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Cost Analysis of Concrete by Partial Replacement of Cement with Pozzolanic Material

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Abstract: *The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for green house effect and the global warming.*

The search for any such material, which can be used as an alternative or as a supplementary for cement so we had taken a research for partial replacement of cement by combine mixing of GGBS, FLY-ASH & SILICA FUME in a constant percentage and studying the effect of special material on concrete as well as cost analysis of concrete.

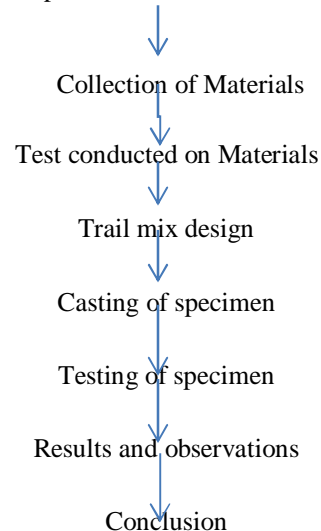
I. INTRODUCTION

Concrete has basic naturally, cheaply and easily available ingredients as cement, sand, aggregate and water. After the water, cement is second most used material in the world. But this rapid production of cement creates two big environmental problems for which we have to find out civil engineering solutions. First environmental problem is emission of CO₂ in the production process of the cement. We know that CO₂ emission is very harmful which creates lots of environmental changes whatsoever. Ground Granulated Blast furnace slag (GGBS) is a by-product for manufacture of pig iron and obtained through rapid cooling by water or quenching molten slag. Here the molten slag is produced which is instantaneously tapped and quenched by water. This rapid quenching of molten slag facilitates formation of “Granulated slag”. Ground Granulated Blast furnace Slag (GGBS) is processed from Granulated slag. Fly ash is one of the residues created during the combustion of coalincoal-fired power plants. Fine particles rise with flue gasses and are collected with filter bags or electrostatic precipitators. Silica Fume is a finely-divided mineral admixture, available in both un compact and compacted forms. This ultra-fine material will better fill voids between cement particles and result in a very dense concrete with higher compressive strengths and extremely low permeability.

II. METHODOLOGY

The study work is to analyses strength properties of partially replaced by GGBS, FLY-ASH, and SILIKAFUME concrete. The tests of concretes are carried out as per IS code for this proposed investigation work.

Steps for Trial...Introduction



III. PROPERTIES OF INGREDIENTS

A. Cement

The cements used in this experimental works are ordinary Portland cement. All properties of cement are tested by referring IS Specification for Ordinary Portland cement. Test results are presented in Table

| SR.NO. | DISCRIPTION OF TEST | RESULT |
|--------|--|-----------------------|
| 01 | Fineness of test | 1% |
| 02 | Specific gravity | 3.15 |
| 03 | Standard consistency of cement | 35% |
| 04 | Setting time of cement a) Initial setting time b) Final setting time | 90minute3 60minute |
| 05 | Soundness test of cement(with le – | 1.5mm |

Table 3.1. Physical Properties of Cement(Confirming to IS 12269-1987)

IV. TESTING OF MIX DESIGN

Result Of Trail Mix (observations and test Results)

- 1) Workability targeted (in mm)
- 2) Workability observed (in mm)
- 3) Remarks
- 4) Corrections
- 5) Cohesiveness: Remarks
- 6) Compressive Strength (Average of Three Test Cubes)
 - a) 3 day (kg/ cm²) 26.216 N/MM²
 - b) 7 day (kg/ cm²) 32.148 N/MM²
 - c) 28 day (kg/ cm²) 36.26 N/MM²

A. Hence This Give Result Of Mix Design For Control Concrete

Ratio (1: 1.47: 1.9) With 28 Days Strength 36.26n/Mm²

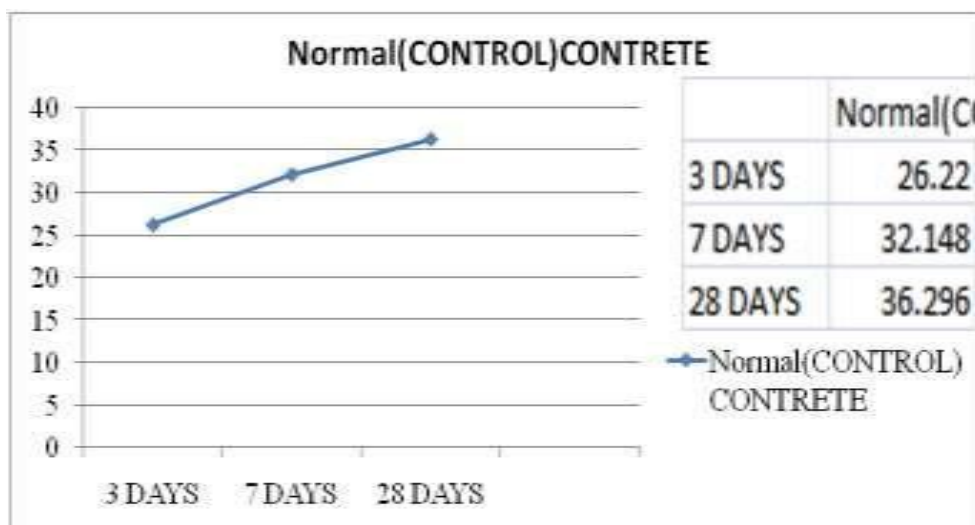


Fig.IV.1: Graph. Days v/s strength(n/mm²)

V. FLEXURAL STRENGTH TEST.

The arrangement for flexural strength test is shown in Figure. Automatic universal testing machine was used for this test according to BS1881-118 [12] Beam samples measuring 500×100×100mm were moulded and stored in water for 28days before test for flexural strength. Three similar samples were prepared for each mix proportion. The casting was made by filling Each mould with freshly mixed concrete in three layers. Each layer was compacted manually using a 25mm diameter steel tamping rod to give 150 strokes on a layer.

