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An Experimental Investigation on Mechanical Properties of High Strength Performance Concrete using GGBS and Alccofine

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Abstract: *The necessity of high performance concrete is increasing because of the increasing demand of the construction materials in the construction industry. Efforts for improving the performance of concrete over the past few years suggest that cement replacement materials along with Mineral & chemical admixtures can improve the strength and durability characteristics of concrete. This project is an attempt to study the behaviour of Alccofine 1203 (5%, 6%, 7%, 8% and 10% replacement by weight of cement) along with Fly Ash (15%) and GGBS (15%) replacement on fresh & hard property of concrete. As well as optimizing the percentage dosage of chemical admixture to achieve required retention period (up to 3hrs) and workability (Slump and Flow) to increase the productivity of concrete design. This paper also studies the effectiveness of applying value engineering to actual concrete mixtures. The application of value engineering to such concrete mixtures results in increase in performance, optimizing the mix by adding appropriate dosage of admixtures so as to work in different situation and increase its value, increase in durability of structure in which concrete will be used, reduction in cost of concrete and overall cost of construction projects, increasing the market share and competitiveness of concrete producers. This research shows that applying the methodology of value engineering to readymixed concrete is an effective way to save around 7.5-8.5 % of the total cost of concrete mixtures supplied to construction projects..*

Keywords: GGBS and Alccofine

I. INTRODUCTION

High performance concrete is a concrete mixture, which possess high durability and high strength when compared to conventional concrete. This concrete contains one or more of cementious materials such as fly ash, Silica fume or ground granulated blast furnace slag and usually a super plasticizer. The term 'high performance' is somewhat pretentious because the essential feature of this concrete is that it's ingredients and proportions are specifically chosen so as to have particularly appropriate properties for the expected use of the structure SUCH as high strength and low permeability. Hence High performance concrete is not a special type of concrete. It comprises of the same materials as that of the conventional cement concrete. The use of some mineral and chemical admixtures like Silica fume and Super plasticizer enhance the strength, durability and workability qualities to a very high extent.

High Performance concrete works out to be economical, even though it's initial cost is higher than that of conventional concrete because the use of High Performance concrete in construction enhances the service life of the structure and the structure suffers less damage which would reduce overall costs.

Concrete is a durable and versatile construction material. It is not only strong, economical and takes the shape of the form in which it is placed, but it is also aesthetically satisfying. However experience has shown that concrete is vulnerable to deterioration, unless precautionary measures are taken during the design and production. For this we need to understand the influence of components on the behavior of concrete and to produce a concrete mix within closely controlled tolerances.

The conventional Portland cement concrete is found deficient in respect of :

- Durability in severe environs (shorter service life and frequent maintenance)
- Time of construction (slower gain of strength)
- Energy absorption capacity (for earthquake resistant structures)
- Repair and retrofitting jobs.

Hence it has been increasingly realized that besides strength, there are other equally important criteria such as durability, workability and toughness. And hence we talk about 'High performance concrete' where performance requirements can be different than high strength and can vary from application to application.

High Performance Concrete can be designed to give optimized performance characteristics for a given set of load, usage and exposure conditions consistent with the requirements of cost, service life and durability. The high performance concrete does not require special ingredients or special equipments except careful design and production. High performance concrete has several advantages like improved durability characteristics and much lesser micro cracking than normal strength concrete.

Any concrete which satisfies certain criteria proposed to overcome limitations of conventional concretes may be called High Performance Concrete. It may include concrete, which provides either substantially improved resistance to environmental influences or substantially increased structural capacity while maintaining adequate durability. It may also include concrete, which significantly reduces construction time to permit rapid opening or reopening of roads to traffic, without compromising long-term servicibility. Therefore it is not possible to provide a unique definition of High Performance Concrete without considering the performance requirements of the intended use of the concrete.

American Concrete Institute defines High Performance Concrete as

"A concrete which meets special performance and uniformity requirements that cannot always be achieved routinely by using only conventional materials and normal mixing, placing and curing practices". The requirements may involve enhancements of characteristics such as placement and compaction without segregation, long-term mechanical properties, and early age strength or service life in severe environments. Concretes possessing many of these characteristics often achieve High Strength, but High Strength concrete may not necessarily be of High Performance .A classification of High Performance Concrete related to strength is shown below.

