7 days, 14 days and 28 days kept outside and wiped of surface moisture. Three numbers of samples in each of the concrete were subjected to compression test using the compression testing machine is shown in fig. 5.2.1.

Fig.5.2.1 compressive strength test

RESULTS AND DISCUSSIONS

GENERAL

In present study compressive strength of M20 grade concrete was to be found out and cubes are to be used for compressive strength. The physical properties of cement, coarse aggregate, fine aggregate and concrete are to be given in appendix.

6.1 OPTIMUM VALUE STUDY

6.1.1. General

Cubes are used for the optimum value study. In that cubes were used to find out the compressive strength of M20 grade of concrete. Three different curing periods are selected for cubes for testing of specimens such as 7 days, 14 days and 28 days.

6.1.2. Compressive Strength of Concrete

As per recommendations of IS: 0516 (1959). Standard dimensions of cubes 150 mm X 150 mm X 150 mm (4 nos) in each of the concrete cubes casted with different cocktail fiber percentages. The samples are taken at the end of 7 days, 14 days and 28 days kept outside and wiped of surface moisture. Four numbers of samples in each of the concrete were subjected to compression test using the Compression testing machine. The result of the average strength of the cubes is reported in table 6.1.2

S.NO	MIX ID	7 days	14 days	28 days
1	Conventional	16.24	19.68	26.64
2	30%	16.64	20.21	27.36
3	40%	17.26	20.84	28.08
4	50%	16.36	19.92	26.96

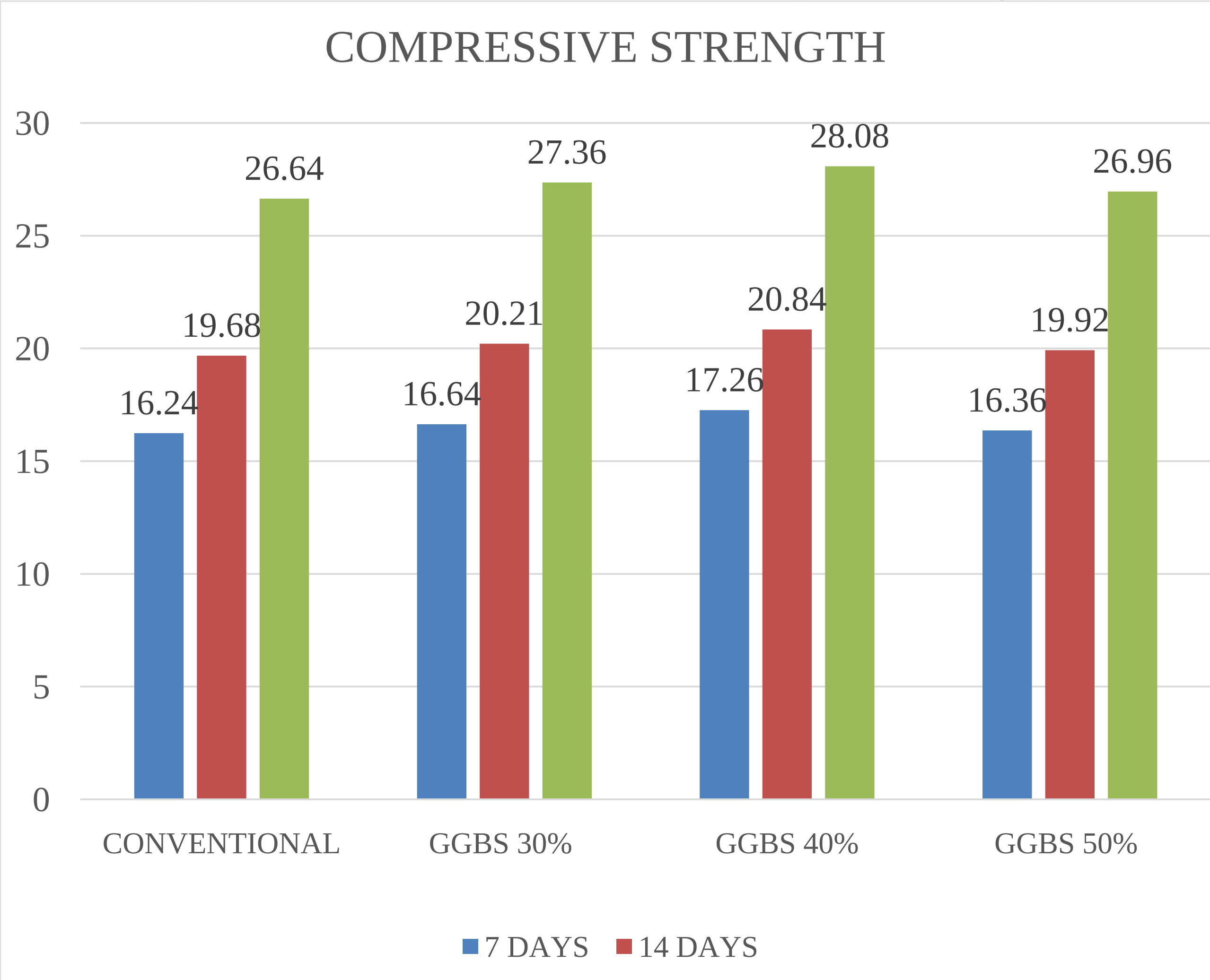
Table 6.1.2 Compressive strength values

MIX ID PROPORTIONS

Conventional = Cement + fine aggregate + coarse aggregate
30% = 70% Cement+ 30% GGBS + fine aggregate+ coarse aggregate
40% = 60% Cement+ 40% GGBS + fine aggregate + coarse aggregate
50% = 50% Cement+ 50% GGBS + fine aggregate+ coarse aggregate

In compressive strength of cubes 40% of replacement gives higher strength. Three different curing periods are selected. In 7 days curing specimen has achieve only 70% strength and for 14 days 90% strength has achieved and for 28 days full design strength.

The compressive test results for GGBS 30%, 40%, 50% represented in the graph as follows:



CONCLUSION

Based on the experimental investigation the following conclusion are drawn:

- Maximum compressive strength obtained for replacement of cement by 40% GGBS.
- Maximum flexural strength achieved for cement replacement by 40% GGBS.
- Maximum split tensile strength is achieved for cement replacement by 50% GGBS.
- From experimental results it has been observed that the Compression Strength is improved.
- By replacing the GGBS by cement as 40% and increases the compressive strength of concrete.
- Due to increase in compressive strength this replacement is used in the construction of prefabrication structures
- It is economical when compared to normal concrete mixtures.