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STRENGTH DEVELOPMENT OF M30 GRADE CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT AND FINE AGGREGATE BY USING DIFFERENT SOLID WASTE MATERIALS

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ABSTRACT
The objective of this experimental work was to produce economical and a carbon dioxide emission free cementious material. Cement production gives rise to Co_2 emissions generated by the calcinations of $CaCo_3$ and by the fossil, being responsible for about 5% of the Co_2 emissions in the world. Due to the rapid extraction of river sand the aquatic life and plantation are affected adversely. In this present study the concrete materials like cement and fine aggregate is partially replaced by fly ash and crusher dust. In the frame work of a comprehensive research or studies shows that fly ash can be used as partial cement replacement and crusher dust can be used as partial fine aggregate replacement. . The present experimental investigation were carried on fly ash, crusher dust, Bottom ash and GGBS partially replaced in the ratio of 10%, 20%, 30% by weight of cement and fine aggregate in concrete. The compressive Strength at the age of 3 days, 7 days and 28 days was obtained and also it is tested while adding admixture for same ratios for increasing strength of concrete. The result indicates that the partial usage of fly ash, crusher dust GGBS and Bottom ash up to 10% it can attain strength and economical.

INTRODUCTION

1.1 General:
Concrete is a strong and durable material that has been utilized since 19thcentury. Concrete is the most widely used construction material all over the world. It is difficult to find out alternate material for construction which is as suitable as that of such material form durability and economic point of view. The manufacture of concrete, primarily its ingredients cement and aggregates present various sustainability issues that need to be dealt. The production of concrete has always lead to massive exploitation of natural resources. Manufacturing 1 tone of Portland cement requires quarrying 1.5 tones of limestone and clay (Civil and Marine, 2007). Moreover, continuous extraction of natural aggregate; sand and gravel; from river beds, lake and other water bodies over the years have led to erosion which eventually leads to flooding and landslides. Further, there is less filtration of rainwater due to reduced amount of natural sand, causing contamination of water needed for human consumption. 1.4 tones of Ordinary Portland cement being produced yearly around the globe contributes to 5 percent of greenhouse gas, carbon dioxide, emissions worldwide (Civil and Marine, 2007). Not only burning fuel to heat the kiln emits carbon dioxide, but also decomposition of limestone emits even more gas. These identified problems clearly, contribute significantly to climate change. The ideal target to partly solve the above phenomenon is to develop a sustainable system loop which can turn resources which are land filled as waste materials into useful products in the construction industry, thus preserving the natural resources.

The replacement of Portland cement with GGBS will lead to significant reduction of CARBON DIOXIDE gas emission. GGBS is therefore an environmentally friendly construction material. It can be used to replace of the Portland cement used in concrete. GGBS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack. As a result, the service life of a structure is enhanced and the maintenance cost reduced.

Coal fired thermal power plants are being set up in large number in the country. Coal fired thermal power plants produce large volumes of coal Bottom Ash. Till now, it is treated as solid waste material and is disposed off on open land. As per Central Electricity Authority, India, report (2014), about 57.63% of coal ash produced by coal fired thermal power plants is used in cement production and in manufacturing of bricks and tiles, construction of ash dykes and reclamation of low lying area.

Fly ash is the ash produced at the thermal power stations by burning coal and lignite. As a result, the cost of the structure and maintenance cost is reduced.

Crusher dust is a angular particles with a rough surface which is obtained when large amounts of stone and aggregates are moved in this process quarries create a large amount of dust which is known as crusher dust. It much looks like sand. And it is a great replacement for sand.

1.2 Need of work:

Concrete is a heterogeneous mix of cement, aggregates and water. The global consumption of cement and natural sand is too high due to its extensive use in concrete. The demand for cement and natural sand is quite high in developing countries owing to rapid infrastructural growth which results supply scarcity. To overcome from this crisis, partial replacement of cement with GGBS and partial replacement of natural sand with Bottom Ash is economic alternative. The concrete industry is constantly looking for supplementary cementations material with the objective of reducing the solid waste disposal problem. Ground Granulated Blast Furnace Slag (GGBS), Bottom Ash is among the solid wastes generated by industry. Substantial energy and cost savings can result when industrial by-products are used as partial replacements for the energy- intensive Portland cement. This investigation attempts to study the feasibility of using locally available GGBS, Bottom Ash as partial replacements for cement and sand in concrete to obtain required compressive strength.

1.3 Objectives of the project:

- To find the optimum percentage of replacement of cement and natural sand with different solid waste materials at which maximum strength is Obtained.
- To provide economical construction material.
- Provide safeguard to the environment by utilizing waste material properly.
- The replacement of Portland cement with GGBS will lead to significant reduction of carbon dioxide gas emission.

1.4 Scope of the project:

1. To study and find permeable voids of the concrete mix and its relation with compressive strength of concrete.

LITERATURE REVIEW

Syed Asif Ali explained in IJSRD journal (2014) "Experimental Study on Partial Replacement of Cement by Fly ash and GGBS" Laboratory investigation on optimum level of Fly ash and Ground Granulated Blast Furnace Slag (GGBS) as a partial replacement of cement to study the strength characteristics of concrete. Portland cement was partially replaced by 5%, 6%, 7%, 8%, 9%, 10% of GGBS and Fly ash by 20%, 40%, and 60% respectively. The water to cementations materials ratio was maintained at 0.45 for all mixes. The strength characteristics of the concrete were evaluated by conducting Compressive strength test, Splitting Tensile strength test and Flexural strength test. The compression strength test were conducted for 7days and 28days of curing and split tensile strength test and flexural strength test were conducted for 28days of curing on a M25 grade concrete. The mix proportion M25 was found to be 1:1.36:2.71.The test results proved that the compressive strength, split tensile strength and flexural strength of concrete mixtures containing GGBS and Fly ash increases as the amount of GGBS and Fly ash increase. After an optimum point, at around 9% of GGBS and 40% of Fly ash of the total binder content, the further addition of GGBS and fly ash does not improve the compressive strength, split tensile strength and flexural strength.

Vinayak Awasare and M. V. Nagendra explained in IJAET journal "Analysis of Strength Characteristics of GGBS Concrete" about Today's construction industry, use of concrete is going on increasing rapidly. Cement is major constituent material of the concrete which produced by natural raw material like lime and silica. Once situation may occurs there will be no lime on earth for production of cement. 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 reduces cost of concrete and help to reduce rate of cement consumption. This study report of strength analysis of GGBS concrete will give assurance to encourage people working in the construction industry for the beneficial use of it. This research work focuses on strength characteristics analysis of M20 grade concrete with replacement of cement by GGBS with 20%, 30%, 40% and 50% and compare with plain cement concrete. Now days crush sand is used to replace natural sand, so study area extends to find best percentage of replacement by using both crush and natural sand.

Reshma Rughooputh and Jaylina Rana (2014) explained in JETEAS journal “Partial Replacement of Cement by Ground Granulated Blast Furnace Slag in Concrete” The increased quest for sustainable and eco-friendly materials in the construction industry has led to research on partial replacement of the conventional constituents of concrete by two selected waste materials. The broad aim of this work was to investigate the effects of partially replaced Ordinary Portland Cement (OPC) by ground granulated blast furnace slag (GGBS) on the properties of concrete including compressive strength, tensile splitting strength, flexure, modulus of elasticity, drying shrinkage and initial surface absorption. Results showed that the compressive and tensile splitting strengths, flexure and modulus of elastic increased as the GGBS content increased. The percentage drying shrinkage showed a slight increment with the partial replacement of OPC with GGBS. However, concrete containing GGBS failed the initial surface absorption test confirming that GGBS decreases the permeability of concrete. The optimum mix was the one with 50% GGBS replacement. Thus, GGBS can potentially be used as a cement replacement material for structural concrete applications in line with the sustainability targets of Mauritius.

Kamran Muzaffar Khan & Usman Ghani explained in Singapore Concrete Institute “Effect of blending of Portland cement with ground granulated blast furnace slag on the properties of concrete” Portland cement, already being a very expensive material constitutes a substantial part of the total construction cost of any project and the situation has further been aggravated by the energy crisis, which has further increased the cost of production of Portland cement. Therefore, it is of current importance for the country to explore and develop cementing materials cheaper than Portland cement. In this research, GGBS (Ground Granulated Blast furnace Slag) was collected from Steel Mills Karachi (Pakistan) and pulverized to a very fine degree from a pulverized. Physical Chemical properties, such as, compressive strength, fineness, setting times, soundness and chemical composition of GGBS (Ground Granulated Blast furnace Slag) were investigated and comparison has been made with the relevant properties of cement Effect of replacement was seen on workability, compressive strength, tensile strength, modulus of rupture, equivalent cube strength by casting mixes of different ratios; 1 :2:4,1 :1.5:3,1 :1.25:2.50, 1:1 :2. WIC ratio for first two mixes was kept as 0.65 and for rest two mixes as 0.45.After cost comparison of GGBS and Ordinary Portland Cement it is concluded that p rice of G GBS is 25% to 50% less than that of Ordinary Portland Cement. This aspect of GGBS makes it economical.

M.P.Kadam, Dr.Y.D. Patil explained in IJAT-CE “Effect of coal bottom ash as sand replacement on the properties of concrete with different w/c ratio” The effects of coal bottom ash as fine aggregates in place of sand was used and compressive strength, split tensile strength, flexural strength, Modulus of Elasticity, Density and water permeability are studied. The natural sand was replaced with coal bottom ash by 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 100% by weight, as water absorption of bottom ash was more so that quantity of water was increased to achieve 100 mm slump. The results shows that the compressive strength, split tensile strength and flexural strength decreased as the percentage of replacement coal bottom ash increased as compared to controlled concrete. In this work slump was kept constant 100 ± 10 mm. To achieve the required slump water quantity was increased as percentage replacement increased. It was observed that up to 30% replacement the results of compressive, flexural, split and water permeability test are approximately same as that of the controlled concrete.

Vikas et al., explained in IOSR-JMCE “Bottom Ash as Partial Sand Replacement in Concrete-Review” This study reviews the characteristics of Concrete incorporated with Bottom Ash as partial replacement for fine aggregates, with a main focus on the mechanical properties such as Compressive strength, splitting tensile strength, flexural strength etc. Ten different research papers are reviewed. The practical use of Bottom ash shows a great contribution to waste minimization as well as resources conservation.

Dr. A. D. Pafole explained in IJSRP journal (2013) "Effective utilization of crusher dust in concrete using Portland pozzolana cement".The purpose for taking up this investigation owing to the fact that now a days natural sand confirming to Indian Standards is becoming scarcer and costlier due to its non-availability in time because of Law of Land, illegal dredging by sand mafia, accessibility to the river source during rainy season, non-confirming with IS 383-1970. Hence the present investigation was taken up with a view to verify the suitability, feasibility and potential use of crusher dust, a waste product from aggregate crushing plant in concrete mixes, in context of its compressive strength and workability and in terms of slump, compacting factor, flow table and modified flow respectively. In view of above discussion, an attempt is made to replace the natural sand in concrete control mixes of M25 and M30 grades designed for 100 to 120mm slump at replacement levels of 30%, 40%, 50% and 60% using Portland Pozzolana Cement. There were in all 5 mixes in each grade of concrete including control mix and four mixes with crusher dust as a partial replacement of natural sand. It was observed that with use of crusher dust at all replacement levels, the workability of concrete was reduced from 1-6%. From the test results, it was observed that the replacement of natural sand by crusher dust increased the compressive strength of concrete by 5-22%. It was also found that amongst all the mixes, the highest compressive strength was obtained for 40% replacement of sand by crusher dust.

P.Appukutty explained in IJDMT journal (2009) "Substitution of quarry dust to sand for mortar in brick masonry works". Substitution of crusher dust for sand in cement mortar for brick masonry is experimented with brick masonry prisms cast indifferent ratios of 1:8, 1:6, 1:5 and 1:4. Bricks with basic compressive strength above 3.5 N/MM2and 7.5 N/MM2were used to cast brick masonry prisms. Three types of fine aggregates, i.e. Cauvery river sand, Crusher dust as is available form stone crushers and crusher dust in which fines below 150 microns removed were used for mortar. Three samples of brick masonry prisms in each mortar ratio were built, cured for 28 days and tested for the basic compressive strength. The results of 12 prisms tested in each fine aggregate with different mortar ratios are compared with allowable compressive strength requirements of brick masonry specified by IS 1905-1989. The investigation indicates that the crusher dust can replace natural sand completely in masonry construction with higher strength and cheaper cost.

K.Dhanasri explained in IJIRSET journal (2013) "Performance of concrete by replacing coarse and fine aggregate with blast furnace slag and crusher dust".The demand of natural sand in the construction industry has consequently increased resulting in thereduction of sources and an increase in price. In such a situation crusher dust can be an economical alternative to the river sand. The Blast furnace slag is a waste of industrial materials, it is relatively more recent pozzolanic material that has received considerable attention in both research and application. It is a non-metallic product consisting essentially of Silicates and Alumina silicates of calcium's developed simultaneously with iron in a blast furnace and is granulated by quenching the molten material in water or steam, and air. The present Investigation has been undertaken to study the effect of blast furnace slag and crusher dust on the mechanical properties of concrete, when coarse aggregates is replaced by blast furnace slag and crusher dust is replaced with fine aggregate in different percentages i.e. 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%. The main parameters investigated were cube compressive strength, split tensile strength and flexural strength. The tests were conducted on concrete with ratio 1:1.86:3.77.