II. SELECTION OF MATERIALS:

The production of High Performance Concrete involves the following three important interrelated steps:

- Selection of suitable ingredients for concrete having the desired rheological properties, strength etc
- Determination of relative quantities of the ingredients in order to produce durability.
- Careful quality control of every phase of the concrete making process

III. OBJECTIVES

- To put the concrete in to service at much earlier age ,for example opening the pavement at 3 days.
- To build high-rise buildings by reducing column sizes and increasing available space.
- To build the space super structure of long span bridges and to enhance the durability of bridge decks.
- To satisfy the specific needs of special applications- such as durability , modulus of elasticity and flexural strength. Some of these applications includes dams, grandstand roofs, marine foundation, parking garages and heavy industrial floors.

IV. MATERIALS

4.1 Cement

Physical and chemical characteristics of cement play a vital role in developing strength and controlling rheology of fresh concrete. Fineness affects water requirements for consistency. When looking for cement to be used in High Performance Concrete one should choose cement containing as little C_3A as possible because the lower amount of C_3A, the easier to control the rheology and lesser the problems of cement-super plasticizer compatibility. Finally from strength point of view, this cement should be finally ground and contain a fair amount of C_3S.

4.2 Fine Aggregate

Both river sand and crushed stones may be used. Coarser sand may be preferred as finer sand increases the water demand of concrete and very fine sand may not be essential in High Performance Concrete as it usually has larger content of fine particles in the form of cement and mineral admixtures such as fly ash, etc. The sand particles should also pack to give minimum void ratio as the test results show that higher void content leads to requirement of more mixing water.

4.3 Coarse Aggregate

The coarse aggregate is the strongest and least porous component of concrete. Coarse aggregate in cement concrete contributes to the heterogeneity of the cement concrete and there is weak interface between cement matrix and aggregate surface in cement concrete. This results in lower strength of cement concrete by restricting the maximum size of aggregate and also by making the transition zone stronger. By usage of mineral admixtures, the cement concrete becomes more homogeneous and there is marked enhancement in the strength properties as well as durability characteristics of concrete. The strength of High Performance Concrete may be controlled by the strength of the coarse aggregate, which is not normally the case with the conventional cement concrete. Hence, the selection of coarse aggregate would be an important step in High Performance Concrete design mix.

4.4 Water

Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement. The strength of cement concrete comes mainly from the binding action of the hydrated cement gel. The requirement of water should be reduced to that required for chemical reaction of unhydrated cement as the excess water would end up in only formation of undesirable voids in the hardened cement paste in concrete. From High Performance Concrete mix design considerations, it is important to have the compatibility between the given cement and the chemical/mineral admixtures along with the water used for mixing.

4.5 Mineral Admixture

Mineral admixtures are fine powders mainly composed of silicate glasses or non crystalline silica which in the presence of moisture, calcium and hydroxyl ions, slowly hydrate to form cementing products. The most commonly used mineral admixtures in our country are Flyash and GGBS. For higher grade of mix, Alccofine 1203 is most accepted by various concrete producers. Mostly these admixtures are used in range of 5 – 50% replacement with cement.

4.6 Fly-Ash

Pozzolans are mainly a type of siliceous or siliceous and aluminous material, which in a finely disintegrated form and it reacts with calcium in the presence of water molecules. Indian standards for using fly ash are IS 3812 Part I and Part II. Flyash was used to replace 15% by weight of cement.

4.7 GGBS

It is a by-product of the iron manufacturing industry. Its production requires less energy as compared with the energy needed for the production of the Portland cement. The replacement of the Portland cement will lead to significant reduction in carbon dioxide gas emission. Indian standards for using GGBS are IS 12089. GGBS was used to replace 15% by weight of cement.

