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High Performance Concrete: Review Paper

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Abstract:
The use of supplementary material is well accepted for the possible improvement of concrete mix. in recent years blast furnance slag when replaced with cement emerged as a major alternative to the conventional concrete and has rapidly used by the cement industry due to its cement saving, cost saving benifits. The main objectives of this study was to investigate the physical properties of high performance concrete (HPC) like strength, elasticity, plasticity using fly ash, silica fume as mineral admisture.HPC is the latest development in concrete and more used in the major projects. Mineral admixture like fly ash,silica fume and rice husk are commonly used in the mixture of concrete. The uses of these admixtures increase and improve the properties of concrete like strength and durability.HPC also resist the attack of chemical like chlorides and sulphates.

Keywords: Admixture, High performance concrete, Durability, Strength.

I. INTRODUCTION

High performance concrete is that type of concrete which give the best performance and acceptable result which cannot be achieved by normal concrete. High performance concrete is widely used in the large scale project due to its demand like high strength, high durability, large flow abilty. A high strength concrete may be high performance concrete but a high performance concrete may not be high strength concrete. High-performance concrete (HPC) is concrete that has been designed to be more durable and, if necessary, stronger than conventional concrete. HPC mixtures are composed of essentially the same materials as conventional concrete mixtures, but the proportions are designed, or engineered, to provide the strength and durability needed for the structural and environmental requirements of the project. High-strength concrete is defined as having a specified compressive strength of 8000 psi (55 MPa) or greater. The value of 8000 psi (55 MPa) was selected because it represented a strength level at which special care is required for production and testing of the concrete and at which special structural design requirements may be needed. .HPC reduce the size of structural member and increased the height of building in limited area and early remove of framework. The use of HPC in prestressed concrete construction work makes early transfer of priestess and application of service load. HPC implies optimized combination of structural properties such as strength, toughness, stiffness, durability, cracking and corrosion.

Mix Design of HPC

The mix design of HPC was done by using the guidelines of IS Code method (IS10262-1982)8. The design stipulations and the data considered for mix design HPC has been presented below.

Characteristic Strength, fck (MPa) : 50
Max Size of Coarse Aggregate : 20mm (Crushed)
[Fraction I-60%, 20mm-12.5mm]
[Fraction II-60%, 12.5mm-10mm]
Degree of Quality Control : Good
Type of Exposure: Severe
Degree of Workability: 0.95 (Compaction Factor)
Target Mean Strength (f'ck), MPa: fck + t x S = 50+1.65x5 = 58.25 Where,
fck = characteristic compressive strength at 28 days,
S = standard deviation, and
t = a statistic, depending upon the accepted proportion of low results and the number of tests; for large number of tests, the value of 't' is given in Table 2 of IS 10262-1982 code.

1.2.1 Physical Properties of Silica Fume

The physical properties of Silica Fume (SF) are the particle size, colour, oversize, specific gravity, etc. are explained briefly:- Particle Size: - SF particles are smooth, spherical size is 1/100 the diameter of Portland cement particle and average particle diameter lies between 0.1 to 0.2 micron range. Fineness:- the specific surface area of SF as measured by nitrogen absorption method usually lies between 13sq.m/g to 28 sq.m/g. Generally the SF has the fineness value of about 22 sq.m/g . Colour:- The colour of SF depends on carbon content, lower the carbon content of SF, the lighter is shade of grey. Usually, ferrosilicon furnaces manufacturing low silicon content alloys shoe darker silica fume. Specific Gravity: - The specific gravity of SF produced from high quality silicon and high grade ferrosilicon alloys typically ranges between 2.2 and 2.3.

Table 1 Chemical Properties of Silica Fume

Chemical Parameter	Silica Fume (%)
SiO_2	97.1
Al_2O_3	0.4
Fe_2O_3	0.3
CaO	0.3
MgO	0.0
SO_3	0.2
Total alkalies (Na_2O)	0.0
LOI	1.7

II. EXPERIMENTAL PROGRAM

Experimental investigations have been carried out on the HPC specimens to ascertain the workability and strength related properties such as compressive strength, split tensile strength, flexural strength and elastic modulus of the designed trial mixes and also non- destructive test(NDT)- ultrasonic pulse velocity(UPV) has been carried out to check the quality of concrete.

A. Materials Used: Silica fume as mineral admixture in dry densified form obtained from ELKEM INDIA (P) LTD, Mumbai conforming to ASTMC-1240.