METHODOLOGY

Cement in general can be defined as a material which possesses very good adhesive and cohesive properties which make it possible to bond with other materials to form compact mass. GGBS is granular product with very limited crystal formation, is highly cementations in nature and, ground to cement fineness, and hydrates like port land cement. Bottom Ash is the coarser material, which drops into the bottom of the furnace in latest large thermal power plants and constitute about 20% of gross ash content of the coal fed in the boilers. An aggregates is one of the concrete filler materials, and its role in the concrete is very important. The proportion of aggregates in the concrete reaches approximately 60% -

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75% of the total volume of concrete. The materials required for the concrete mix were collected from different sources.

The present investigation has been undertaken to cement replaced with GGBS and Fly Ash and sand replaced with Bottom Ash and crusher dust. In this study M30 grade of concrete mix was done as per 10262-2009 and water cement ratio 0.45 with targeted slump of 100mm.

Based on the design mix the concrete mix is prepared, slump cone test & compaction factor test was conducted on fresh concrete for knowing workability of concrete. All the cubes casted will be cured for 3 days, 7 days & 28 days with placing an identify mark on each cube for identify in curing tank separate normal water. The project follows the methodology for given flow chart.

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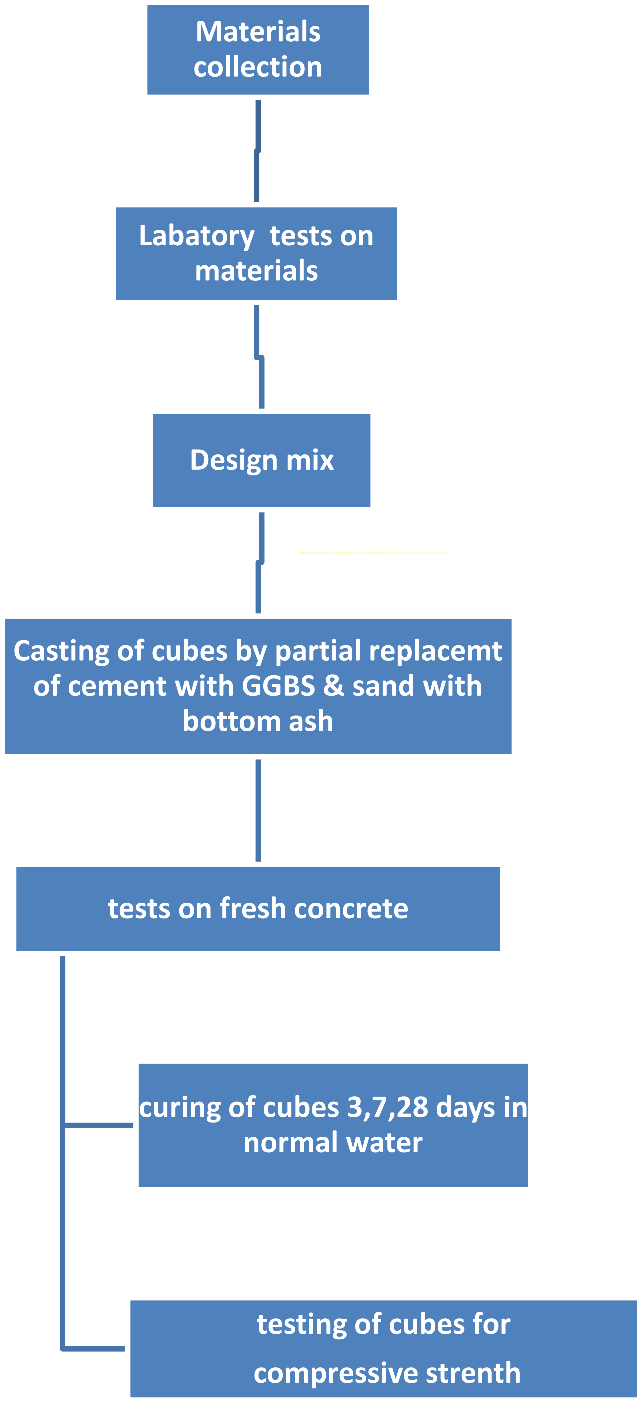

Figure 3.1.Flow chart for methodology

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MATERIALS

4.1 Cement:

4.1.1 History of Cement:

The history of cement is as old as engineering construction. Early man lived in extremely hostile world. One of his first concerns was the construction shelter. Anthropologists and archeologists believe that early man lived either in natural caves or in natural huts built in twigs, mud and rock. It is believed that early Egyptians mostly used cementing materials, obtained by burning gypsum. The early Greeks and Romans used cementing materials obtained by burning lime stone. Roman builders used volcanic stuff found near Pozzuoli village in Italy. This volcanic stuff or ash is mostly siliceous in nature or artificial, having nearly the same composition as that of volcanic stuff or ash found at Pozzuoli practice of thorough mixing and long continued ramming of lime mortar with or without addition of surkhi yielded strong and impervious mortar.

The natural cement is obtained by burning and crushing the stones containing clay, lime carbonate and some mount of magnesium carbonate. The clay content is about 20-40%. The natural cement is brown in color and its best variety is known as roman cement, it sets quickly after the addition of water. This is not as strong as artificial cement and hence it has limited use in practice. In the recent times, the most important advances in knowledge of cements, the forerunner of all modern cement as undoubtedly the investigations carried out by john smeatonin 1796, hydraulic cement was made calcining nodules of argillaceous lime stones. In about 1800 the product was called "roman cement". The artificial cements were obtained by burning at very high temperature a mixture of calcareous and argillaceous materials. The mixture of ingredients should be intimate and they should be in correct proportions. The calcined product is known as clinker. A small quantity of gypsum is added to the clinker and it is then pulverized into fine powder known as cement. The common variety of artificial cement is known as ordinary Portland cement (OPC).

The invention of OPC is attributed to Joseph Aspidin a mason in leads in England. The name Portland was given to the resemblance of this hardened. Cement to the natural stone occurring at Portland in England. Joseph aspidin took the patent of OPC on 21st October 1824. In the early period cement was used for making association of engineers, consumers and manufactured has been established to specify standards for cements. In India, OPC was first manufactured in 1904 near madras, by south India industrial limited, but this venture was failed. Between 1913 and 1914, the Indian cement Co.ltd. Was established at porbandar. During the first five – year plan (1951-56) cement production in India rose from 2.69 million tons.

4.1.2 Definition of Cement:

Portland cement is defined as hydraulic cement produced by pulverizing clinkers consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulphate as an inter ground addition.

$$CaSO_4\,2H_2O \xrightarrow{\text{Heat treatment}} CaSO_4\ 1\backslash 2\ H_2O + CaSO_4 \xrightarrow{H_2O} CaSO_4 2H_2O$$

Hydraulic cements are defined as cements that not only harden by reacting with water but also water resistant product.

The raw materials used for manufactured of cement comprises mainly of lime, silica, alumina and iron oxide. These oxides interact with one another in the kiln at high temperature to form more complex compounds

4.1.3 Physical Properties of Cement:

Ordinary Portland cement of 53 grade of the cement conforming to ISI standards has been procured, and following tests have been carried out of physical properties.

Table 4.1 Physical properties of Cement

Fineness (Sp. Surface)	303 m^2/Kg
Specific Gravity	3.1
Soundness (Le-Chatlier Exp.)	10mm
Comp. Strength -7 days	51.6 Mpa
Comp. Strength -28 day	71.3 Mpa
Initial setting time	30 min
Final setting time	10 hrs

4.1.4 Chemical Properties of Cement:

Ordinary Portland cement of 53 grade of the ACC cement Branch conforming to ISI standards has been procured, and following tests have been carried out according IS:8112-1989 chemical properties.

Table 4.2 chemical properties cement

Chemical composition	**Percentages**
Al_2O_3	6.19
Fe_2O_3	2.45
Mgo	3.55
Cao	60.29
SiO_2	18.24
SO_3	2.38

4.2 Ground Granulated Blast furnace Slag:

The Blast furnace slag is a by-product of the iron manufacturing industry. Iron ore, coke and limestone are fed into the furnace and the resulting molten slag floats above the molten iron at a temperature of about 1500ºC to 1600ºC. The molten slag has a composition of about 30% to 40% SiO_2 and about 40% CaO, which is close to the chemical composition of Portland cement. After the molten iron is tapped off, the remaining molten slag, which consists of mainly siliceous and aluminous residue (Higgins, 2007) is then water-quenched rapidly, resulting in the formation of a glassy granulate. This glassy granulate is dried and ground to the required size (Hooton, 2000), which is known as Ground Granulated Blast Furnace Slag (GGBS).

GGBS is off-white in colour and substantially lighter than Portland cement. The production of GGBS requires little additional energy as compared with the energy needed for the production of Portland cement. The replacement of Portland cement with GGBS will lead to significant reduction of carbon dioxide gas emission. GGBS is therefore an environmentally friendly construction material. It can be used to replace as much as 80% of the Portland cement used in concrete. GGBS concrete has better water impermeability characteristics as well as improved resistance to corrosion and sulphate attack. As a result, the service life of a structure is enhanced and the maintenance cost reduced.

Figure 4.1 Ground Granulated Blast Furnace Slag

Superior quality concrete:

- Improved workability, Pump ability and compaction characteristic for concrete compaction placement.
- Increase strength.
- Reduced permeability.
- More chemical stable
- High resistance chlorine penetration.
- High resistance sulphate attack.
- High resistance to alkali silica factor.
- Very low heat of hydration.
- Improved resistance to attack form fire.

Low Environmental Impact:

- Production of GGBS involves virtually zero co2 emissions.
- Use of GGBS extends the life cycle of concrete structures.
- Enhanced durability, reduced maintenance and repair costs.
- Reduces life time construction costs.

Superior appearance:

- Improved surface finish.
- Lighter and more even colour.
- Enhanced reflectivity for greater visibility and safety.
- Suppresses eliminates efflorescence.

4.2.2 Physical Properties of GGBS:

Colour:

GGBS powder is almost white in colour in the dry state. Fresh GGBS concrete may show mottled green or bluish-green areas on the surface mainly due to the presence of a small amount of sulphide. This colour fades subsequently after casting; as the sulphide decomposes in air to form hydrogen sulphide (Slag Cement Association, 2005).

Durability:

GGBS cement is routinely specified in concrete to provide protection against both sulphate attack and chloride attack. GGBS has now effectively replaced sulphate resisting Portland cement (SRPC) on the market for sulphate resistance because of its superior performance and greatly reduced cost compared to SRPC. Most projects are being done using GGBS un subsurface concrete for sulphate resistance.

To protect against chloride attack, GGBS is used at a replacement level of 50% in concrete. Instance of chloride attack occur in reinforcement concrete in marine environments and in road de-icing slats. In most NRA projects in GGBS is now specified in structural concrete for bridge piers and abutments for protection against chloride attack. The use of GGBS in such instances will increase the life of the structure by up to 50% had only Portland cement been used, and precludes the need for more expensive stainless steel reinforcing.

GGBS is also routinely used to limit the temperature rise in large concrete pours. The more gradual hydration of GGBS cement generates both lower peak and less total overall heat than Portland cement. This reduces thermal gradients in the concrete, which prevents the occurrence of micro cracking which can weaken the concrete and reduce its durability.

Appearance:

In contract to the stony grey of concrete made with Portland cement, the near – white color of GGBS cement permits architects to achieve a lighter color for expressed fair – faced concrete finishes, at no extra cost. To achieve a lighter color finish, GGBS is usually specified at between 50% to 70% replacement levels, although levels as high as 85% can be used. GGBS cement also produces a smother, more defect free surface, due to the fineness of the GGBS cement prevents the occurrence of efflorescence, the staining of concrete surface by calcium carbonate deposits. Due to its much lower lime content and lower permeability, GGBS is effective efflorescence when used at replacement levels 50% to 60%.

Strength:

Concrete containing GGBS cement has a higher ultimate strength then concrete made with Portland cement. It has a higher proportion of the strength enhancing calcium silicate hydrates(CSH) than concrete made with Portland cement only, and a reduced content made with GGBS continues to gain strength over time, and has been shown to double its 28 days strength over periods of 10 to 12 years.

Sustainability:

Since GGBS is a by – product of steel manufacturing process, its use in concrete is recognized by LEED etc. as Improving the sustainability of the project and will therefore add points towards LEED certification. In this respect, GGBS can also be used for superstructure in addition to the cases where the concrete is in contact with chloride and sulfates. This is provided that the slower setting time fore casting of the superstructure is justified.