4.8 Alccofine1203

Alccofine-1203 is a new generation micro fine concrete producing material and which is important in respect of workability as well as strength. It lowers water binder ratio, improves packing density of concrete paste and also increases strength in compression and flexure. It possesses 10% strength as compared to cement and with addition to it improves strength of concrete to a great extent

V. LITERATURE REVIEW

The technique of the production of polymer-based concretes along with the replacement of cement by metakaolin is the main objective of this literature survey. The present investigation aims in finding the gaps in the literature in terms of effective utilization of natural rubber latex modified metakaolin incorporated High Performance concrete (NRLMKHPC). The importance and the advantage of HPC has gained popularity among the architects and engineers in the present days in the construction of multistory buildings, roads, bridges, airports, nuclear power plants and in the construction of dams. For such constructions high performance concrete is essential and hence the production of HPC has gained popularity due to strength and durability properties like resistance against frost, chloride attack, impermeability and thermal cracking. The conventional concrete which posses compressive strength of 40 MPa and less is not suitable for construction of high-rise buildings. In such circumstances, high performance concrete is preferred and hence the use of high performance concrete has become essential.

High performance concrete produced for industrial application is likely to vary and hence the identification of HPC will vary based on w/c ratio, strength and durability characteristics. High performance concrete containing mineral admixtures and polymers posses high strength compared to plain high performance concrete. In this present investigation, it has been planned to carry out the production of high performance concrete containing polymers, mineral admixtures and superplasticisers .The polymers (elastomers) used in this investigation is Natural Rubber Latex, metakaolin the mineral admixture. For better understanding and application of high performance concrete containing natural rubber latex and metakaolin there is a need to conduct literature research review regarding the properties of high performance concrete. The aim of the present investigation is todevelop the polymer-modified concrete resulting in producing high strength and durability characteristics. To produce the HPC in this investigation a low water binder ratios are adopted. The natural rubber latex with variation in percentages has been made use and the metakaolin is proposed in different percentages by weights. The workability properties, the mechanical properties such as compressive strength, flexure strength, split tensile strength and the durability properties have been presented.

Literature Review on Strength and Durability Properties

- S. Kavitha and T. Felix Kala (2016) have explained about the use of alccofine within the SCC as strength properties with increase in the strength enhancer. They found the improvement in alccofine dosage and the results of their investigation proved that alccofine can be used as a strength enhancer within the SCC.
- D. Sharma, S. Sharma and Ajay. G (2016) conducted experimental investigation about the strength improvement of concrete using foundry slag as an alternative for conventional fine aggregate and alccofine as substitute for cement.
- They concluded that reasonably high strength concrete can be achieved by means of substituting fine aggregate with 10% to 45% of foundry slag and replacement of cement with 15% of alccofine.
- M. V. Sekhar Reddy, k. A. Latha and k. Surendra (2016) had done experimental work on partical replacement of cement with fly ash and alccofine for M40 Grade concrete. The fly ash and alccofine are replaced at 5%, 10%, 15%, 20% with cement. The conclusion summarizes that the addition of alccofine indicates an early strength gaining capacity and is ecofriendly to nature. Alccofine showed greater results then compared with fly ash in long term Strength Properties.
- K. Gayathri, K. R. chandran and J. Saravanan (2016) performed research on performance of alccofine replacing the cement in concrete at 5%, 10%, 15% and 20%. It is found that 15% replacement of cement by alccofine is yielding good strength when compared to other percentages and also alccofine increases the cementing efficiency at earlier ages of concrete.
- M. Y. Patel, Darji and Purohit (2015) conducted experimental investigation on overall performance of compression test on concrete mix at 28 and 56 days. They concluded that concrete with combination of alccofine and glass powder gives higher compressive strength. The maximum strength was attained by replacing cement by 10% alccofine and 30% glass powder.
- S. M. Zubair and S.S. Jamkar (2015) conducted research which involves the use of Fly ash, Alccofine and Silica fume at different proportions to enhance the compressive strength of high performance concrete. They

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conducted experimental investigation by 10% fly ash along with 17% of alccofine and 10% fly ash along with 17% of silica fume by weight of cementitious binder s a partical replacement of cement. They concluded that alccofine performs better than that of silica fume together with fly ash in fresh and harden stages of concrete.

- D. S. kumar, T. H. latha, N. S. Sri, T. Shobana and C. Soundarya (2015) conducted studies on the performance of M 50 grade concrete with partically replacing cement with alccfine at 10 % by weight. The mechanical & durability examinations were conducted and found that the strength attained by the use of 10% alccofine showed greater to that of the nominal mix with 7 day and 28 days curing and the durability of the alccofine concrete is relatively higher than that of nominal mix

VI. PROPERTIES OF CONCRETE

Properties of concrete are influenced by many factors mainly due to mix proportion of cement, sand, aggregates and water. Ratio of these materials control the various concrete properties which are discussed below.

