Performance of Concrete Mixes Containing Fly Ash

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Abstract- *Infrastructure growth or construction activity is the very important aspect all over the world today. For developing Country economy is the main factor, therefore for the construction industries, it is big challenge to minimize the construction cost and to increase the performance of structural concrete without losing its original properties. Fly ash is one of the best replacement in concrete production as industrial by-product from the combustion of lignite in the thermal power plants.*

Concrete is an essential component of the national and international infrastructure. Concrete is made by blending sand with crushed stone or gravel and binding them together in a paste made with water and the manufactured powder known as Portland cement. In recent years, the cement and concrete industries have been effective in reducing both the energy required and the CO2 released in the production of Portland cement. One of the most powerful strategies for reducing the embodied energy and CO2 footprint of cement and concrete is the substitution of coal fly ash (also known as fly ash, coal combustion residuals, and/or coal combustion products.) For over 50 years it has been shown that a reduction in the amount of cement required to produce concrete can be achieved by substituting coal fly ash for a significant portion of the Portland cement. The resulting concrete not only has a lower embodied energy and CO2 footprint, but also has improved properties leading to a more durable, longer lasting infrastructure. Fly ash is widely used in concrete production and in this manner an industrial waste product is converted to a valuable resource.

Keywords- Fly ash 1, Aggrgate 2,Sand 3, Concrete 4,

I. INTRODUCTION

STUDY OF MATERIAL

As The project "Study of Concrete mix containing Fly Ash of different fineness" is an innovative concept in civil engineering. In construction industries civil engineers are always interested in long term performance of construction materials by using Ordinary Portland Cement and fly ash for making concrete.

MATERIAL AND EQUIPMENT REQUIRED

The materials given below are use for concrete:

MATERIALS

1) Ordinary Portland Cement :- L&T 43 grade was used for concrete.
2) Fly Ash: Collected From Khaparkheda Thermal Power Station, Nagpur.
3) Water
4) Aggregate
5) Concrete

4.1 Cement

Strength/grade of cement: Grade of cement e.g. 43 grade or 53 grade can influence the mix design. Grade of cement indicates minimum strength of cement in N/mm2 tested as per standard conditions laid down by IS codes (OPC 43 grade – IS 8112-1989, OPC 53 grade – IS 12269 – 1987 e.g. a 43 grade cement should give minimum strength of 43 N/mm2 at 28 days). Higher the strength of cement, higher is the strength of concrete for the same water/cement ratio. In other words a higher strength of cement permits use of higher water/cement ratio to achieve the same strength of concrete. Finding the 28 days strengths of cement consumes time. It is not practical in many cases to wait for 28 days strength of cement to start the mix design. In such cases 28 days strength reports of the manufacturers may be used and can be supplemented by accelerated strength of cement found by reference mix method given in IS 10262 Apart from strength of cement, the type of cement e.g. Ordinary Portland Cement, pozzolona cement (blended cement) etc, is also important factor affecting the gain of strength. Blended cements achieve strengths later than Ordinary Portland Cements and require extended curing period. However, use of thes cements result in more durable concrete by offering greater resistance to sulphate and chloride attacks.

Fly Ash

Fly ash is the most commonly used pozzolona with cement. A Pozzolana is essentially a silicious material, which in itself -possessing no cementations properties, will in finely divided form and in presence of water react with calcium

hydroxide at ordinary temperature to form compounds possessing cementitious properties. The hydration of cement is an exothermic reaction resulting in formation of gel (binding material) & calcium hydroxide (free lime).

Fly ash is one of the residues generated in combustion and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In An industrial context , fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captures by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal –fired power plants, and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (Sio2) and calcium oxide (Cao) , both being endemic ingredients in many coal- bearing rock strata.

The reactive silica present in fly ash converts free lime into calcium silicate hydrates, which is insoluble in water and possesses cementitious properties. It leads to further gain of strength at later ages in concrete. **The IS allows upto 35% replacement of cement by fly ash**. The fly ash particles are spherical (which is advantageous from the water requirement point of view) and are of least the same fineness as cement (although with fewer fine particles) so that the silica is readily available for reaction.

Two classes of fly ash are defined 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. The Chemical properties of the fly ash are largely influenced by the chemical content of the coal burned i.e anthracite , bituminous and lignite Not all fly ashes meet ASTM C618 requirement , although depending on the application ,this may not be necessary. Ash used as a cement replacement must meet strict construction standards, but no standard environmental regulation have been established in the United states. 75% of the ash must have a fineness of 45um or less, and have a carbon content, measured by the loss on ignition (LOI) ,of less than 4%. In the U.S. ,LOI needs to be under 6%.The particle size distribution of raw fly ash is very often fluctuating constantly, due to changing performance of the coal mills and the boiler performance. This makes it necessary that, fly ash is used in an optimal way to replace cement in concrete production, it needs to be processed using beneficiation methods like mechanical air classification. But if fly ash is used also as a filler to replace sand in concrete production, unbeneficiated fly ash with higher LOI can be also used. Especially important is the ongoing quality verification. This is mainly expressed by quality control seals like the Bureau Of Indian Standards mark or the DCL mark of the Dubai Municipality

