CHAPTER – III

EXPERIMENTAL INVESTIGATIONS
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3.0 GENERAL

In the present experimental investigation properties of concrete using cement blended with silica fume, fly ash and micro silica has been studied. The replacement of cement with various percentages of fly-ash, silica fume and micro silica and comparing the properties like compressive strength, split tensile strength, flexural strength, workability, drying shrinkage, Creep, Permeability, Durability etc. between them is carried out. Studies also have been carried out on properties like compressive strength, split tensile strength, flexural strength, workability, permeability etc. with and without fibres. The details are as follows.

3.1 MATERIALS

3.1.1 Cement

Ordinary Portland cement available in the local market of standard brand was used in the investigation. Care has been taken to see that the procurement made from a single batch is stored in airtight containers to prevent it being affected by the atmospheric and monsoon moisture and humidity. The cement procured was tested for physical requirements in accordance with IS: 269 and for chemical requirements in accordance with IS: 4032. The details are given in Table 4.1.1. The cement conforms to 53 Grade.

3.1.2 Fly Ash

The fly ash obtained from Vijayawada thermal power station, Krishna Dist. A.P. is used in the present experimental work. The specific gravity of the fly ash is found to be 2.12 while the Blains fineness is 4580 cm²/gm. The fly ash is in conformity with the IS requirements as per IS 3812-1981. The general physical and chemical requirements
for fly ash are as per the IS 3812 (part-1)–1981 and the test results of fly ash used in the present experiment are tabulated in Table- 4.1.2

### 3.1.3 Silica Fume

The silica fume is obtained from the Navabharath Ferro alloys Ltd. Ferro alloy silica plant located in Palvancha of Khammam Dist in A.P. The specific gravity of silica fume is 2.1, while the Blain's fineness is 18500 cm²/gm. The silica fume is in conformity with the general requirement of pozzolana. The test results on silica fume used in the experiment are tabulated in the Table- 4.1.3

Comparison of physical and chemical properties of the cement, fly ash, silica fume and micro silica used in these investigations is shown in Table- 4.1.4

### 3.1.4 Micro Silica

Micro silica is a very fine off white pozzolanic material processed from a naturally occurring amorphous silica deposit in New Zealand's Rotorua district. The specific gravity of micro silica is 2.32, while the Blain's fineness is 20000 cm²/gm. The micro silica is in conformity with the general requirement of pozzolana. The test results are tabulated in Table-4.1.4 & Table-4.1.5.

### 3.1.5 Fine Aggregate

The locally available sand is used as fine aggregate in the present investigation. The sand is free from clayey matter, salt and organic impurities. The sand is tested for various properties like specific gravity, bulk density etc., in accordance with IS 2386-1963. These test results are tabulated in table 4.1.8. Sieve analysis is carried out and the results are shown in table 4.1.6. The fine aggregate is conforming to standard specifications.
3.1.6 Coarse Aggregate

Machine crushed angular granite metal of 20mm nominal size from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc. The course aggregate is also tested for its various properties. The specific gravity, bulk density and fineness modules of coarse aggregate are found to be 2.67, 1630 kg/m³ and 7.13 respectively. The details are tabulated in Table-4.1.7 and Table-4.1.8.

3.1.7 Water

The locally available potable water accepted for local construction is used in the experimental investigation after testing. The results and also the IS limitations are indicated in the Table-4.1.9.

3.2 PREPARATION OF TESTING SPECIMEN

3.2.1 Mixing

Mixing of ingredients is done on a nonabsorbent concrete platform. Thorough mixing by hand, using trowels is adopted.

The cementitious materials are thoroughly blended with hand and then the aggregate is added and mixed followed by gradual addition of water and mixing. Wet mixing is done until a mixture of uniform colour and consistency are achieved which is then ready for casting. Before casting the specimens, workability of the mixes was found by compaction factor test.