1. Grades (M20, M25, M30 etc.)
2. Compressive strength
3. Characteristic Strength
4. Tensile strength
5. Durability
6. Creep
7. Shrinkage
8. Unit weight
9. Modular Ratio
10. Poisson's ratio

Grades of Concrete

Concrete is known by its grade which is designated as M15, M20 etc. in which letter M refers to concrete mix and number 15, 20 denotes the specified compressive strength (fck) of 150mm cube at 28 days, expressed in N/mm2.
Thus, concrete is known by its compressive strength. M20 and M25 are the most common grades of concrete, and higher grades of concrete should be used for severe, very severe and extreme environments.

Compressive Strength of Concrete

Like load, the strength of the concrete is also a quality which varies considerably for the same concrete mix. Therefore, a single representative value, known as characteristic strength is used.

Characteristic Strength of Concrete:

It is defined as the value of the strength below which not more then 5% of the test results are expected to fall (i.e. there is 95% probability of achieving this value only 5% of not achieving the same)

Design Strength (fd) and Partial Safety Factor for Material Strength

The strength to be taken for the purpose of design is known is known as design strength and is given by
Design strength (fd) = characteristic strength/ partial safety factor for material strength
The value of partial safety factor depends upon the type of material and upon the type of limit state. According to IS code, partial safety factor is taken as 1.5 for concrete and 1.15 for steel
Design strength of concrete in member = 0.45fck

Tensile Strength of Concrete

The estimate of flexural tensile strength or the modulus of rupture or the cracking strength of concrete from cube compressive strength is obtained by the relations fcr = 0.7 fck N/mm2. The tensile strength of concrete in direct tension is obtained experimentally by split cylinder. It varies between 1/8 to 1/12 of cube compressive strength.

Creep in Concrete

Creep is defined as the plastic deformation under sustained load. Creep strain depends primarily on the duration of sustained loading. According to the code, the value of the ultimate creep coefficient is taken as 1.6 at 28 days of loading.

Shrinkage of Concrete

The property of diminishing in volume during the process of drying and hardening is termed Shrinkage. It depends mainly on the duration of exposure. If this strain is prevented, it produces tensile stress in the concrete and hence concrete develops cracks.

Modular Ratio

Short term modular ratio is the modulus of elasticity of steel to the modulus of elasticity of concrete.
Short term modular ratio = Es / Ec
Es = modulus of elasticity of steel (2 x 10 5 N/mm2)
Ec = modulus of elasticity of concrete (5000 x SQRT(fck) N/mm2)
As the modulus of elasticity of concrete changes with time, age at loading etc the modular ratio also changes accordingly. Taking into account the effects of creep and shrinkage partially IS code gives the following expression for the long term modular ratio.
Long term modular ratio (m) = 280/ (3fcbc)
Where, fcbc = permissible compressive stress due to bending in concrete in N/mm2

VII. EXPERIMENTAL INVESTIGATION

7.1 Properties of Cement

A. Cement

CEMENT is a material with adhesive & cohesive properties. Cement, when mixed with mineral fragments & water, binds the particles into a compact whole, this description includes a large number of cementing materials. For the purpose of construction works, the cement is used to bind stones, sand, bricks, etc. Our study is limited to cement used for construction works, particularly for concrete work.
Cement is the most important and costly as ingredient of all great. Joseph Aspadin of U.K. invented it in 1924. He named it Portland cement because the hardened concrete made out of cement, fine Aggregates, coarse Aggregate and water in definite proportions resembled the natural stone occurring at Portland in England. The materials, which set & harden in the presence of water are said to possess, hydraulic properties. As cement gets strength due to chemical action between cement and water (known as hydration) and its ability to harden underwater, it is also known as hydraulic cement.
Portland cement is manufactured by grinding together calcareous (limestone or chalk) and argillaceous (shale or clay) in dry or wet condition. The mixture is burnt in a kiln
to 13000 – 15000 C where it sinters and produces small clinkers. Clinkers (of nodular shape) are called and mixed with above 2% gypsum to avoid flash setting (to delay the chemical action when water is added). The mixture is ground to required fineness in ball mills to get the finer product as cement. One bag of cement masses to 50 kg is equivalent to 34.5 liters (1440kg/m3).

