Material aspects of high performance concrete

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\textbf{Abstract.} High performance concrete envisages the better performance concrete in terms of strength and durability properties by the quality of constituent materials. The study emphasis on effect of mineral admixtures such as fly ash and silica fume in high performance concrete. The high performance concrete of grade M60 is prepared with replacement of 10%, 20% and 30% of cement by fly ash and 2% and 4% of cement by silica fume as mineral admixtures of desired mix proportions as per IS 10262-1982. The chemical admixture of conplast SP430, superplasticizer of 1% is added to ensure better workability for high performance concrete mix. The mechanical properties like workability, compressive strength and split tensile strength for all different cases were studied and the results are compared to find the optimum performance of fly ash and silica fume content. The optimal percentage of fly ash is about 20% with 4% silica fume to have better strength properties.

1. \textbf{Introduction}

High performance concrete is a specific combination of concrete mix from M60 grade encounters the rigorous performance than the conventional constituents with different curing practices [1]. The high performance concrete can be produced along with chemical and mineral admixtures as main ingredients to enhance better strength and durability properties [2]. Supplementary cementitious material includes combination of fly ash, Ground granulated blast-furnace slag, foundry sand and silica fume are the industrial by-products widely used in concrete for various purposes [3, 10]. Silica fume and fly ash are most common mineral admixtures used by several researchers for high performance concrete. The silica fume size is too smaller than cement particles to have as better pore filling material in concrete. However, its high specific area increases the water demand in matrix mix [4-5]. The combination of fly ash and silica fume increases the workability characteristics based on water demand by which super plasticizer is added to counteract the water content. Mineral admixtures in the concrete affect the physical properties particularly around the aggregate surface where porosity exists ensures high workability, density, low permeability and resistance to chemical attack [6]. M sand will play a significant role as an ingredient in concrete strength. The naturally available granite rock is crushed and sized in quarry to produce course aggregate, finely grained fine aggregate with variety of crushing equipment’s such as impact crushers, roll crushers, road rollers etc., The texture, chemical properties, mineral properties of the raw material for M sand is based on the parent rock
subjected to changes [7]. The crusher wash sand along with 20% of micro silica can be replaced with cement for high Performance Concrete, to acquire strength improvement by 16.5% [8]. The along with glass and nylon fibres are also been used to increase the tensile properties [9]. The addition of fibres along with cementitious materials in the concrete improves the crack resistance properties, ductility and flexural strength of concrete. [11-12]. Many researches on high performance concrete are done to improve the properties of concrete with respect to strength and durability studies. The initial cost of high Performance concrete is quiet higher than the control concrete but latter works out to be cost-effective throughout the service life of the structure and reduces the damage. Therefore, it can be designed in such a way that to acquire better performance [13].The main objective of this research is to utilize the waste by products from various industry as mineral admixtures in concrete to attain better strength. The performance study rely on material aspects of fly ash and silica fume with percentage replacement of cement to enhance the later age strength of concrete.

2. Materials and Methods

2.1 Materials

Ordinary Portland cement of 53 Grade, Locally available M sand and crushed granite stones of 20mm conforming to graded coarse aggregate as per IS: 383–1970 were used for the study. Fly ash Confiming to IS: 3812 – Part 1 – 2003 were used in high performance concrete. The mineral admixture includes silica fume was added as dry powder with small replacement percentage. The chemical admixture of conplast SP430 super plasticizer was used to enhance the workability of the concrete. The ordinary potable water was used for mixing concrete.

2.2 Methods

The concrete specimens of grade M60 with various mix constituents are studied for the mechanical properties such as workability, compressive strength and split tensile strength properties of the concrete at the age of 7, 14 and 28 days. The mix ratios such as Mix 1, Mix 2, Mix 3, Mix 4, Mix 5 and Mix 6 were obtained by replacing 0, 2 and 4 percent of cement mass by silica fume, replacing 10, 20 and 30 percent of the cement mass by fly ash. The water cement ratio (w/c) is taken as 0.30.The mix ratio is prepared based on various proportions of replacement of cement materials as shown in Table: 1. Experimental investigations are carried out on test specimens to study the behaviour of high performance concrete and its material aspects.