3.2.2 Casting of Specimens

The cast iron moulds are cleaned of dust particles and applied with mineral oil on all sides before concrete is poured in the moulds. The moulds are placed on a level platform. The well mixed green concrete is filled in to the moulds by vibration with
needle vibrator. Excess concrete was removed with trowel and top surface is finished level and smooth.

3.2.3 Curing of the Specimens

The specimens are left in the moulds undisturbed at room temperature for about 24 hours after casting. The specimens are then removed from the moulds and immediately transferred to the curing pond containing clean and fresh water. The curing water is renewed at every 5 days.

3.3 TESTING OF SPECIMENS

A time schedule for testing of specimens is maintained to ensure their proper testing on the due date and time.

The cast specimens are tested as per standard procedures, immediately after they are removed from curing pond and wiped off the surface water, as per IS 516-1959. The test results are tabulated carefully.

3.3.1 Description of Compression Testing Machine

The compression testing machine (Microprocessor based) used for testing the cube specimens is of standard make. The capacity of the testing machine is 200 Tonnes or 2000 KN. The machine has an ideal gauge on which the load applied can be read directly. The oil level is checked, the MS plates are cleaned and the machine is kept ready for testing specimens.

3.3.2 Testing Arrangements

The specimens are removed from the curing pond just before testing on the specified due date and time and cleaned to wipe off the surface water. The cube specimen is placed on the lower platen such that the load is applied centrally on the lower platen such that the load is applied centrally on the faces other than top and bottom faces of casting.
3.3.3 Testing Procedure

The oil pressure valve is closed tightly and the specimen is gradually loaded by operating the pumping lever uniformly and slowly. The pumping is continued until the black needle on the dial gauge stops moving up and a little later the black needle starts moving leaving the red needle statically. The pumping is stopped and the reading against the needle on the gauge is noted which gives the load at failure.

After testing of each specimen the pressure valve is released, the platens are cleaned free from debris and dust, keeping the machine ready for testing the next specimen.

The same procedure is repeated for testing all the specimens on the due dates as per testing time schedule and the results are tabulated.

3.4 TESTS CONDUCTED

3.4.1 Compressive Strength of Micro Silica Cement Mortar Cubes

In the preparation of standard cement mortar cubes to assess the cement strength a fixed w/c ratio is followed as per the codal procedure. However when cement is replaced with micro-silica by certain percentage this procedure may yield adverse results. Because the water content in the mix may not be sufficient to combine with all particles of micro silica which are very fine. Hence to know the influence of micro-silica replacement on cement strength various w/c ratios have been adopted and strengths at various ages have been found. This procedure has been repeated for various percentages of micro-silica replacements. Based on the results an optimum of 12 % replacement of cement by micro silica has been arrived. The results are tabulated in Table-4.4.1
3.4.2 Compressive Strength of Concrete Specimens

Based on investigations on 1:2:4 nominal mixes, studies were conducted on M20, M30, M40, M50 mixes nominal and designed as per the Indian Standard method in accordance with SP: 23-1982 replacing cement upto 12% by micro silica to study the effects on compressive strengths and workability and also with the combination of Fly ash and Silica fume with and without fibres. The results are tabulated in Table-4.4.2

3.4.3 Splitting Tension Test

Cylinder specimens 150mm in diameter and 300mm long, cast for 1:2:4, for water cement ratio 0.5, 0.45, 0.40, 0.35 for 12% replacement of Cement by micro silica and for different percentages of Silica fume with and without fibres were tested with the cylinder axis horizontal, and applying diametrical compression as per IS: 516. The results are tabulated in the Table-4.5.3

3.4.4 Flexural Strength Test

Beam specimens of size 100x100x500mm long cast for 1:2:4, for water cement ratio 0.5, 0.45, 0.40, 0.35 with 12% replacement of cement by micro silica and different percentage of Silica fume with and without fibres tested by applying third point loading over a 500mm span as per IS:516. The results are tabulated in the Table-4.5.4.