VIII. METHODOLOGY

8.1 MIX DESIGN: Introduction

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depends upon many factors, e.g. quality and quantity of cement, water and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate, thus the aim is to produce as lean a mix as possible. From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.

The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt that the quality control adds to the cost of concrete. The extent of quality control is often an economic compromise, and depends on the size and type of job. The cost of labour depends on the workability of mix, e.g., a concrete mix of inadequate workability may result in a high cost of labour to obtain a degree of compaction with available equipment.

Requirements of Concrete Mix Design

The requirements which form the basis of selection and proportioning of mix ingredients are :

a) The minimum compressive strength required from structural consideration

b) The adequate workability necessary for full compaction with the compacting equipment available.

c) Maximum water-cement ratio and/or maximum cement content to give adequate durability for the particular site conditions

d) Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

8.2 Types of Mixes

1. Nominal Mixes

In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement-aggregate ratio which ensures adequate strength are termed nominal mixes. These offer simplicity and under normal circumstances, have a margin of strength above that specified. However, due to the variability of mix ingredients the nominal concrete for a given workability varies widely in strength.

2. Standard Mixes

The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes.

IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In this designation the letter M refers to the mix and the number to the specified 28 day cube strength of mix in N/mm2. The mixes of grades M10, M15, M20 and M25 correspond approximately to the mix proportions (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) respectively.

3. Designed Mixes

In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. The approach results in the production of concrete with the appropriate properties most economically. However, the designed mix does not serve as a guide since this does not guarantee the correct mix proportions for the prescribed performance.

For the concrete with undemanding performance nominal or standard mixes (prescribed in the codes by quantities of dry ingredients per cubic meter and by slump) may be used only for very small jobs, when the 28-day strength of concrete does not exceed 30 N/mm2. No control testing is necessary reliance being placed on the masses of the ingredients.

8.3 Factors Affecting the Choice of Mix Proportions

The various factors affecting the mix design are:

1. Compressive Strength

It is one of the most important properties of concrete and influences many other describable properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water-cement ratio of the mix. The other factor affecting the strength of concrete at a given age and cured at a prescribed temperature is the degree of compaction. According to Abraham's law the strength of fully compacted concrete is inversely proportional to the water-cement ratio.

2. Workability

The degree of workability required depends on three factors. These are the size of the section to be concreted, the amount of reinforcement, and the method of compaction to be used. For the narrow and complicated section with numerous corners or inaccessible parts, the concrete must have a high workability so that full compaction can be achieved with a reasonable amount of effort. This also applies to the embedded steel sections. The desired workability depends on the compacting equipment available at the site.

3. Durability

The durability of concrete is its resistance to the aggressive environmental conditions. High strength concrete is generally more durable than low strength concrete. In the situations when the high strength is not necessary but the conditions of exposure are such that high durability is vital, the durability requirement will determine the water-cement ratio to be used.

4. Maximum Nominal Size of Aggregate

In general, larger the maximum size of aggregate, smaller is the cement requirement for a particular water-cement ratio, because the workability of concrete increases with increase in maximum size of the aggregate. However, the compressive strength tends to increase with the decrease in size of aggregate.

IS 456:2000 and IS 1343:1980 recommend that the nominal size of the aggregate should be as large as possible.

5. Grading and Type of Aggregate

The grading of aggregate influences the mix proportions for a specified workability and water-cement ratio. Coarser the grading leaner will be mix which can be used. Very lean mix is not desirable since it does not contain enough finer material to make the concrete cohesive.

The type of aggregate influences strongly the aggregate-cement ratio for the desired workability and stipulated water cement ratio. An important feature of a satisfactory aggregate is the uniformity of the grading which can be achieved by mixing different size fractions.

6. Quality Control

The degree of control can be estimated statistically by the variations in test results. The variation in strength results from the variations in the properties of the mix ingredients and lack of control of accuracy in batching, mixing, placing, curing and testing. The lower the difference between the mean and minimum strengths of the mix lower will be the cement-content required. The factor controlling this difference is termed as quality control.