Fineness:

As with all cementing materials, the reactively of slag is determined by its surface area. In the united kingdom, GGBFS is marketed at a surface area of 3750-4250 cm^2/g Blaine, whereas some slag's in the united states have a surface area in the range of 4500-5500cm^2/g, Canadian slag's are about 4500cm^2/g, while in india it is found to corresponding influence in the strength development. The fineness of GGBFS is a very crucial parameter, which is dependent on energy- saving and economic consideration, influence the reactivity of GGBFS in concrete, early strength development of concrete and water requirement. For this reason, slag with two fineness of 1500 cm^2/g and 2850 cm^2/g are used.

Specific surface area:

There is a number of different methods of grinding Granulated Blast furnace Slag. Traditionally, standard ball mills have been used but during the last 15 years the use of roller presses and vertical mills has increased. Ground Granulated Blast furnace Slag is a very hard material and as result necessitates the use of high wear resistant materials in the grinding process typically GGBS possesses a specific surface area of 450 m^2/kg.

Specific gravity:

In general the specific gravity of GGBS will be ranging from 2.861 - 2.886. on the average it will be about 2.873. In general, the physical characteristics of fly ashes vary over a significant range, corresponding to their sources.

4.2.3 Chemical properties of GGBS:

Table 4.3 chemical properties of GGBS

S.No.	Chemical composition	Percentages
1.	Cao	30-45%
2.	Sio2	17-38%
3.	Al2o3	15-25%
4.	Fe2o3	0.5-2%
5.	Mgo	4-17%
6.	Mno2	1-5%
7.	Glass	85-98%

4.3 Bottom Ash:

Bottom Ash is the by-product of coal combustion. The rock detritus filled in the fissures of coal become separated from the coal during pulverization. In the furnace, carbon, other combustible matter burns, and the non-combustible matter result in coal ash. Swirling air carries the ash particles out of hot zone where it cools down. The boiler flue gas carries away the finer and lighter particles of coal ash. The boiler flue gases pass through the electrostatic precipitators before reaching the environment. In the electrostatic precipitators, coal ash particles are extracted from the boiler flue gases. The coal ash collected from the electrostatic precipitators is called fly ash. Fly ash constitutes about 80% of coal ash. During the combustion process some particles of the coal ash accumulate on the furnace walls and steam pipes in the furnace and form clinkers. These clinkers build up and fall to the bottom of furnace. In addition, the coarser particles, which are too heavy to remain in suspension with the flue gases, settle down at the base of the furnace. The ash collected at the bottom of furnace is called coal Bottom Ash. Bottom Ash constitutes about 20% of coal ash and the rest is fly ash. At present, India is the third largest consumer of coal. About 524 million tons of coal is burnt in coal fired thermal power annually (CEA, 2014).

They are the main source of production of coal ash. Indian coals have higher ash content up to 45% depending upon the source of the coal and result in large volumes of coal ash (CEA, 2014). As per Central Electricity Authority, India, report (CEA, 2014), 143 no coal fired thermal power plants with installed capacity of 133381 MW produced about 173 million tons of coal ash annually. With the capacity addition of 22282 MW by the end of 2017, the production of coal ash is estimated to about 220 million tons per year.

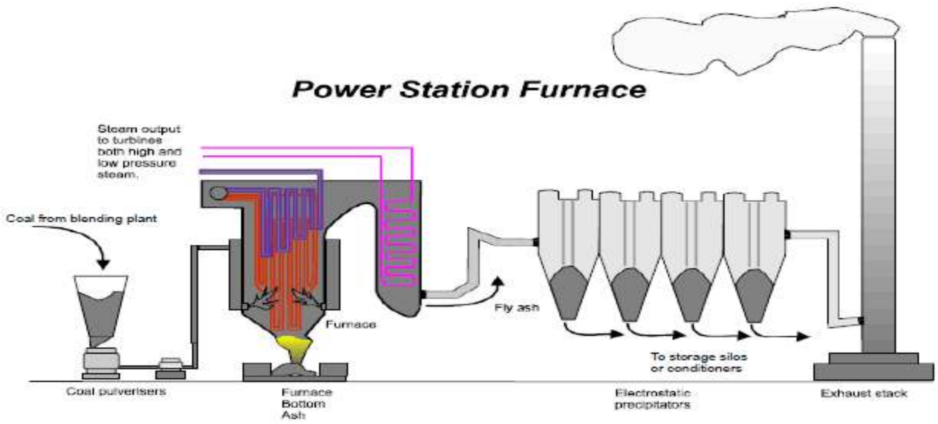

Figure 4.2 Production Bottom Ash.

4.3.1 Physical properties of Bottom Ash:

The Bottom Ash is mainly due to the presence of rock detritus in the fissures of the coal seams. The variability in the rock detritus from one source to another therefore causes variation in the properties of coal Bottom Ash as well. The factors that affect the properties of Bottom Ash are

- Degree of pulverization of coal**.**
- Firing temperature in the furnace.
- Type of furnace.

Bottom Ash has angular, irregular, porous and rough surface textured particles. The particles of Bottom Ash range from fine sand to fine gravel. Bottom Ash has appearance and particle size distribution similar to that of river sand. Bottom Ash is usually a well-graded material although variations in particle size distribution can be encountered from the same power plant. Particles of Bottom Ash have interlocking characteristics. Bottom Ash is lighter and more brittle as compared to natural river sand. The specific gravity of Bottom Ash varies from 1.2 to 2.47 depending upon the source and type of coal. Bottom Ash with low specific gravity has a porous texture that readily degrades under loading or compaction. Bottom Ash derived from high sulphur coal and low rank coal is not very porous and is quite dense.

Table 4.4 Physical properties of Bottom Ash

Property	Bottom Ash
Specific gravity	2.1-2.7 KN/m^3
Dry unit weight	7.07-15.72 KN/m^3
Plasticity	None
Absorption	0.8 – 2.0%

4.3.2 Chemical Composition of Bottom Ash:

Coal ash produced on burning of lignite or sub bituminous coal contains high calcium oxide content. This type of coal ash has cementations properties in addition to pozzolonic properties.

Table 4.5 Chemical Composition of Bottom Ash

Chemical composition	Percentages
Sio_2	38.64
Al_2o_3	21.15
Fe_2o_3	11.96
Cao	13.80
Mgo	2.75
So_3	0.61
N_2o	0.90
K_2o	2.06
Free lime	0.03
Loss on ignition	7.24

Anthracite or bituminous coals on burning result in low-calcium coal ash which has pozzolonic properties and very small fraction of calcium oxide (ASTM C 618-03). Bottom Ash is mainly composed of silica, alumina and iron with small amounts of calcium, magnesium, sulphate etc. Its chemical composition is controlled by the source of the coal.

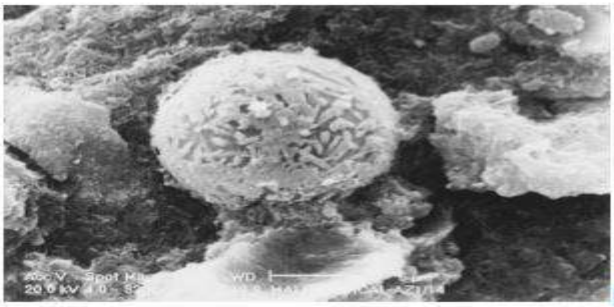

Figure 4.3 Bottom Ash particle starting to react with Ca(OH)2

Figure 4.4 Coal Ash disposal site at NTPC.

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4.3.3. Uses of Bottom Ash:

Coal Bottom Ash can be beneficially utilized in a variety of manufacturing and construction applications. At present in USA, coal Bottom Ash is predominantly being used for the following applications.

- Road base and sub-base
- Structural fill
- Backfill
- Drainage media
- Aggregate for concrete, asphalt and masonry
- Abrasives/traction
- Manufactured soil products
- Snow and ice control

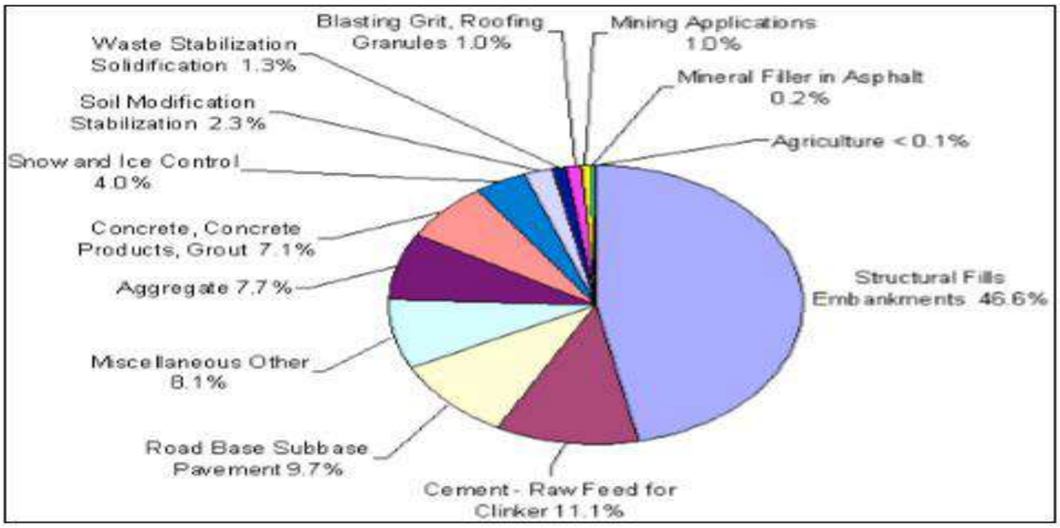

Figure 4.5 Bottom Ash applications as a percentages of total reused

4.4 FLYASH

4.4.1 General

The flyash is a by-product of the National Thermal Power Plant (NTPC) industry. Flyash is a complex material having wide range of chemical physical and mineralogical composition. The chemistry of flyash depends on type of coal burnt in boiler furnace, temperature of furnace degree of pulverization of coal efficiency of ESP etc. The major constituents of most of the flyashes are silica (sio2) , alumina (Al2o3), ferric oxide (Fe2o3), calcium oxide (Cao). The other minor constituents of the fly ash are MgO, Na_2O,K_2O,So3,MnO, TiO2 and unburnt carbon.

Fly ash is light grey in colour like the colour of cement. Generally fly ash is defined as two classes by ASTM C618. Class F fly ash and class C fly ash. The chief difference between these classes is the amount of calcium, silica, alumina and iron content in the ash. Fly ash particles are generally spherical in shape and range in size from 0.5 micro meters to 300 micro meters. Fly ash concrete can have better chemical resistance and durability and significant improvement in workability of concrete. As a result, the service life of a structure is enhanced and the maintenance cost reduced.

Figure.4.6 Fly ash

4.4.2 Advantages of Fly ash

Superior quality concrete

- Improved workability, Pump ability and compaction characteristic for concrete compaction placement
- Increase strength
- Reduced permeability
- More chemical stable
- High resistance chlorine penetration
- High resistance to alkali silica factor
- Very low heat of hydration
- Improved workability
- Improved durability

4.4.3 Physical Properties of Fly ash

The flyash particles are generally glassy,solid or hollow and spherical in shape . the hallow spherical particles are called as cenospheres , the fineness of individual flyash particles range from 1 micron to 300 microns size. The fineness of fly ash particles has a significant influence on its performance in cement concrete. The fineness of particles is measured by measuring specific surface area of flyash by blaines specific area technic. Greater the surface area more will be the fineness of flyash, the other method is used for measuring fineness of flyash is dry and wet sieving.
The specific gravity of flyash varies over a wide range of 1.9-2.55.

Table.4.6 physical properties of Fly ash

PROPERTIES	VALUES
Air content %	7
Specific surface m^2/kg	392
Autoclave expansion %	0.02
Specific gravity	1.9-2.25

4.4.4 Chemical properties of Fly ash

Table.4.7 chemical properties of Fly ash

s.no	Chemical composition	Percentages
1.	Cao	0.37-27.68
2.	Sio2	27.88-59.40
3.	Al2o3	5.23-33.99
4.	Fe2o3	1.21-29.63
5.	Mgo	0.42-8.79
6.	So_3	0.04-4.71
7.	Loss of ignition	0.21-28.37

4.5 Crusher Dust

4.5.1 General:

Crusher dust is a angular particles with a rough surface which is obtained when large amounts of stone and aggregates are moved in this process quarries create a large amount of dust which is known as crusher dust. It much looks like sand. And it is a great replacement for sand.

Crusher dust is also created when metals such as iron are separated from ore and the resulting slag is crushed into fine particles. Crushed dust looks much like sand but is made up of angular particles with a rough surface. Crusher dust compacts very well, creating a stable surface. It is used under concrete pavers bedding sand is best for this application. Crusher dust is also used to make concrete aggregate, concrete sand and glass insulation. In addition, it is frequently used as fill in trenches and around water tanks .In agriculture the material can help to aerate soil.

The crusher dust features grey or brown colour and the size is perfectly fine. In most situation, these are used as the cement aggregate to form a specific texture. The stone crusher dust which is designed with the diameter larger than 5mm is recognized as the large class.