Super plasticizer (chemical admixture) based on sulphonated naphthalene formaldehyde condensate- CONPLAST SP 430 conforming to BIS: 9103-1999 and ASTM C-494

B. Mix Design for HPC

Since there are no specific methods for mix design found suitable for HPC, a simplified mix design procedure, is formulated by combining the BIS method, ACI methods for concrete mix design and the available literatures on HPC using SF.

1) Calculation of binder contents

The binder or cementitious contents per m2 of concrete is calculated from the w/b ratio and the quantity of water content per m3 of concrete. Assuming the percentage replacement of cement by SF(0-15%), the SF content is obtained from the total binder contents. The remaining binder content is composed of cement. The cement content so calculated is checked against the minimum cement content for the requirements of durabilility as per table 5and 6 of BIS: 456-2000 and the greater of the two values is adopted.

2) Moisture adjustments

The actual quantities of CA, FA and water content are calculated after allowing necessary corrections for water absorption and free (surface) moisture content of aggregates.

The volume of water included in the liquid plasticizer is calculated and subtracted from the initial mixing water

3) Unit mass of concrete

The mass of concrete per unit volume is calculated by adding the masses of the concrete ingredients.

4) Selection of water- binder (w/b) ratio

The water binder ratio for the target mean compressive strength is chosen from figure BIS: 456- 2000 w/b ratio Fig 1. Proposed w/b ratio Vs compressive strength relationship from **BIS:**

456- 2000 Figure 1 shows that the proposed w/b ratio vs compressive strength relationship. The w/b ratio so chosen is checked against the limiting w/c ratio for the requirements of durability as per table5 of BIS: 456- 2000, and the lower of the two values is adopted.

5) Trial mix proportion

Because of many assumptions underlying the forgoing theoretical calculations, the trial mix proportions must be checked, if necessary the mix proportion should be modified to meet the desired workability and strength criteria, by adjusting the % replacement of cement by SF, % dosage of super plasticizer solid content of binder, air content and unit weight by means of laboratory trial batches to optimize the mix proportion. Fresh concrete should be tested for workability, unit weight and air content. Specimens of hardened concrete should be tested at the specified age. C. Mixer Proportions and Casting of Specimens Mix proportions are arrived for M80 and M100 grades of concrete based on the above formulated mix design procedure by replacing 0, 2.5, 5, 7.5, 10, 12.5 and 15% of the mass of cement by SF and the material requirements per m^3 of concrete are given in table 6 and 7. The ingredients for the various mixes are weighed and mixing was carried out using a drum type mixer and casting were done in steel moulds for concrete cubes 150mm size, cylinders 150mmx300mmand beams 100mmx100mmx500mm. Curing was done under water for various desired periods.

III. RESULTS AND DISCUSSIONS

A. Tests on Fresh Concrete

The test results of workability are listed in shown in figures 2, 3 and 4. It was observed that the workability of concrete decreased as the percentage of SF content was increased.

B. Tests on Hardened Concrete

The results of cube compression strength, cylinder compression strength, split tensile strength, flexural strength, and modulus of elasticity and water-binder materials are shown Figure 5, & 6. The optimum percentage of cement replacement by SF is 10% for the above test for M80 & m100 grades of concrete. This may be due to the fact that the decrease of strength characteristics is due to pozzolonic reaction and filler effects of SF. The ratio of cylinder to cube compressive strength was found to be 0.81. The flexural strength obtained experimentally are higher than the value calculated by the expression 0.7fck^0.5 as per BIS:456-2000. The variation of modulus of elasticity values with respect to percentage of SF for 28 days for M20 and M100 grades of concrete are shown in figure 6. For 10% SF content this is found to be optimum for modulus of elasticity also. The modulus of elasticity achieved was 3.97 GPa and 4.15 GPa for M80 and M100 grades of concrete respectively at the age of 28 days of concrete the values are comparatively lower than the values calculated by the expression 5000fck^0.5 as per BIS:456-2000. The velocities prove that the quality of concrete is excellent.

IV. CONCLUSIONS

Based on the investigations carried out on HPC mixes the following conclusions are drawn.

1) A simplified mix design procedure for HPC using SF and super plasticizer is formulated by combining BIS and ACI methods of mix design and available literatures on HPC.

2) The optimum percentage of cement replacement by SF is 10% for achieving maximum compressive, split tensile and flexural strength and elastic modulus.

3) The 7 days to 28 days compressive strength ratio of HPC is 0.75 -0.8.

4) The BIS 456-2000 code underestimates the flexural strength and over estimates the modulus of elasticity for HPC.

5) The use of SF in concrete reduces the workability.

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