Mix Proportion designations

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates. For e.g., a concrete mix of proportions 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4 or the mix contains one part of cement, two parts of fine aggregate and four parts of coarse aggregate. The proportions are either by volume or by mass. The water-cement ratio is usually expressed in mass

8.4 Factors to be considered for mix design

- The grade designation giving the characteristic strength requirement of concrete.
- The type of cement influences the rate of development of compressive strength of concrete.
- within the limits prescribed by IS 456:2000.
- The cement content ð Maximum nominal size of aggregates to be used in concrete may be as large as possible is to be limited from shrinkage, cracking and creep.
- The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

8.5 Procedure

1. Determine the mean target strength ft from the specified characteristic compressive strength at 28-day fck and the level of quality control.

ft = fck + 1.65 S

where S is the standard deviation obtained from the Table of approximate contents given after the design mix.

2. Obtain the water cement ratio for the desired mean target using the emperical relationship between compressive strength and water cement ratio so chosen is checked against the limiting water cement ratio. The water cement ratio so chosen is checked against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.

3. Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.

4. Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table.

5. Determine the percentage of fine aggregate in total aggregate by absolute volume from table for the concrete using crushed coarse aggregate.

6. Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given in table.

7. Calculate the cement content form the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.

8. From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations:

where V = absolute volume of concrete

= gross volume (1m3) minus the volume of entrapped air

Sc = specific gravity of cement

W = Mass of water per cubic metre of concrete, kg

C = mass of cement per cubic metre of concrete, kg

p = ratio of fine aggregate to total aggregate by absolute volume

fa, Ca = total masses of fine and coarse aggregates, per cubic metre of concrete, respectively, kg, and

Sfa, Sca = specific gravities of saturated surface dry fine and coarse aggregates, respectively

9. Determine the concrete mix proportions for the first trial mix.
10. Prepare the concrete using the calculated proportions and cast three cubes of 150 mm size and test them wet after 28-days moist curing and check for the strength.
11. Prepare trial mixes with suitable adjustments till the final mix proportions are arrived at.

IX. CONCRETE MIX DESIGN FOR GRADE M70

Mix Design:
TARGET MEAN STREGTH FOR MIX PROPORTION:
F’ck=fck+1.65*S
(OR)
F’ck=fck+X
F’ck=70+1.65*6 =79.9 N/mm^2
(S =value from table 2 pg.No: 15)
(or)
F’ck= fck+ X
=70+1.65*6=79.9 N/mm^2 (X value from table no.1 IS 10262-2019)
The higher value is to be adopted therefore the target mean strength will be 79.9N/mm^2
Determination of W/C :

The W/C ratio depends up on exposure condition.

From table no 5 of IS456-2000(pg.no 20
Maximum water cement ratio = 0.304(sever)
Target slump is 75 mm
(Selection of water content from table 4)
=192.48+(192.48*3/100)
Water content =198.25kg/m^3 Reduce 20% that is 158.6kg/m^3
w/c ratio =0.304
water content = 158.6kg/m^3
Quality of cement w/c=X
W/X =C
Cement quantity C = 158.6/0.304 = 521.71 kg/m^3
With an increase of 10% of cementiteiuous
Material content =521.71*1.10 =573.881 kg/m^3
Cement content = 521.71kg/m^3
w/c =0.304
mix calculation:
total volume of concrete is 1 m^3
Volume of cement = mass of cement /specific gravity *1/1000
=521.71/3.125*1/1000
=0.166m^3
Volume of water =mass of water /specific gravity * 1/1000
=158.6/1 *1/1000 =0.1586m^3
Volume of chemical admixture = 1/1000 *mass of cement *% of admixture /sp.gravity
=1/1000*521.71*1/100/1.12
=0.0046
All aggregates = 1- entrapped air -volume cement+ volume water +volume of admixture
= 1-0.00716-0.1586+0.0046+0.166
=0.664m^3

Mass of coarse aggregate= volume of all aggregates * specific gravity of coarse aggregare) *1000*volume of coarse aggregate =0.664*2.83*1000*0.564
=1059.82 kg/m^3
Coarse aggregate in dry condition:
. =mass of C.A in SSD condition/1+water absorption/100
=1059.82/1+0.2/100 = 1057.70 kg/m^3
F.A in dry condition : =mass of F.A in SSD condition/1+water absoption/100
= 810.6111/1+0.2/100 =808.99kg/m^3