3.4.5 Workability

The workability was measured using the compaction-factor apparatus as per IS:1199 for Silica fume combination with fly-ash and Micro silica concretes with and with out fibres. The results are tabulated in the Table-4.3.1 & 4.5.1.

3.4.6 Drying Shrinkage

Investigations were also carried out to find out drying shrinkage of micro silica Cement concrete with water / (cement + micro silica) ratio of 0.60 with 12 percent of cement replacement by Micro silica for 1:2:4 mix in accordance with IS: 9459. The results are tabulated in the Table-4.4.9
3.4.7 Creep

Creep is defined as the long term deformations under sustained loading. Test specimens of 100mm diameter x 200mm length cylinders cast with 1:2:4 mix with a water/(cement + Micro silica) ratio of 0.60 with replacement of 12 percent of Portland cement with micro silica were used in the test. The specimens were loaded at 28 days and the immediate elastic deformation and creep deformations were noted for a period of 90 days under normal conditions of temperature and humidity for a stress strength ratio of 0.4. Drying shrinkages under no load condition were also measured. The results are tabulated in the Table-4.4.10

3.4.8 Permeability

Penetration of concrete by materials in solution will adversely effect its durability. This penetration depends on the permeability of the concrete. Hence tests for determining the permeability of concrete were conducted with 12 percent replacement of cement by Micro silica and these results are compared with concretes without any replacement.

The test setup is as shown in plate: 8.1.13. Concrete test specimens cured for 28 days are loaded in the cells and these specimens are sealed with jute and wax such that water kept above the specimens in the cells percolates through the top surface and comes out from the bottom surface and collects in bottles through funnels. Then a constant air pressure of 1 to 2 Kg/cm² is applied in the cells using an air compressor. Under this constant pressure water percolates through the specimen and the water is collected in the bottle over a specific period of time. Then the coefficient of permeability is calculated using K = Q/({H/L}*A*T)

Where K = Coefficient of permeability in cm/sec.
Q = quality of water in cc
T = time of collection in sec.
A = area of the specimen face in cm²
H/L = ratio of pressure read to thickness of specimen

The results are tabulated in the Table -4.4.8
3.4.9 Durability

The durability of micro silica cement concrete was tested for resistance against mineral and organic acids such as Sulphuric acid, hydrochloric acid etc. The affect of chemical attack on plain concrete and micro silica concretes was studied by physical observation and loss in weight.

For conducting these tests, concrete cubes of size 100mm x 100mm x 100mm with M20 and M50 grades with a replacement of cement by 12 percent of micro silica were used. These cubes were immersed in 2 percent solutions of Sulphuric acid, hydrochloric acid etc. for different periods of 7, 14, 90 days and deterioration was studied by means of loss of weight. Photographs are shown in 8.1.1, 8.1.2, 8.1.3 & 8.1.4. The results are tabulated in the Table-4.4.

3.4.10 Micro Silica Reinforced Cement Concretes Beams

To study the suitability of the concretes made with cement partially replaced with micro silica for reinforced concrete works, investigations were carried out on beam specimens for conducting ultimate load and load deflection characteristics. For casting beams a concrete mix of 1:1.5:3 with a water/(cement + micro silica) ratio of 0.53 with 0% and 12% replacement of cement by micro silica is used with and without fibres.

Reinforced concrete beams for sizes 100x150x1400 mm were cast with the above said mix. For the first type beam specimens 2 rods of 8mm diameter (0.44%) were used as tension reinforcement and shear reinforcement of 6mm at 150mm is used. For the second type of beams specimens 2 rods of 8mm diameter were used as tension reinforcement and 6mm diameter stirrups were used as shear reinforcement with micro silica 12 percent replacement by cement with and without 1 percent fibres. To hold the stirrups in position two hanger rods of 8mm diameter were used at the top. These specimens were cured in water for 28 days and tested for ultimate load, defections and failure characteristics under one third point loading. The test setup is shown in photograph 8.1.10, 8.1.11 & 8.1.12. The results are tabulated in the Table-4.7.1