II. MIX DESIGN

Concrete Mix Design:

Concrete is the basic engineering material used in most of the civil engineering structures. Its popularity as basic building material in construction is because of, its economy of use, good durability and ease with which it can be manufactured at site. The ability to mould it into any shape and size, because of its plasticity in green stage and its subsequent hardening to achieve strength, is particularly useful. Concrete like other engineering materials needs to be designed for properties like strength, durability, workability and cohesion. Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way. With advent of high-rise buildings and pre-stressed concrete, use of higher grades of concrete is becoming more common. Even the revised IS 456-2000 advocates use of higher grade of concrete for more severe conditions of exposure, for durability considerations. With advent of new generation admixtures, it is possible to achieve higher grades of concrete with high workability levels economically. Use of mineral admixtures like fly ash, slag, meta kaolin and silica fume have revolutionized the concrete technology by increasing strength and durability of concrete by many folds. Mix design of concrete is becoming more relevant in the above-mentioned scenario. However, it should be borne in mind that mix design when adopted at site should be implemented with proper understanding and with necessary precautions.

Advantages of mix design

Mix design aims to achieve good quality concrete at site economically.

I. Quality concrete means

- Better strength
- Better imperviousness and durability
- Dense and homogeneous concrete

II. Economy

a) Economy in cement consumption

It is possible to save up to 15% of cement for M20 grade of concrete with the help of concrete mix design.

In fact higher the grade of concrete more are the savings. Lower cement content also results in lower heat of hydration and hence reduces shrinkage cracks.

b) Best use of available materials:

Site conditions often restrict the quality and quantity of ingredient materials. Concrete mix design offers a lot of flexibility on type of aggregates to be used in mix design. Mix design can give an economical solution based on the available materials if they meet the basic IS requirements. This can lead to saving in transportation costs from longer distances.

c) Other properties:

Mix design can help us to achieve form finishes, high early strengths for early deshuttering, concrete with better flexural strengths, concrete with pumpability and concrete with lower densities.

Factor Influencing The Choice of Mix Proportions:

Concrete is an extremely versatile building material because, it can be designed for strength ranging from M10 (10Mpa) to M100 (100 Mpa) and workability ranging from 0 mm slump to 150 mm slump. In all these cases the basic ingredients of concrete are the same, but it is their relative proportioning that makes the difference.

Basic Ingredients of Concrete: -

1. Cement – It is the basic binding material in concrete.
2. Water – It hydrates cement and also makes concrete workable.
3. Coarse Aggregate – It is the basic building component of concrete.
4. Fine Aggregate – Along with cement paste it forms mortar grout and fills the voids
in the coarse aggregates.
5. Admixtures – They enhance certain properties of concrete e.g. gain of strength,
workability, setting properties, imperviousness etc Concrete needs to be designed for certain properties in the plastic stage as well as in thehardened stage.

Properties desired from concrete in plastic stage: -

• Workability
• Cohesiveness
• Initial set retardation

Properties desired from concrete in hardened stage: -

• Strength
• Imperviousness
• Durability

Concrete mix design is the method of correct proportioning of ingredients of concrete, in order to optimise the above properties of concrete as per site requirements. In other words, we determine the relative proportions of ingredients of concrete to achieve desired strength & workability in a most economical way.

Compressive Strength:

The usual primary requirement of good concrete is a satisfactory compressive strength in its hardened state. Many of the desirable properties like durability, impermeability, and aberration resistance are highly influenced by the strength of concrete. For purpose of mix design, the strength of concrete can be considered slowly dependent on the water cement ratio for low and medium strength concrete mixes. In the case of high strength concrete mixes, the aggregate cement ratio workability of the mix and the type and maximum size of aggregate influence the selection of water cement ratio for a desired of concrete.

Workability:

The workability of concrete mix is mainly determined to suit the type of construction, placing condition and the means of compaction available at the site. The properties of fresh concrete, amount and condition of reinforcement and the shape and size of mould are important factor, which control workability. For heavily reinforced section, more workable concrete should be used than in massive condition. The main factor affecting workability is the water content in the mix. Other parameter influencing workability is the maximum size of aggregate, its grading, texture and shape and the mix proportions.

Type, Size and Grading of Aggregate:

Good concrete can be made by using different types of aggregate like rounded and irregular gravel and crushed rock, which is mostly angular in shape. The maximum nominal size of aggregate to be selected for a particular job depends upon the width of section and the spacing of reinforcement. According to the Indian standard code of practice IS: 456, the maximum size of aggregate is restricted to 5mm less than the minimum clear distance between the main bars for heavily reinforced concrete member such as ribs

of main beams. It is generally advantageous to use as large as a maximum size of aggregate as possible.