Figure.4.7 Crusher Dust

4.5.2 Physical properties of Crusher dust

Table.4.8 Physical properties of Crusher dust

PROPERTY	UNIT	VALUES
Specific gravity	-	2.6-2.9
Maximum dry density	t/m^3	2 - 2.15
Optimum moisture content	%	10-13
Bulk density (loose)	t/m^3	1.35-1.45
Bulk density (compacted)	t/m^3	1.50-1.60
Particle density (dry)	t/m^3	2.70-2.80
Particle density (SSD)	t/m^3	2.75-2.85
Water absorption	%	2.5-2.35
Plasticity index	-	Non-plastic
Organic impurities	-	Free
P_h	-	10-12

4.5.3 Chemical composition of Crusher dust

Table.4.9 Chemical composition of Crusher dust

Chemical composition	Percentages
Sio_2	62.42
Al_2o_3	18.72
Fe_2o_3	6.54
Cao	4.83
Mgo	2.56
So_3	0.61
Na_2o	NIL
K_2o	3.18
TiO_2	0.48
Loss on ignition	0.48

4.5.4 Advantages of Crusher dust

- Consistent chemistry
- Excellent load bearing capacity
- Nonplastic
- Resistant to heat and fire
- Alkaline in presence of moisture

- Effective utilisation of an industrial by product conserving natural resources

4.5.5 Uses of Crusher dust

- It is used s concrete aggregate
- Crusher dust also have application in horticulture as natural fertiliser
- It can e used as a cost effective filing and packing material around water tanks
- Crusher dust is used as a material to backfill trenches

4.6 Aggregates

Aggregates are the important constituents in concrete. They give body to the concrete, earlier aggregates were considerd as chemically inert materils but now it has been recognised and also that some of the aggregates are chemically active and also that interface of aggregate and paste. Aggregates generally occupy 70-80% of the volume of concrete and can therefore be expected to have an important influence on its properties. They are granular materials derived for the most part from natural rock and sands. Moreover,synthetic materials such as slag and expended clay or shale are used to some extent, mostly in light weight concrete. In addition to their use as economical filler, aggregtes generally provided concrete with better dimensional stability and wear resisitence. Based on their size, aggregates are divided into coarse and fine fractions. The coarse aggregate fraction is that retained on the 4.75 mm sieve. While the fine aggregate fraction is that passing the same sieve. Based on their origin, aggregates can be classified as natural aggregates.

Mineral aggregates consisit of sand,gravel,stones and crushed stones. construction aggregates make up more than 80% of the total aggregates market ,and are used mainly for road base, rip-rap, cement concrete and asphalt. In 1998, roughly 3400 U.S quarries producede about 1.5 billon tons of crushed stones, of which about 1.2 billion tons was used in construction applications. The sources of mineral aggregates are by directly extracting from the original sources like river basins or by manufacturing them into a desired shape from the parent rock in a crusher mill. It was also found that manufacture sand offers available alternative to the natural sand by providing a higher compressive strength and delivering environmental benefits . All natural aggregates particles are originally formed as part of a larger parent mass. This may have been fragmented by natural process of weathering and abrasion or artificially by crushing. Thus, many properties of the aggregates depend on the properties of the parent rock, e.g chemical stability , pore structure and color. On the other hand , there are some properties possessed by the aggregates but absent in the parent rock partical shape and size, surface and absorption.

The reasons for their advent in concrete construction are :

i. Environmental considerations are increasingly affecting the supply of aggeregate.
ii. There are strong objections to opening of pits as well as to quarrying.
iii. At the same time, there are problems with the disposal of construction demolition waste and with dumping of domestic waste.

4.7 Water

Water is a key ingredient in the manufacture of concrete. Attention should be given to the quality of water used in concrete the time – honered rule of thumb for water quality. A large amount of concrete is made using any water source. A popular yard-stick to the suitablilty of water for mixing concrete. This does not appear to be a true statement for all conditions. Some waters containing a small amount of sugar would concrete and conversely water suitable for making concrete may not necessaily be fit for drinking. Some specifications requires that if the water is not obtained from source that has proved satisfactory, the strength of concrete or motar made with questionable water should be compared with similar concrete or mortar made with pure water. Some specification also accept water for making concrete if the pH value of water lies between 6 and 8 and the water is free from organic matter. Instead of depending upon pH value and other chemical composition, the best course to find out whether a particulate source of water is suitable for concrete making or not, is to make concrete with this water and compare its 7 days and 28 days strength with companion cubes made with distilled water. If the compresive strength is upto 90 %, the source of water may be accepted

TESTS ON MATERIALS

5.1 Tests on Cement:

5.1.1 Fineness of Cement:

This method serves only to demonstrate the presence of coarse cement particles. This preliminary suited to checking and controlling production process. The fineness of cement is measured by sieving it on standard sieves. The production of cement of which grain sizes are larger than the specified mesh size. The apparatus used are 90µm sieve, Balance capable of weighing 10g. A nylon or pure brush, preferably with 25 to 40 mm, bristle, for cleaning the sieve.

Apparatus:

- Test sieve of nominal sieve size 90µ.ie. I.S .sieve no: 9
- Analytical balance with standard weights weigh up to an accuracy of ±0.0002.
- A nylon or pure bristle brush.
- A collecting tray.

Procedure:

- Weigh 100g. of cement to the nearest 0.01g. and place it on a clean and dry 90u.I.S sieve with pan attached.
- Break down any air set lumps in the cement sample with fingers and mix it uniformly.
- Continuously sieve the sample by holding the sieve in both hands for 15min. with a gentle wrist motion.
- While sieving it, ensure that there is no spilling of the cement and the cement shall be kept well spread out on the sieve.
- Do not use washers, shots and slugs on sieve.
- Slightly brush under side of the sieve after every 5 min of sieving.
- Find the weight of residue on the sieve and the value as a percent of the original sample taken.

Observations:

Table 5.01 Observations of fineness of Cement

S.No.	Weight of cement taken in gm.(w_1)	Weight of residue in gm (w_2)	% of weight residue (W_2/W_1)x100
1	100	2.0	2.0%
2	100	2.3	2.3%
3	100	2.5	2.5%

Calculations:

Weight of cement taken (w_1) = 100g
Weight of residue (w_2) = 2.26g
Percentage of residue = (w_2/w_1) x 100

Result: Fineness of Cement = 97.73%

5.1.2 Specific Gravity of Cement:

Apparatus:

- Density bottle
- Electronic weighting machine capable of weighting accurately up to 0.1g

Procedure:

- Take empty weight of density bottle as W_1
- Take weight of density bottle after filling it with cement up to ¾th level of its volume as $w_{2.}$
- Fill the remaining portion with kerosene & weight it as W_3
- Empty the bottle & fill it with water as $W_{5.}$

Observations:

Table 5.02 Observations specific gravity of Cement

S.No	Observations	Sand in gms
1	Weight of empty density bottle (w_1)	33.30
2	Weight of density bottle + cement (w_2)	49.00
3	Weight of density bottle +cement+ kerosene (w_3)	83.00
4	Weight of density bottle with kerosene . (w_4)	71.60
4	Weight of density bottle with water (w_4)	81.78

.

Calculations:

Specific gravity of kerosene = $(w_4 – w_1) / (w_5 – w_1)$
= (71.6 – 33.3) / (81.7 - 33.33)
= 0.79

Specific gravity of cement = $(w_2-w_1) / (w_4-w_1) – (w_3-w_1)$ x 0.79
= (49-33.3) / (71.6-33.3) - (83 – 49) x 0.79
= 2.99

Result: Specific gravity of Cement = 2.99.

5.1.3. Standard Consistency of Cement:

Apparatus:

- Vicat's apparatus with plungers
- Tray
- Measuring jar
- Balance of capacity 1000g with an accuracy of ±1.0g
- Gauging trowels

Procedure:

- Take 400g of cement sample and place it on a non-absorbent plate.
- Take 25% of water by weight of cement as first trial and mix it thoroughly with cement using gauging trowels. Ensure that time of gauging shall be within 3 to 5 min.
- Keep the mould on a non – absorbent plate. Apply a thin coat of oil inside the mould.
- Fill the vicat's mould with cement paste as stretch and tamp the mould so as make the spread uniformly in the mould.
- Fix the plunger of 10mm dia. & 50mm long to the touch the mould's top surface & leave it quickly.
- Note the plunger penetration reading to the scale of apparatus. The recorded penetration value of reckoned from the bottom of the mould.
- Remove the plunger & cement paste from the mould. Take fresh sample of cement & repeat the entire process & with X% off water & note down the plunger penetration.
- Repeat the above process with varying percentages of water and note down the penetration of plunger till the penetration.

Observations:

Table 5.03 Observations standard consistency of Cement

Trail No	Quantity of water added		Reading of vicat's scale in mm		Penetration from bottom of mould
	%	Ml	Initial in mm	Final in mm	
1	25	100	3	29	26 mm
2	27	108	3	20	17 mm

Calculations:

Weight of cement taken = 400g
Percentage of water added = 27%
Initial reading on vicat's scale in mm = 3mm
Final reading on vicat's scale in mm = 20mm
Percentage of plunger measured from bottom of mould in mm = 17 mm

Result: The standard consistency of given Cement = 27%

5.1.4. Initial and Final setting time of Cement

Apparatus:

- Vicat's apparatus with plunger.
- Tray
- Measuring jar
- Balance of capacity 1000g with accuracy of ±1.0g
- Gauging trowels

Procedure:

A. Preparation of test block:

- Prepare a neat cement paste by mixing the cement water required to give a paste of standard consistency.
- Start a stop watch at the instant when the water is added to cement. Thoroughly mix cement and water using gauging trowels till the required uniformly is attained in mixing. Fill the mould, which is resting on the non-porous plate with cement paste prepared. Fill the mould completely and smoothen the surface , the paste by making it level with top of the mould. The cement block thus prepared in the test block.

B. Initial setting time:

- Place the test block with porous plate at bottom, under the rod bearing needle.
- Lower the needle gently until it comes in contact with the surface of test block and quickly release allowing it to penetration into test block.
- Repeat this procedure at regular intervals of time until the needle, when brought in contact with the test block and released as above falls to the block for 5 to 7 mm measured from the bottom of the mould.
- The period elapsed between the time when water is added to the cement and the time at which the needle falls to the block at 5 to 7mm measured from the bottom of the mould shall be prepared as initial setting time.

C. Final setting time:

- Replace the needle of the vict's apparatus by an angular attachment.
- Prepare the test block according to the procedure given above.
- The cement shall be considered as finally set when upon applying the needle gentle to the surface of the block, the needle makes an impression there, while the attachment fails to do so.

- The period elapsing between the time when water is added to the cement and tike at which the needle makes an impression on the attachment fails to do so shall be the final setting time.

Observations:

A. **Initial setting time**:

Weight of cement sample = 400g
Weight of water to be added = [0.85p/100] x weight of sample
= 0.85 x 27 x 400 /100
= 91.8 ml

Where p = standard consistency of cement

Table 5.04 Observations of initial setting time of Cement

Trail no	1	2	3	4	5	6	7
Initial reading in mm	3	3	3	3	3	3	3
Final reading in mm	3	3	5	10	13	15	19
Penetration in mm	0	0	2	7	10	12	16
Time elapsed = initial setting time min	5	10	15	20	25	30	35

B. **Final setting time:** Final setting time of cement taken = 600min.

5.2. Tests on Fine Aggregates

5.2.1 Specific gravity of fine aggregates

Apparatus:

i. Pyhcnometer
ii. Electronic weighting machine capable of weighing accurately up to 0.1g

Procedure:

- Take empty weight of pycnometer as W1
- Take weight of pycometer after filling it with aggregates up to3/4th level of its volume as W2
- Fill the remaining portion with water & weigh it as W3
- Empty the pyconmeter & fill water & weigh as W4

Observations:

Table 5.05 Observations of specific gravity of Sand

S.No	Observations	Sand in gms
1	Weight of empty pycnometer (w_1)	620
2	Weight of pycnometer + Sand (w_2)	1609
3	Weight of pycnometer + Sand + water . (w_3)	2026
4	Weight of empty pycnometer (w_4)	1423.6

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Calculations:

Specific gravity of fine aggregate = $(w_2-w_1) / (w_4-w_1) – (w_3-w_1)$

= (1609-620) / (1423.6 – 620) - (2026 – 620)
= 2.55

Result: Specific gravity of fine aggregate = 2.55

5.2.2 Specific gravity of Bottom Ash

Apparatus:

- Pyhcnometer
- Electronic weighting machine capable of weighing accurately up to 0.1g

Procedure:

- Take empty weight of pycnometer as W1
- Take weight of pycometer after filling it with aggregates up to3/4th level of its volume as W2
- Fill the remaining portion with water & weigh it as W3
- Empty the pyconmeter & fill water & weigh as W4.

Observations:

Table 5.06 Observations of specific gravity of Bottom ash.