| Type of Mix | SILICA FUME % | FLY ASH % |
|-------------|---------------|-----------|
| MIX 1       | 2             | 10        |
| MIX 2       | 2             | 20        |
| MIX 3       | 2             | 30        |
| MIX 4       | 4             | 10        |
| MIX 5       | 4             | 20        |
| MIX 6       | 4             | 30        |
| CONTROL MIX | M60           |           |

3. ANALYSIS AND TEST RESULT

3.1 Test for workability

The workability of the concrete is tested using slump cone method for all the sample specimens. The test is employed to measure the slump degradation and the diameter of concrete spread based on different types of mixes and its proportions as reported in table: 2. The difference in slump value is lesser than 10 mm for variation in silica fume content with control mix. Therefore, the Mix 4 and Mix 5 can be taken as suitable and optimal mix for 4% silica fume in terms of workability as shown in figure.1. The addition of fly ash and silica fume does not imparts better workability.
Table 2: Workability test results

| Type of Mix | Slump Value, mm |
|-------------|-----------------|
| MIX 1       | 54              |
| MIX 2       | 58              |
| MIX 3       | 60              |
| MIX 4       | 58              |
| MIX 5       | 64              |
| MIX 6       | 66              |
| CONTROL MIX | 56              |

Figure 1: Workability test results

3.2 Test for Compression strength

The average compressive strength of high performance concrete is obtained by testing the concrete cubes specimens after 7 days, 14 days and 28 days for different fly ash and silica fume ratios are presented in table 3. The maximum compressive strength is achieved for Mix 5 shows 63.8 N/mm² for 28 days than the control mix concrete with 61.2 N/mm² respectively. The compressive strength is greatly influenced by 20% fly ash with 4% silica fume considerably as shown in figure 2.

Table 3: Compressive strength on high performance concrete

| Compressive Strength Mpa   | Type of Mix | 7 DAYS | 14 DAYS | 28 DAYS |
|----------------------------|-------------|--------|---------|---------|
| MIX 1                      | 38.25       | 41.25  | 61.8    |
| MIX 2                      | 38.29       | 43.38  | 62.5    |
| MIX 3                      | 39.5        | 44.82  | 62.9    |
| MIX 4                      | 40.4        | 45.63  | 63.4    |
| MIX 5                      | 41.6        | 46.72  | 63.8    |
| MIX 6                      | 42.5        | 47.85  | 62.4    |
| CONTROL MIX                | 38.1        | 40.25  | 61.2    |
3.3 Test on Split Tensile strength

The test results on average split tensile strength of 7 days, 14 days and 28 days for different mix proportions of fly ash and silica fume ratios are presented in figure 3. The result shows that the split tensile strength increases with increase in fly ash and silica fume ratio are shown in table 4. The addition of fly ash increases in latter age strength when compared to early strength in 7 days. The split tensile strength increases for Mix 6 shows 5.88N/mm² than the control mix of 4.62N/mm² for 28 days strength.

Table: 4 Split tensile strength on high performance concrete

| Type of Mix | 7 DAYS | 14 DAYS | 28 DAYS |
|-------------|--------|---------|---------|
| MIX 1       | 3.12   | 3.76    | 4.65    |
| MIX 2       | 3.18   | 3.79    | 4.68    |
| MIX 3       | 3.21   | 3.82    | 5.12    |
| MIX 4       | 3.25   | 3.85    | 5.67    |
| MIX 5       | 3.26   | 3.89    | 5.82    |
| MIX 6       | 3.33   | 3.91    | 5.88    |
| CONTROL MIX | 3.23   | 3.85    | 4.62    |

Figure: 2 Compressive strength test results

Figure: 3 Split Tensile strength test results
4. CONCLUSION

The following conclusions were arrived based on experimental studies of M60 grade high performance concrete. The replacement of fly ash and silica fume plays a significant role in strength enhancement. The addition of mineral admixtures in concrete does not impart workability significantly. The compressive strength of concrete with 20% of fly ash replacement and 4% of silica fume replacement are identified with maximum strength enhancement of 63.8N/mm² for 28 days. The split tensile strength of concrete with optimum replacement percentage of 30% of cement by fly ash and 4% replacement of silica fume for Mix 6 are identified with strength of 5.88N/mm² for 28 days. The slump value increases for the Mix 6 with percentage replacement of 30% fly ash and 4% silica fume than the control mix concrete. The further studies are to be employed for higher percentage replacement of fly ash above 30% in high performance concrete.

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