The grading of aggregate is a major factor, influencing the workability of concrete mix. The grading of the aggregates should be such as to ensure that the voids between the larger aggregates are filled with smaller fractions and mortar so as to achieve maximum density and strength. The coarser and finer fractions of aggregates available at site can be suitably combined to obtain the desired standard grading, it is important to note that good concrete can be made by using gap graded or continuously graded aggregate within a permissible limiting range.

Aggregate / Cement Ratio:

The various factors involved in selecting the aggregate/cement ratio of a mix are, the desired workability, size, shape, texture and overall grading of the aggregates. The choice of the aggregate/cement ratio is generally made from charts or tables prepared from comprehensive laboratory investigations. It is also possible to reduce the combined grading curve to a numerical value in terms of the specific surface or fineness modulus, and then the workability can be linked mathematically by an equation or graphically by a series of curve to the aggregate/cement ratio, the water cement ratio and the angularity.

The aggregate/cement ratio affects the strength of concrete in the high strength range to a significant degree and this is one of the reasons for considering the design of high strength concretes separately. It is important to note that mixes with very low water/cement and aggregate/cement ratio, having an extremely high cement content of the order of450 to 550 Kg/m3, exhibit retrogression of strength, especially when large size aggregate are used. The reduction of strength is attributed to the loss of aggregate - cement bond due to stress induced by shrinkage. For a constant cement ratio, a leaner mix leads to a higher strength according to the inventions of Singh. This pattern of behavior due to the absorption of water by aggregates leading to reduction in the effective water cement ratio mix.

Generalized Format Of Concrete Mix Design :

The various method of mix proportioning generally used for the design of ordinary concrete are all based on the relation between strength and water/cement ratio as well as on the relation between workability, water/cement and aggregate/cement ratios. The basic factor influencing the sequential decision to be made in the coarse of mix design are complied in the flow chart shown *in* fig. In view of large number of variables, involved in the design of a concrete mix, trail mixes are invariably made using the designed proportions of ingredients. The desired properties of the trial mixes are checked and suitable adjustments are made and the process repeated until a satisfactory mix suitable for a particular job is obtained. Mix design methods being mostly empirical, minor variations exist in the process of selecting the mix proportions to using different methods. The widely used American concrete institute method and the procedure recommended in road note no. 4 differ especially in the estimation of water content in the mix. In the design of mixes based on surface and angularity factors, the water/cement ratio is first fixed on the basis of desired strength while the aggregate cement ratio is estimated using the aggregate properties, workability and the water content in the mix.

Objectives of Mix Design:

Following are the objectives of Mixed Design

- To achieve a specified characteristic compressive strength of 28 days period. (of cube)
- To achieve the specified workability.
- To have sufficient durability.
- To have desired strength in hardened stage.
- To have the economy as much as possible.
- To have satisfactory appearance.
- To comply with certain other specified properties and not to have certain drawbacks such as honey combing and segregation etc.

Methods of Proportioning (Mix. Design):

Following are the methods which are used for proportioning.

- Arbitrary Proportions Method.
- Maximum Density Method.
- Fineness Modulus Method.
- Surface Area Method.
- ACI Committee Method.
- Road No.4 Method.
- IRC-44 Method.
- High Strength Concrete Mix Design Method.
- Method based on Flexural Strength.
- Indian Standard Method.
- Trial Method.

III. CONCLUSIONS

The project achievements are as follows:

- Compressive strength increases with the increase in the percentage of Fly ash up to replacement 37.50% FA of Cement in Concrete for different mix proportions.
- In this project, the review and research of current usage of Fly Ash in the concrete for different sectors is studied, such as for constructions, industries, applications, previous research and investigation are done..
- In this project, Fineness of Fly Ash is Studied.
- As we increase percentage of Fly Ash Slump goes on decreasing.
- The maximum 90 days compressive strength was obtained with 25 % fly ash replacement.

Present work is aimed at developing predictive tool with respect to normal density aggregate and normal weight concrete. However, the work can be extended to the concrete of light weight and heavy density. In the presented work many factors are considered, which are believed to affect strength of concrete.

- If we increase percentage of Fly Ash Compressive Strength goes on decreasing.
- As Fly Ash is easily available, We can use it as partial replacement in concrete as compare to other recourses.
- As the fineness of Fly Ash increases, Compressive Strength goes on increasing..
- To investigate the fineness of fly ash of various hopper.
- compressive strength for M20, M25 and M30 grade concrete for 7 days,28 days and 90 days is obtained and the results is comp aired with conventional concrete, it shows Compressive Strength goes on increasing fineness to hopper no. 5 with P.R. F.A. 25.00%.
- The above results shown the density of such concrete increases, with the fineness of Fly Ash its density goes on decreasing and vis-versa.
- The workability of concrete considerably reduced as the amount of Fly Ash increased. From this project, we can concluded that the Fly Ash concrete can be used in the infrastructures work, for compressive strength up to 30MPa.

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