S.No	Observations	Sand in gms
1	Weight of empty pycnometer (w_1)	645.8
2	Weight of pycnometer + Bottom Ash (w_2)	1163
3	Weight of pycnometer + Bottom Ash + Water (w_3)	1698.3
4	Weight of empty pycnometer (w_4)	1423.3

Calculations:

Specific gravity of fine aggregate = $(w_2-w_1) / (w_4-w_1) – (w_3-w_1)$

= (1163 – 645.8) / (1423.3 – 645.8) - (1698.3- 645.8)
= 2.13

Result: Specific gravity of Fine Aggregates = 2.13

Observations:

Table. 5.07 Observations of specific gravity of Crusher dust.

S.No	Observations	Sand in gms
1	Weight of empty pycnometer (w_1)	645.8
2	Weight of pycnometer + Crusher dust (w_2)	1163
3	Weight of pycnometer + Crusher dust + Water (w_3)	1698.3
4	Weight of empty pycnometer(w_4)	1423.3

Calculations:

Specific gravity of fine aggregate = $(w_2-w_1) / (w_4-w_1) – (w_3-w_1)$

= (1163 – 645.8) / (1423.3 – 645.8) - (1698.3- 645.8)
= 2.13

Result: Specific gravity of fine aggregates = 2.13

5.2.3. Sieve Analysis of Fine Aggregates

Apparatus:

- Electronic weighing balance
- Sieve shaker

- Set of standard sieves
  - 4.75mm
  - 2.36mm
  - 1.18mm
  - 0.6mm
  - 0.3mm
  - 0.15mm

Procedure:

- Dry the given sample of aggregates by keeping it in oven at a temperature of 100 to 110^{o}c for a period of 24 hours.
- Take the weight of air day sample of aggregates in the top most sieve in the sieve of the set with lager size at top and lower size at bottom. Care shall be taken to ensure that the sieves are clean before use.
- Each sieve shall be shaken separately over a clean try for a period of not less than 2 minutes.
- The shaking is done with a varied motion backwards and forwards, left, right, clock- wise, anti-clock-wise so that the material is kept moving over the surface in frequently changing directions.
- Find the weights of aggregates retained on each sieve taken in order.
- If sieve is carried out with a set of sieves on machine, not less than 10 minutes sieving will be required for each test.

Observations for fine aggregates:

Table 5.08 Observations of sieve analysis of fine aggregates.

S.No	Sieve size in mm	Weight of sand retained in gms	Cumulative weight retained in gms	Cumulative weight retained %	Cumulative percent of passing N(100-X)
1	4.75	35.6	35.60	3.56	96.44
2	2.36	33.20	68.20	6.82	93.80
3	1.18	194.50	262.70	26.27	73.73
4	0.60	242.10	504.80	50.48	49.52
5	0.30	343.40	848.20	84.82	15.18
6	0.15	132.90	981.50	98.15	1.85

Fineness modulus = (cumulative percentage of weight retained) /100
= 270.1 /100
= 2.70

Result: Fineness modulus of Fine aggregates 2.70

Table 5.09 Grading limits for fine aggregates as per IS - 383 – 1970 Table -4

Is sieve size in mm	Cumulative percentage of passing			
	Grading zone-I	Grading zone-II	Grading zone-III	Grading zone -IV
10	100	100	100	100
4.75	90-100	90-100	90-100	90-100
2.36	60-95	75-100	85-100	95-100
1.18	30-70	55-90	75-100	90-100
0.60	15-34	35-59	60-79	80-100
0.30	5-20	8-30	12-40	15-50
0.15	0-10	0-10	0-10	0-15

5.2.4. Sieve Analysis of Bottom Ash

Apparatus:

- Electronic weighing balance
- Sieve shaker
- Set of standard sieves
  - 4.75mm
  - 2.36mm
  - 1.18mm
  - 0.6mm
  - 0.3mm
  - 0.15mm

Procedure:

- Dry the given sample of aggregates by keeping it in oven at a temperature of 100 to 110^{o}c for a period of 24 hours.
- Take the weight of air day sample of aggregates in the top most sieve in the sieve of the set with lager size at top and lower size at bottom. Care shall be taken to ensure that the sieves are clean before use.
- Each sieve shall be shaken separately over a clean try for a period of not less than 2 minutes.
- The shaking is done with a varied motion backwards and forwards, left, right, clock- wise, anti clock-wise so that the material is kept moving over the surface in frequently changing directions.
- Find the weights of aggregates retained on each sieve taken in order.
- If sieve is carried out with a set of sieves on machine, not less than 10 minutes sieving will be required for each test.

Observations for fine aggregates:

Table 5.10 Observations of sieve analysis of Bottom Ash

S.No	Sieve size in mm	Weight of sand retained in gms	Cumulative weight retained in gms	Cumulative weight retained %	Cumulative percent of passing N(100-X)
1	4.75	5.0	5.0	0.5	99.5
2	2.36	5.9	10.9	1.09	98.91
3	1.18	18.3	29.2	2.92	97.08
4	0.60	300.99	330.1	33.01	66.99
5	0.30	522.30	852.4	85.24	14.76
6	0.15	128.3	980.7	98.01	1.93

Calculations: Fineness modulus = (cumulative percentage of weight retained) /100

= 220.77 /100

= 2.20

Result: Fineness modulus of Fine Aggregates (Bottom Ash - 2.20)

Note: Grading zone of Bottom Ash is related to ZONE-III if it is consider as fine aggregates (sand) as per IS 383-2013

Table. 5.11 Observations of sieve analysis of Crusher dust

S.No	Sieve size in mm	Weight of Crusher dust retained in gms	Cumulative weight retained in gms	Cumulative weight retained %	Cumulative percent of passing N(100-X)
1	4.75	5.00	5	0.5	99.95
2	2.36	135.5	140.5	14.05	85.95
3	1.18	180.7	321.2	32.12	67.88
4	0.60	99.8	421	42.1	57.9
5	0.30	191.7	612.7	61.7	38.73
6	0.15	254.9	867.6	86.76	13.24

Calculation

Fineness modulus = (cumulative percentage of weight retained) /100
= 237.23/100
= 2.37

Result: fineness modulus of fine aggregate 2.37

NOTE: Grading Zone of C.D is related to Zone II, if it is consider as fine aggregate (sand) as per IS383-2013

5.2.5 Bulking of Sand:

Apparatus:

- Measuring jar
- Mixing pan
- Gauging trowels

Procedure:

- Take the dry sand sample and pour it into the glass jar up to 250ml mark.
- Remove the sand from glass jar and pour it in mixing pan.
- Add 2% of water, by volume to sand and mix it thoroughly.
- Place this sand gently in the measuring jar and note the graduation. This will be slightly more than the initial reading of 250ml mark.
- Repeat the steps 3 & 4 with increased water content and note down the observations. It can be observed that increase in moisture content shall make the sand to increase in volume up to certain limit. Thereafter, further increase in moisture content decreases volume of sand.
- The addition of water at uniform rate is 2% will be continued until the original volume of 250ml mark is obtained.
- The moisture content or percentage of water at which maximum increase in volume of sand occurs shall be taken to calculate percentage of bulking of sand.

Observations for Fine aggregate:

Table 5.12 Observations of Bulking of Sand

S.No	Original volume of sand (ml)	% of water added	Final volume (ml)	Increase in volume (ml)	Percentage of bulking
1	50	2%	55	5	10
2	50	4%	57	7	14
3	50	6%	59	9	18
4	50	8%	57	7	14
5	50	10%	55	5	10

Observations:

Initial volume of sand = v_1 = 50ml.
Final volume of sand = v_2 = 57ml.
% of bulking of sand = $(v_1-v_2) / v_1 \times 100$ =14%

Result: Percentage of bulking of Sand = 14% @ 8% of water added.

5.3. Tests on Coarse Aggregates

5.3.1. Specific Gravity of Coarse Aggregates

Apparatus:

- Pychonometer
- Electronic weighting machine capable of weighing accurately up to 0.1g

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Procedure:

- Take empty weight of pyconometer as w_1
- Take weight of pycnometer after filling it with aggregates up to ¾th level of its volume as W_2
- Fill the remaining portion with water & weigh it as W_3.
- Empty the pycnometer & fill it with water & weigh it as W_4.

Observations:

Table 5.13 Observations of Specific gravity of coarse aggregates

S.No	Observations	Aggregates
1.	Weight of empty pycnometer . (w_1)	450.0
2.	Weight of pycnometer with coarse aggregates (w_2)	1233.9
3.	Weight of pycnometer with coarse aggregate & water (W_3)	1799.0
4.	Weight of pycnometer (W_4)	1296.1

Calculations:

Specific gravity of fine aggregate = $(w_2\text{-}w_1) / (w_4\text{-}w_1) – (w_3\text{-}w_1)$

= (1233.9 – 450) / (1296.1 – 450) – (1799 -1233.9)

= 2.79

Result: Specific gravity of Coarse Aggregates taken = 2.79

5.3.2. Sieve Analysis of Coarse of Aggregates

Apparatus:

- Electronic weighting balance.
- Sieve shaker
- Set of standard sieves
  - 40mm
  - 31.5mm
  - 25mm
  - 20mm
  - 10mm
  - 4.75mm

Procedure:

- Dry the given sample of aggregates by keeping it in oven at a temperature of 100 to110^{o}c for a period of 24 hours.
- Take the weight of air dry sample of aggregates in the top most sieve of the set with lager size at top and lower size at bottom. Care shall be taken to ensure that the sieves are clean before use.
- Each sieve shall be shaken separately over a clean tray for a period of not less than 2 minutes.
- The shaking is done with a varied motion backwards and forwards, left, right, clock-wise, anti clock-wise so that the material is kept moving over the surface in frequently changing directions.
- Fine the weights of aggregates retained on each sieve taken in order.
- If sieve is carried out with a set of sieves on machine, not less than 10 minutes sieving be for each test.

Observations:

Table 5.14 Observations of Sieve analysis of Coarse Aggregates

S.No	Sieve size in mm	Weight of sand retained in gms	Cumulative weight retained in gms	Cumulative weight retained %	Cumulative percent of passing N(100-X)
1	20	539	539	26.95	70.05
2	16	940.8	1479.8	73.99	26.01
3	12.5	509	1988.8	99.4	0.66
4	10	11.2	2000	100	0

Calculations:

Fineness modulus of coarse aggregates = cumulative percentage of weight retained / 100
= 300.38 / 100
= 3

Result: Fineness modulus of Coarse Aggregates = 3

CONCRETE MIX DESIGN

6.1 General:

One of the ultimate aims of studying the various properties of the material of concrete is to enable a concrete technologist a design a concrete mix for a particular strength and durability. Design of concrete mix needs not only the knowledge of material properties and properties of concrete in plastic condition; it needs winder knowledge and experience of concreting. Even then the proportion of the materials of concrete found out at the laboratory requires modification and readjustments to suit the field conditions. Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their properties with the object of producing concrete of certain minimum strength and durability as economically as possible.

It is an important phase of concrete technology as to ensure quality and economy.

Empirical relations afford resonant accurate guide to select the best combination of ingredients, so as to achieve the desired properties. The following assumptions can be made in the design of plastic of medium strength.

1. The compressive strength of concrete is governed by its water – cement ratio.
2. Its water content for the given characteristics governs workability of concrete.

Considerable interaction happens between the above two criteria in the case of high. Strength of concrete with low workability and such assumptions may have limited validity. Moreover, the properties of concrete are affected by many factors such as quality and quantity of cement, water, aggregates and techniques used in batching, mixing, placing, compaction and curing. Specific relations used in the proportion should be taken as a basic for making initial guess at the optimum combination of the ingredients and the final mix properties are accomplished only on the basic of trail mixes.

6.2 Factors Affecting Mix Proportions

Various factors affecting mix proportions are:

1. Grade of concrete
2. Water- cement ratio
3. Type of cement
4. Maximum size of aggregate
5. Workability
6. Grading of aggregates s
7. Quality control

1. **Grade of concrete**

Grade of concrete in the minimum strength required for the structural design. This is referred as characteristics strength of concrete in India, characteristics strength of concrete is determined using cubes of standard size 150mm x 150mm x 150mm.stregth of concrete depends for the target mean strength is the strength of concrete below which not more than 5% results are expected to fall.

2. **Water – cement ratio**

Water – cement ratio is a very important factor in the mix design. As the water- cement ratio decreases, strength of the concrete increase. Water – cement ratio is selected keeping in view the require strength concrete, super plasticizers are added to get the required workability at low water – cement ratio.

3. **Type of cement**

There are different types of cements, choice of cement depends on the requirement of concrete. For high strength concrete, higher grade portal and cements, conforming to IS 8112-1976 is suitable For general constructions, OLD 33, 43, 53 grade cements are used.

4. **Maximum size of aggregates**

Maximum size of the aggregates is the sieve size in mm through which more than 90% of the material passes.

Workability is more for large size aggregates when compared to smaller aggregates. This is because, smaller aggregates will have larger surface area, hence they require more water fir wetting and more paste is required to lubricate the surface to reduce internal friction. At the same time, strength is more for smaller aggregates. Maximum size of the aggregates depends on the element. It will influence the entrapped air content and spacing of the reinforcement. Entrapped air increases as the size of the aggregates decreases.