Mass of F.A :
= Volime of all aggregate *sp.gravity of F.A *1000*volume of fine aggregate =0.664*2.80*1000*0.43
=810.611kg/m^3
Water content =158.6 kg/m^3
=C.A in dry condition- mass of C.A in SSD
= 1059.82-1057.70 =2.12
F.A in dry condition – mass of F.A in SSD (SATURATED SUFACE CONDITION) =810.611-808.99 = 1.621
TOTAL WATER = C.A +F.A
=2.12+1.621 =3.741
WATER CONTENT : 158/.6+3.741
Final water content = 162.341 kg/m^3
Mix calculation: Cement = 521.71
Fine aggregate = 808.99
w/c ratio = 0.304
water content = 162.341 kg/m^3
chemical admixture =5.21
cement =521.71 = 1
f.A =808.99/521.71 =1.55
C.A =1057.70/521.71 =2.027

X. CUBE TESTS & RESULTS

Preparation of Concrete Cubes:
It should be filled in 50 mm layers and compacted, with a steel tamping bar, with a minimum of 25 or 35 tamps per layer for a 100 or 150 mm mould respectively. After tamping each layer, the mould should be lifted slightly and dropped or the sides tapped, to close the top surface of each layer.

Compressive Strength Definition:
Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates.

Compressive Strength Formula
Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.
Compressive Strength = Load / Cross-sectional Area

Procedure Compressive Strength Test of Concrete Cubes:
For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical molds of size 15cm x 15cm x 15cm are commonly used

This concrete is poured in the mould and appropriately tempered so as not to have any voids. After 24 hours, moulds are removed, and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by placing cement paste and spreading smoothly on the whole area of the specimen.
These specimens are tested by compression testing machine after seven days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete

Apparatus for Concrete Cube Test
Compression testing machine

Preparation of Concrete Cube Specimen
The proportion and material for making these test specimens are from the same concrete used in the field.

Specimen
6 cubes of 15 cm size Mix. M15 or above

Mixing of Concrete for Cube Test
Mix the concrete either by hand or in a laboratory batch mixer

Hand Mixing
1. Mix the cement and fine aggregate on a watertight none-absorbent platform until the mixture is thoroughly blended and is of uniform color.
2. Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.
3. Add water and mix it until the concrete appears to be homogeneous and of the desired consistency.

Sampling Cubes for Test:
1. Clean the mounds and apply oil.
2. Fill the concrete in the molds in layers approximately 5 cm thick.
3. Compact each layer with not less than 35 strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet-pointed at lower end).
4. Level the top surface and smoothen it with a trowel.

Curing of Cubes
The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the molds and kept submerged in clear freshwater until taken out prior to the test.

Precautions for Tests
The water for curing should be tested every 7 days and the temperature of the water must be at 27+-2oC.

Procedure for Concrete Cube Test
1. Remove the specimen from the water after specified curing time and wipe out excess water from the surface.
2. Take the dimension of the specimen to the nearest 0.2m
3. Clean the bearing surface of the testing machine
4. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.

5. Align the specimen centrally on the base plate of the machine.
6. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
7. Apply the load gradually without shock and continuously at the rate of 140 kg/cm2/minute till the specimen fails
8. Record the maximum load and note any unusual features in the type of failure.

Note:

Minimum three specimens should be tested at each selected age. If the strength of any specimen varies by more than 15 percent of average strength, the results of such specimens should be rejected. The average of three specimens gives the crushing strength of concrete. The strength requirements of concrete.

XI. CONCLUSION

1. Experimental work are carried out various percentage of Alccofine replaced to the cement in 7% and both the fresh and hardened properties. GGBS replaced 20%.
2. For normal strength and high strength compared. Using the alccofine as mineral admixture get early strength in concrete.
3. The fresh properties and hardened properties of concrete with alccofine are enhanced compared control mix.
4. The hardened properties like Compression strengthand split tensile strength of concrete is obtained at 15%.
5. We observed in the above experimental work the alccofine increases the strength of normal strength of the concrete up to 11% for hardened properties then after decreases as increasing the alccofine. But in high strength concrete hardened properties increases at 10% then decreased for the increased percentage of alccofine.

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