5. **Workability**

Workable concrete is the one which exhibits very little internal friction between particle and particle or which overcome the frictional resistance offered by the form work surface or reinforcement contained in concrete with just the amount of homogeneity with which concrete can be mixed, place, transport, compacted and finished. The degree of workability required depends on type of work, distance of transport, method of placing, mode of placing, mode of compaction and many other factors. Workability can be measured by:

1. Slump cone test
2. Compaction factor test

6. **Grading of aggregates**

Generally, locally available aggregates do not conform to the standard grading. Hence, there is a need for combining the aggregates in suitable proportions. This can be done either figureically or analytically, well- graded produce dense and workable concrete. Grade of aggregates will be confirmed with reference to IS: 383 -1970.

7. **Quality control**

Depending on quality control at the site, the value of standard varies. The degree of quality control is divided in to categories as per IS 456 – 2000 table 8:

1. Very good
2. Good
3. Fair

For general construction, the degree of quality is to be taken the category of "Good"

6.3 Design Mix for M30 Grade Concrete without admixture

Test data for materials

Cement used	= OPC 53 Grade.
Specific gravity of cement	= 3.15
Specific gravity of fine aggregates	= 2.61
Specific gravity of Coarse aggregates	= 2.79
Minimum cement content	= 320 kg/ m^3 (as per IS – 456 -2000)

Maximum cement content = 450 kg/ m^3
Fine aggregates = Zone - II

Step: 1 Target mean strength:

F́ck = fck +1.65S
S = standard deviation N/mm^2 = 5 (table -1-IS 10262)
F́ck = target characteristic compressive strength at 28 days in N/mm^2
Fck = characteristic compressive strength at 28 days in N/mm^2
F́ck = 30 + 1.65x5
= 38.25 N/mm^2

Step: 2 Selection of water cement ratio

From IS 10262
From table 5 IS 456 maximum w/c ratio = 0.45
Adopt w/c ratio = 0.45

This water cement ratio is to be selected both from strength consideration and maximum w/c denoted in table -5 of IS 456 and lesser of the two is to be adopted for durability requirement.

Step: 3 Selection of water content

From table -2 IS10262
Nominal maximum size of aggregates = 20mm
Maximum water content per cubic meter of concrete = 186 lit
as per IS 10262 table -4
Estimated water content for 100mm slump = 186x(6/100)+186
(3% increase for every 25mm slump over and above 50mm slump)
=197.16 kg ≃ 198kg.

Step: 4 Calculation of cement content

W/c ratio = 0.45
Water used = 198kg
Cement content = w/c = 0.45
C = 198/0.45
Cement = 440kg/m^3

Step: 5 Calculations of C.A and F.A

From table -3-10262-2009 volume of coarse aggregates corresponding for 20mm size aggregates and fine aggregates and fine aggregate zone-II for w/c ratio = 0.50 is found out to be 0.62
In present case w/c 0.45 i.e. is less by 0.05 as the w/c is reduced it's desirable to increased C.A proportion to reduce the F.A constant.
The C.A is increased at the ratio = 0.05
(0.01/ 0.05) x 0.05 = 0.01
Volume of C.A = 0.62
= 0.62+0.01 = 0.63
Corrected proportion of volume of C.A = 0.63
Since it is angular aggregates and concrete is to be pumped the C.A can be reduce by 10%
Final volume of C.A = 0.63x0.9 = 0.567
Volume of F.A = 1- 0567 = 0.433

Step:6 Calculation of mix proportions

Volume of concrete = 1 m^3
Absolute volume of cement = (440/3.15)x(1/1000)
= 0.139m^3
Volume of water = 0.198m^3
Absolute volume of all materials expet total aggregates = 0.139+0.198=0.337m^3
Absolute volume of total aggregates = 1- 0.337 = 0.663m^3
Weight of C.A = 0.567x0.663x2.89x1000 = 1052.57 kg/m^3 ≃ 1053 kg/m^3
Weight of F.A= 0.433x0.663x2.7x1000 = 775.11 kg/m^3 ≃ 775 kg/m^3

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Mix proportions are 1m^3 Concrete:

Cement = 440 kg/m^3
F.A = 1053 kg/m^3
C.A = 775 kg/m^3
Water = 198 kg/m^3

Step: 6. Actual quantities of required for the mix per bag of Cement

Cement	:	F.A	:	C.A	:	Water
440	:	775	:	1053	:	198
1	:	1.76	:	2.39	:	0.45

6.4 Design Mix for M30 Grade Concrete With Add Mixture

Test data for materials

Cement used	= OPC 53 Grade.
Specific gravity of cement	= 3.15
Specific gravity of fine aggregates	= 2.61
Specific gravity of Coarse aggregates	= 2.79
Minimum cement content	= 320 kg/ m^3 (as per IS – 456 -2000)
Maximum cement content	= 450 kg/ m^3
Fine aggregates	= Zone - II

Step: 1 Target mean strength

Ḟck = fck +1.65S
S = standard deviation N/mm^2 = 5 (table -1-IS 10262)
Ḟck = target characteristic compressive strength at 28 days in N/mm^2
Fck = characteristic compressive strength at 28 days in N/mm^2
Ḟck = 30 + 1.65x5
= 38.25 N/mm^2

Step: 2 Selection of water cement ratio

From IS 10262
From table 5 IS 456 maximum w/c ratio = 0.40
Adopt w/c ratio = 0.40

This water cement ratio is to be selected both from strength consideration and maximum w/c denoted in table -5 of IS 456 and lesser of the two is to be adopted for durability requirement.

Step: 3 Selection of water content

From table -2 IS10262
Nominal maximum size of aggregates = 20mm
Maximum water content per cubic meter of concrete = 186 lit
as per IS 10262 table -4
Estimated water content for 100mm slump = 186x(6/100)+186
(3% increase for every 25mm slump over and above 50mm slump)
=197.16 kg ≈ 198kg.

In the absence of such trial, It is assumed that the efficiency of super plasticizer used as 25%

Actual water to be used = 198x0.75
= 148.5 ≈ 149kg

Step: 4 Calculation of cement content

W/c ratio = 0.40
Water used = 149kg
Cement content = w/c = 0.40
C = 149/0.40
Cement = 332.5 kg/m^3 ≈ 373 kg/m^3

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Step: 5 Calculations of C.A and F.A

From table -3-10262-2009 volume of coarse aggregates corresponding for 20mm size aggregates and fine aggregates and fine aggregate zone-II for w/c ratio = 0.50 is found out to be 0.62

In present case w/c 0.45 i.e. is less by 0.05 as the w/c is reduced it's desirable to increased C.A proportion to reduce the F.A constant.

The C.A is increased at the ratio = 0.05

(0.01/ 0.05) x 0.05 = 0.01

Volume of C.A = 0.62

= 0.62+0.01 = 0.63

Corrected proportion of volume of C.A = 0.63

Since it is angular aggregates and concrete is to be pumped the C.A can be reduce by 10%

Final volume of C.A = 0.63x0.9 = 0.567

Volume of F.A = 1- 0567 = 0.433

Step:6 Calculation of mix proportions

Volume of concrete = 1 m^3

Absolute volume of cement = (373/3.15) x (1/1000)

= $0.1184m^3$

= $0.1184m^3$

Volume of water = $0.149m^3$

Volume of chemical add mixture = ((0.7x373) / (100x1.2))x(1/1000))

= $2.17 \times 10^{-3}\ m^3$

Absolute volume of all materials expect total aggregates = 0.1184+0.198+0.0027

= $0.270m^3$

Absolute volume of total aggregates = 1- 0.270 = $0.73m^3$

Weight of C.A = 0.567x0.73x2.89x1000 = 1158.94 $kg/m^3 \approx 1159\ kg/m^3$

Weight of F.A= 0.433x0.73x2.7x1000 = 853.40 $kg/m^3 \approx 854\ kg/m^3$

Mix proportions are 1m^3 Concrete

Cement	=	373 kg/m^3
F.A	=	853 kg/m^3
C.A	=	1159 kg/m^3
Water	=	149 kg/m^3
Add mixture	=	2.71 kg/m^3

Step: 6. Actual quantities of required for the mix per bag of Cement

Cement	:	F.A	:	C.A	:	Water	:	Add mixture
373	:	853	:	1159	:	149	:	2.1
1	:	2.28	:	3.10	:	0.40	:	0.00726

6.5 Test on fresh concrete

Keeping the need in view in the present work. Only the workability tests have been conducted on fresh concrete.

The following methods give the measure of workability and have found universal acceptance owing to the simplicity of operations with and ability to detect variations in the uniformity of a mix.

1. Slump cone test
2. Compaction factor test

1. Slump cone test

This method can be employed both in the laboratory and the side of work. It is not suitable for very wet or very dry concrete. This method is suitable for medium slump. For the present work, slump tests were conducted as per IS 1199-1959 for all mixes. The largest slumps was taken from IS 456-2000.

2. Compaction factor test

This test is more suitable for concrete mixes of low workability since such dry concrete is insensitive to slump test. It works on the principle of determining the degree of compaction achieved by a fall though a standard height. The test was conducted as per IS 1199-1959

Compaction factor = (weight of partially compacted concrete) / (weight of fully compacted concrete)

On fresh concrete the tests related to workability measure are conducted as per IS specifications.

EXPERIMENTAL PROGRAM

7.1 Casting of the Specimen:

The following procedure has been adopted for casting of concrete test specimens. Aggregates, used in the concrete were soaked in water for 24 hours and dried in air to get saturated surface dry conditions so that the aggregates do not absorb the mixing water required for effective hydration. Coarse aggregates are passing through 20mm sieve and retained on 4.75mm sieve were used. Extreme care is taken to avoid of foreign matter.

Day sand is free from organ impurities; passing through 2.36mm IS sieve and retained on 150µ IS sieve was used. Bottom Ash used in partial replacement of sand in passing through 4.75mm IS sieve and retained in 150µ in Bottom Ash is used and experimental investigation was made partial replacement sand with Bottom Ash 10%, 20% and 30%.

OPC 53 grade cement used in concrete and experimental investigation was made with partial replacement cement with GGBS 10%, 20% and 30% used in concrete. It was a fresh and had uniform consistency and color. Available tap water was for both mixing of concrete and curing of cast concrete specimens. In this investigation M30 grade of concrete mix was done as per IS: 10262 – 2009.

7.2 Quantities for 1m^3 Concrete

Quantities for 1m^3 of M30 grade concrete without replacement of Cement &Sand

Cement	440 kg
Fine aggregates	775 kg
Coarse aggregates	1053
Water	198

7.2.1 Quantities for 1 Cube:

Quantities for 1 Cube with replacement of Cement & Sand

S.No	% of replacement Cement & Sand	Cement in Kg	GGBS in Kg	Sand in kg	Bottom Ash in Kg	Coarse aggregates in Kg	Water content in Kg
1	10%	1.33	0.14	2.35	0.26	3.55	0.66
2	20%	1.18	0.297	2.09	0.52	3.55	0.66
3	30%	1.03	0.44	1.83	0.78	3.55	0.66

S.No	% of replacement Cement&Sand	Cement in Kg	Fly ash in Kg	Sand in kg	Crusher dust in Kg	Coarse aggregates in Kg	Water content in Kg
1	10%	1.33	0.14	2.35	0.26	3.55	0.66
2	20%	1.18	0.297	2.09	0.52	3.55	0.66
3	30%	1.03	0.44	1.83	0.78	3.55	0.66

7.2.2 Quantities for 9 Cubes:

Quantities of 9 Cubes with replacement of Cement & Sand

S.No	% of replacement Cement & Sand	Cement in Kg	GGBS in Kg	Sand in kg	Bottom Ash in Kg	Coarse aggregates in Kg	Water content in Kg
1	10%	11.97	1.26	21.15	2.34	31.95	5.94
2	20%	10.62	2.67	18.81	4.68	31.95	5.94
3	30%	9.27	3.96	16.47	7.02	31.95	5.94

S.No	% of replacement	Cement in Kg	Fly ash in Kg	Sand in kg	Crusher dust in Kg	Coarse aggregates in Kg	Water content in Kg
1	10%	11.97	1.26	21.15	2.34	31.95	5.94
2	20%	10.62	2.67	18.81	4.68	31.95	5.94
3	30%	9.27	3.96	16.47	7.02	31.95	5.94

7.3 Batching of Materials:

The measurement of material for making concrete is known as batching. Uniformity of proportions and aggregate grading in successive batching are necessary, to ensure concrete of same quality in all batches mixed.

There are two methods of batching;

1. Volume batching
2. Weigh batching

Weigh batching is carried out in this study, as it is a more accurate process.

7.4 Mixing of Constituent Materials:

The object of mixing is to coat the surface of all aggregates particles with cement paste and to blend all the ingredients of concrete into uniform mass. Though mixing of materials is essential for the producing of concrete of uniform properties. The mixing must ensure that the mass becomes homogenous, uniform colour and consistency. Two methods are adopted for mixing concrete.

1. Hand mixing
2. Mechanical mixing

Replacement of cement with GGBS and Replacement of sand with Bottom Ash was to extents of 0%, 10%, 20%, 30% to fine aggregates.

7.5 Moulds:

The test cubes were cast in iron moulds. Thus moulds are strong enough to resist. There are made in such a manner as to facilitate the removal of the mould specimen without damage and are so machined that when it's assembled, it's ready for use to offer accurate dimensions for all specimens.

In this present work 150 mm x 150 mm x 150 mm size moulds where used for cube casting. After mixing, the uniformly mixed concrete was transformed into the mould currently assembled and properly oiled.

7.6 Preparation of test Cubes:

- Weigh the required proportions cement and standard sand of three grades and place them on a non – absorbent plate.
- Mix the ingredients in dry condition using gauging trowels. Add the measured quantity of water to the dry matrix them thoroughly applying sufficient presser till uniform consistency is achieved. Ensure the time taken for mixing shall not exceed four minutes.
- Place the entire quantity of mortar into the mould and tamp the mould using 12mm dia tamping rod by 25 times.

7.7 Compaction:

The compaction of concrete is necessary for expelling the end trapped air form the concrete. In this process of placing and mixing of concrete, air likely to get entrapped in the concrete. Thus mould filled with concrete, where tamping or vibrated on the table vibrator.

7.8 Curing:

The specimen where de-moulded after a time interval of 24 hours from commencement of casting. The remoulding specimen where transferred into a curing tank and submerged under water till the time of testing.

Cubes were cured for a time of 3, 7 days and 28 days in normal water

7.9 Compressive Strength test:

The compressive strength of concrete is generally determined by testing cubes made in laboratory or field of the various strength of concrete. The determination of compressive strength has received a large amount of attention because the concrete is primarily meant to with stand compression the cube specimen of size of 150mm x150mm x 150mm where tested for compressive strength in the C.T.M as per IS 516 - 1959.

RESULTS & DISCUSSION

8.1 Compressive Strength of Concrete for 10% replacement of Cement &Sand

8.1.1 Compressive Strength of Concrete for 3 days curing

Table 8.01 compressive strength of concrete with 10% replacement of Cement &Sand

S.No	10% replacement of Cement with GGBS & Sand with Bottom Ash (10% GGBS + 10% B.A)	Compressive Strength in N/mm^2
1.	Cube-1	14.66
2.	Cube-2	19.55
3.	Cube-3	15.11
Avg		16.44

Table.8.02 compressive strength of concrete with 10% replacement of Cement &Sand

S.No	Replacement of Cement with 10% F.A + Sand with10% C.D	Compressive Strength in N/mm^2
1.	Cube-1	18.6
2.	Cube-2	16.3
3.	Cube-3	16.4
Avg		17.2

8.1.2 Compressive Strength of Concrete for 7 days curing

Table 8.03 compressive strength of concrete with 10% replacement of Cement &Sand

S.No	10% replacement of Cement with GGBS & Sand with Bottom Ash (10% GGBS + 10% B.A)	Compressive Strength in N/mm^2
1.	Cube-1	20.44
2.	Cube-2	21.77
3.	Cube-3	22.66
Avg		21.62

Table.8.04 compressive strength of concrete with 10% replacement of Cement &Sand

S.No	Replacement of Cement with 10% F.A + Sand with10% C.D	Compressive Strength in N/mm^2
1.	Cube-1	24.88
2.	Cube-2	23.71
3.	Cube-3	22.32
Avg		23.40

8.1.3 Compressive Strength of Concrete for 28 days curing

Table 8.05 compressive strength of concrete with 10% replacement of Cement& Sand

S.No	10% replacement of Cement with GGBS & Sand with Bottom Ash (10% GGBS + 10% B.A)	Compressive Strength in N/mm^2
1.	Cube-1	39.11
2.	Cube-2	28.88
3.	Cube-3	32.00
Avg		33.33

Table.8.06 compressive strength of concrete with 10% replacement of Cement& Sand

S.No	Replacement of Cement with 10% F.A + Sand with10% C.D	Compressive Strength in N/mm^2
1.	Cube-1	31.64
2.	Cube-2	34.12
3.	Cube-3	36.45
	Avg	34.07

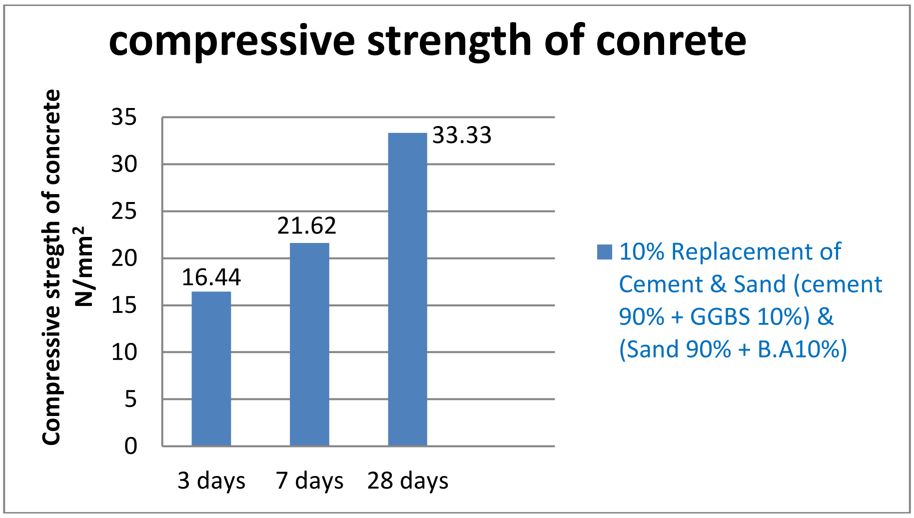

Figure 8.1 compressive strength of concrete with 10% replacement of Cement & Sand

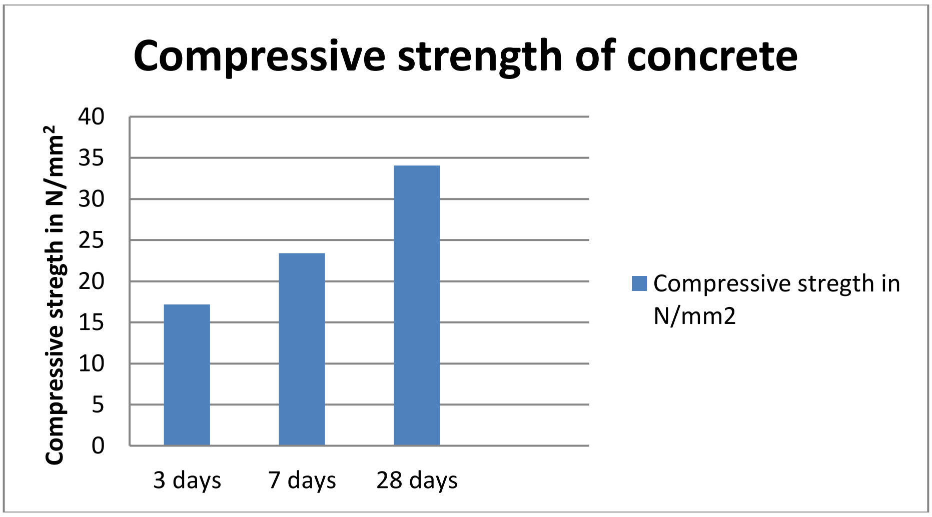

Figure.8.2 compressive strength of concrete with 10% replacement of Cement & Sand

8.2 Compressive Strength Concrete for 20% replacement of Cement &Sand

8.2.1 Compressive Strength of Concrete for 3 days curing

Table 8.07 compressive strength of concrete with 20% replacement of Cement &Sand

S.No	20% replacement of Cement with GGBS & Sand with Bottom Ash (20% GGBS + 20% B.A)	Compressive Strength in N/mm^2
1.	Cube-1	9.77
2.	Cube-2	9.77
3.	Cube-3	9.33
	Avg	9.62

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Table.8.08 compressive strength of concrete with 20% replacement of Cement &Sand

S.No	Replacement of Cement with 20% F.A + Sand with20% C.D	Compressive Strength in N/mm^2
1.	Cube-1	13.77
2.	Cube-2	14.12
3.	Cube-3	16.00
Avg		14.66

8.2.2 Compressive Strength of Concrete for 7 days curing

Table 8.09 compressive strength of concrete with 20% replacement of Cement &Sand

S.No	20% replacement of Cement with GGBS & Sand with Bottom Ash (20% GGBS + 20% B.A)	Compressive Strength in N/mm^2
1.	Cube-1	15.11
2.	Cube-2	16.00
3.	Cube-3	16.00
Avg		15.70

Table.8.10 compressive strength of concrete with 20% replacement of Cement &Sand

S.No	Replacement of Cement with 20% F.A + Sand with20% C.D	Compressive Strength in N/mm^2
1.	Cube-1	19.55
2.	Cube-2	20.00
3.	Cube-3	18.22
Avg		19.25

8.2.3 Compressive Strength of Concrete for 28 days curing

Table 8.11 compressive strength of concrete with 20% replacement of Cement &Sand

S.No	20% replacement of Cement with GGBS & Sand with Bottom Ash (20% GGBS + 20% B.A)	Compressive Strength in N/mm^2
1.	Cube-1	24.88
2.	Cube-2	24.00
3.	Cube-3	27.55
Avg		25.47

Table.8.12 compressive strength of concrete with 20% replacement of Cement &Sand

S.No	Replacement of Cement with 20% F.A + Sand with20% C.D	Compressive Strength in N/mm^2
1.	Cube-1	26.12
2.	Cube-2	28.37
3.	Cube-3	28.67
Avg		27.72

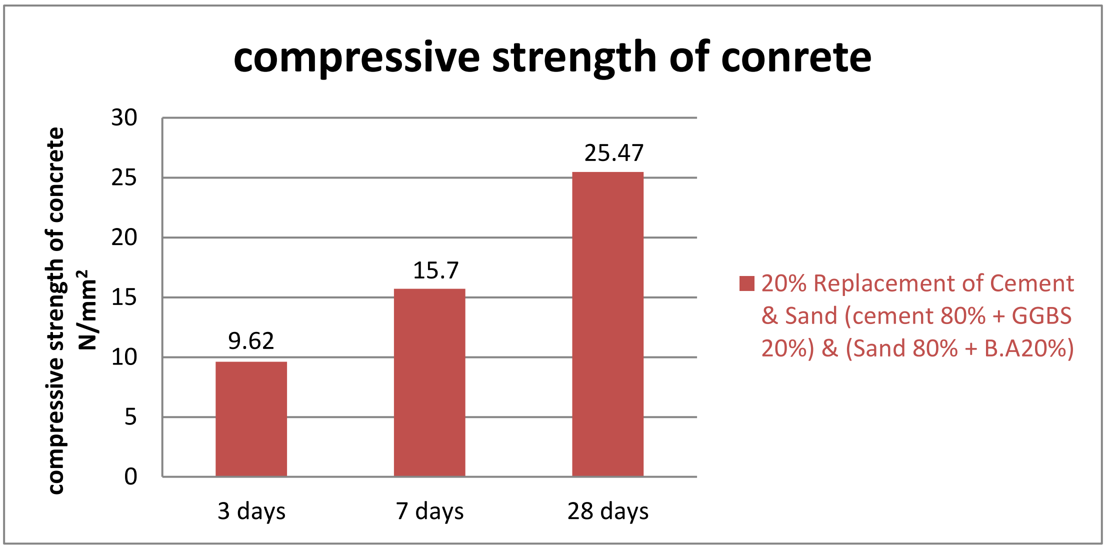

Figure 8.3 compressive strength of concrete with 20% replacement of Cement &Sand

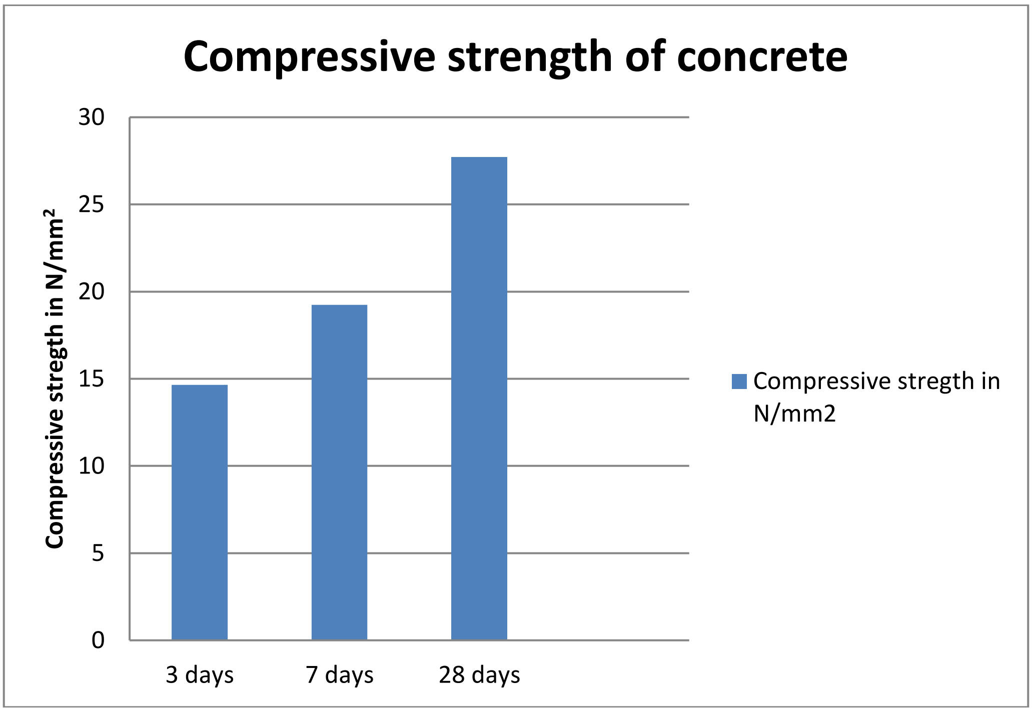

Figure.8.4 compressive strength of concrete with 20% replacement of Cement &Sand

8.3 Compressive Strength Concrete for 30% replacement of Cement &Sand

8.3.1 Compressive Strength of Concrete for 3 days curing

Table 8.13 compressive strength of concrete with 30% replacement of Cement &Sand

S.No	30% replacement of Cement with GGBS & Sand with Bottom Ash (30% GGBS + 30% B.A)	Compressive Strength in N/mm^2
1.	Cube-1	9.33
2.	Cube-2	8.88
3.	Cube-3	9.77
Avg		9.32

Table.8.14 compressive strength of concrete with 30% replacement of Cement &Sand

S.No	Replacement of Cement with 30% F.A + Sand with 30% C.D	Compressive Strength in N/mm^2
1.	Cube-1	10.33
2.	Cube-2	10.44
3.	Cube-3	10.36
Avg		10.44

8.3.2 Compressive Strength of Concrete for 7 days curing

Table 8.15 compressive strength of concrete with 30% replacement of Cement &Sand

S.No	30% replacement of Cement with GGBS & Sand with Bottom Ash (30% GGBS + 30% B.A)	Compressive Strength in N/mm^2
1.	Cube-1	10.66
2.	Cube-2	12.88
3.	Cube-3	9.33
Avg		10.95

Table.8.16 compressive strength of concrete with 30% replacement of cement and sand

S.No	Replacement of Cement with 30% F.A + Sand with30% C.D	Compressive Strength in N/mm^2
1.	Cube-1	11.55
2.	Cube-2	11.55
3.	Cube-3	11.33
Avg		11.44

8.3.3 Compressive Strength of Concrete for 28 days curing

Table 8.17 compressive strength of concrete with 30% replacement of Cement &Sand

S.No	30% replacement of Cement with GGBS & Sand with Bottom Ash (30% GGBS + 30% B.A)	Compressive Strength in N/mm^2
1.	Cube-1	14.62
.	Cube-2	19.55
3.	Cube-3	15.11
Avg		16.42

Table.8.18 compressive strength of concrete with 30% replacement of Cement &Sand

S.No	Replacement of Cement with 30% F.A + Sand with30% C.D	Compressive Strength in N/mm^2
1.	Cube-1	21.33
2.	Cube-2	19.55
3.	Cube-3	22.45
Avg		21.10

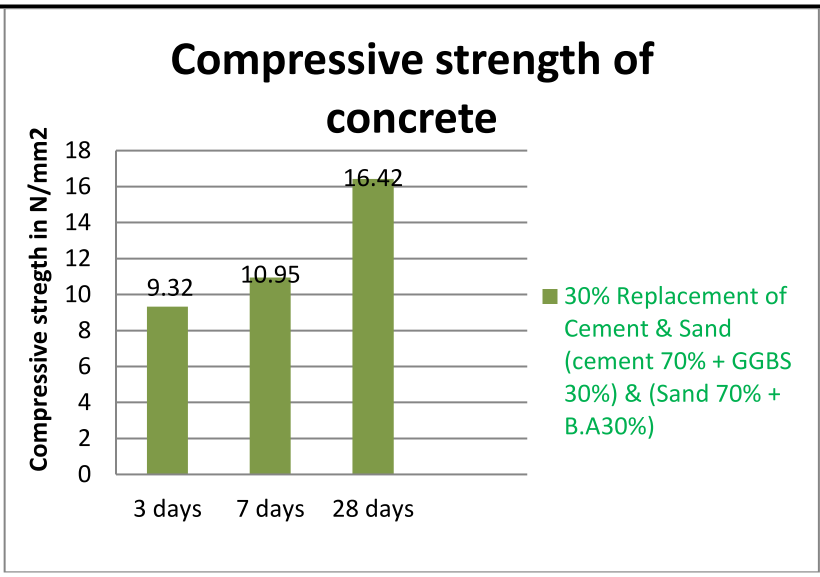

Figure 8.5 compressive strength of concrete with 30% replacement of Cement &Sand

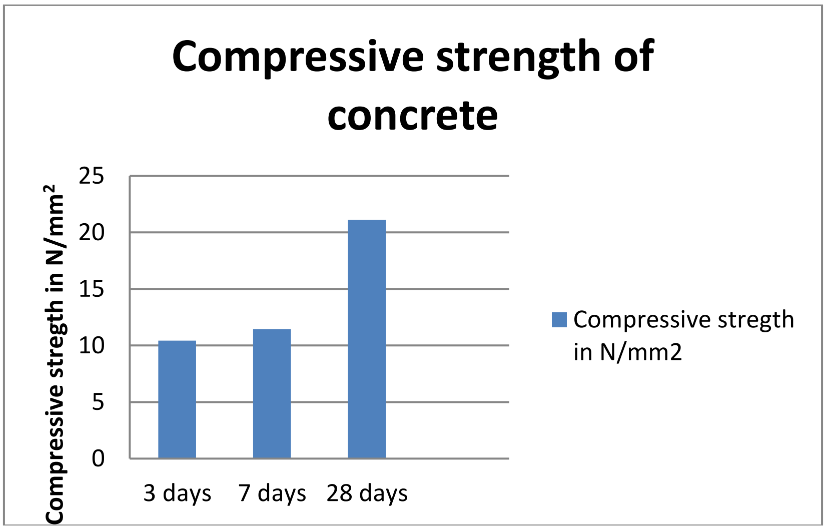

Figure.8.6 compressive strength of concrete with 30% replacement of Cement &Sand

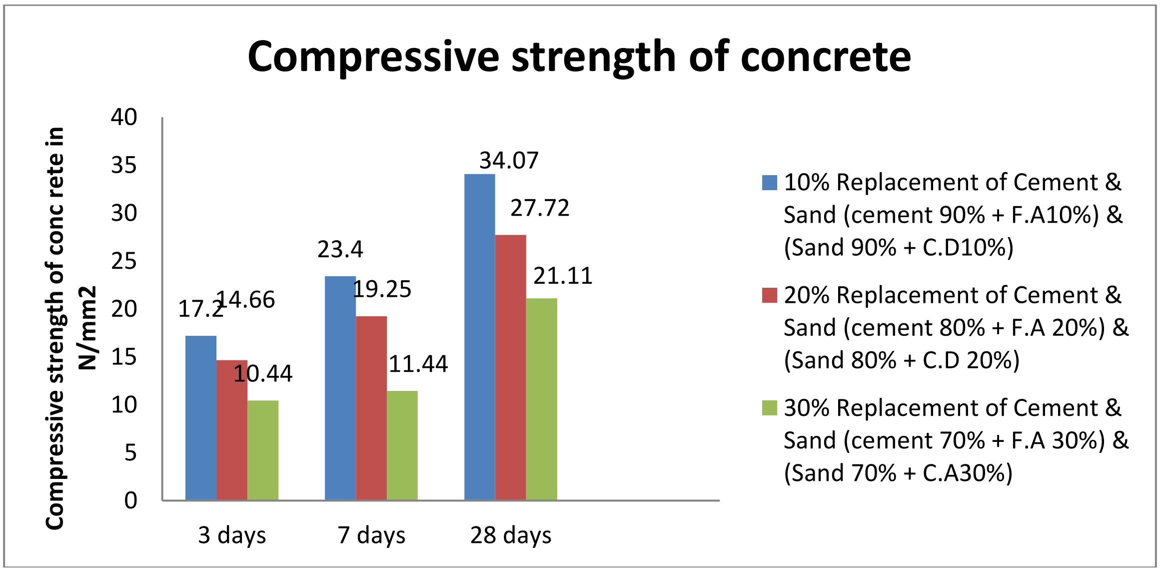

Figure.8.7 compressive strength of concrete for different % of replacement of cement with F.A and sand with C.D

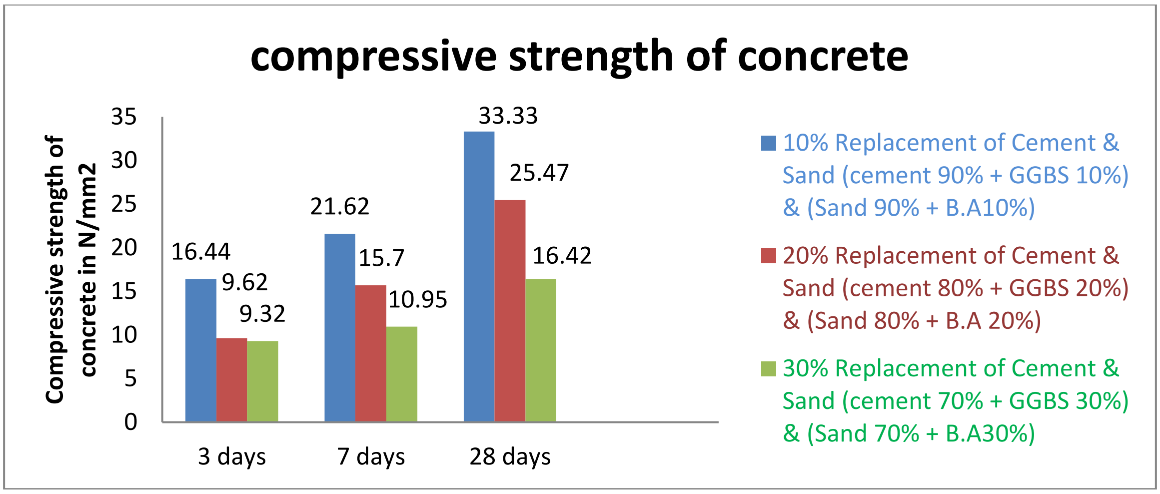

Figure 8.8 Compressive strength of concrete with different % replacements of Cement with GGBS &Sand

8.7 DISCUSSIONS

- The compressive strength of M30 grade concrete for 3, 7,and 28 days was increased up to 10% replacement of cement and sand and after that the compressive strengths were decreased from 20% to 30% replacement with adding admixture and without adding admixture.
- The compressive strength of concrete cubes casted with partial replacement of Cement with GGBS and Sand with Bottom Ash up to 10% replacement without adding admixture were comparatively increased 28days strength i.e 33.33 N/mm^2 and the compressive strength is decreased with increasing percentages of 20% and 30% replacements.
- The compressive strength of concrete cubes casted with partial replacement of Cement with GGBS and Sand with Bottom Ash up to 10% replacement with adding superplastcizer (conplast Sp 430) using in concrete were comparatively increased 28 days strength i.e 35.52 N/mm^2 and the compressive strength is decreased with increasing percentages of with 20%,30% replacements
- The usage of Bottom ash in concrete reduces workability due to the increase in water demand.
- Compressive strength of concrete with replacement of sand with bottom ash is lower than the normal concrete specimens at all the ages
- The life span of construction will be more when the usage of GGBS for the construction. So the usage of GGBS for the construction purpose will be economical and safe.
- The compressive strength M30 grade of concrete for 3, 7,and 28 days was increased up to 10% replacement and after that compressive strengths were decreased from 20% to 30% replacement with adding admixture and without adding admixture.
- The compressive strength of concrete is increased 34.07 N/mm^2 when the usage of 10% replacement of cement and sand with F.A and C.D respectively without using any admixture
- The compressive strength of concrete is increased 37.37 N/mm^2 when the usage of 10% replacement of cement and sand with F.A and C.D respectively with using admixture
- The workability of Crusher dust in concrete reduces with the increase in Crusher dust content due to the increase in water demand.
- Compressive strength of sand replaced Crusher dust concrete will be lower than normal concrete specimens at all the ages

CONCLUSION

In this present study from the experimental results we obtain the following conclusions

- The usage of concrete for 10% replacement of cement with GGBS and Sand with Bottom Ash is economical for the construction purpose when we consider the compressive strength only.
- 10% of replacement of cement and sand will be economical and safe in the concrete for the construction purpose when we consider the compressive strength only.

- The present study concluded that fly ash ,GGBS crusher dust ,Bottom ash can be replaced in concrete is the optimum amount to get favourable strength, saving in environment and reducing the cost.

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