The hardened beam was placed on the universal testing machine simply supported over a span 3times the beam depth on a pair of supporting rollers. Two additional loading rollers were placed on top the beam. The load was applied without shock at a rate of 200m/s. The flexural strength was then calculated using.

The formula below

$$F_{cl} = \frac{PL}{D_1 D_2}$$

Where,

P = breaking load (in N);

D₁ and D₂ = lateral dimensions of the cross sections (In mm);

L = distance between the supporting rollers (In mm)

| 1: 1.47 : 1.9 mix | Water/ cement ratio =0.4 | Flexural strength | Average | | | | | | |
|-------------------|--------------------------|-------------------|---------|----------------------|----------------------|-----------------------------------|---------------------------------------|------|------|
| 1:1.47 : 1.9 mix | p | L | A=PL | D ₁ MM | D ₂ MM | D ₂ ² MM | B = D ₂ *D ₂ | A/B | Avg. |
| | 7926.5 | 400 | 3170600 | 100 | 100 | 10000 | 1000000 | 3.17 | 3.28 |
| | 8473.5 | 400 | 3389400 | 100 | 100 | 10000 | 1000000 | 3.39 | |
| | 6926.5 | 400 | 2770600 | 100 | 100 | 10000 | 1000000 | 2.77 | 2.88 |
| | 7473.5 | 400 | 2989400 | 100 | 100 | 10000 | 1000000 | 2.99 | |

Table V.I

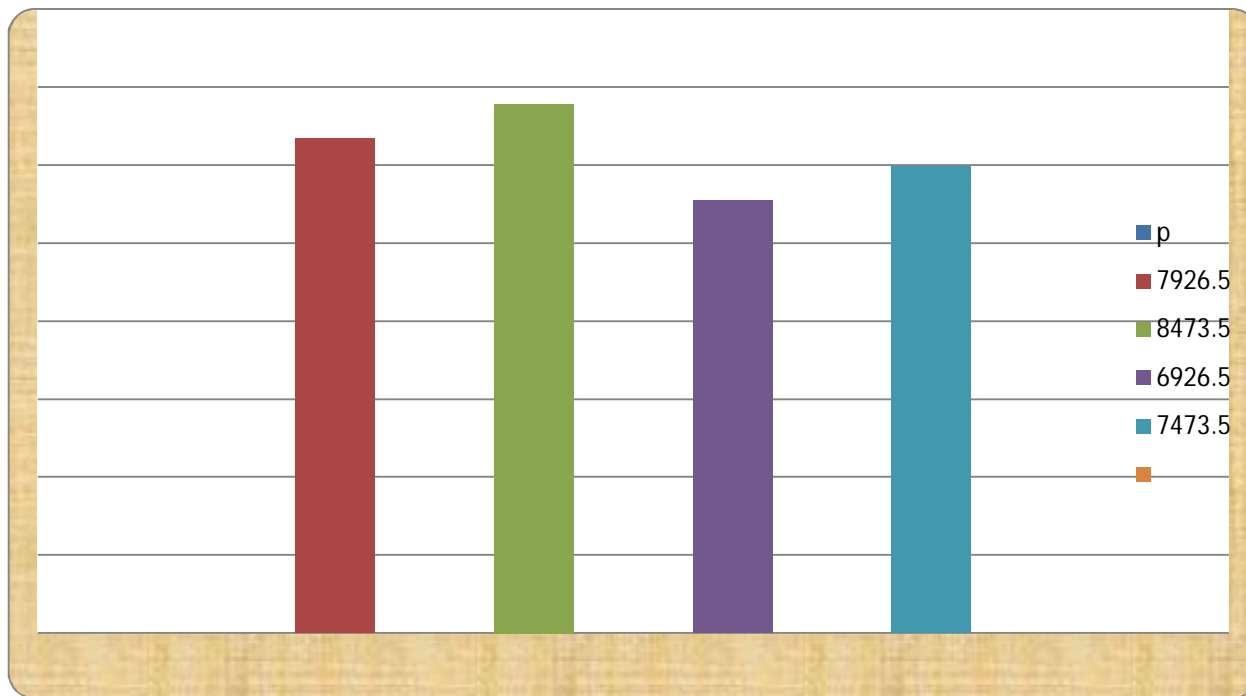


Fig V.2: Graph. load (P) v/s flexural strength(n/mm²)

A. Strength of Concrete Having Cement Constant I_e 50%

Comparison of control concrete strength with constant cement (50%) replacement strength

Table2.1 Strength of control concrete with replacement of constant cement

| DAYS / STRENGTH(Mpa) | SLUMP(MM) | 3DAYS | 7 DAYS | 28 DAYS |
|---|-----------|----------|-----------|-----------|
| NORMAL CONCRETE(CONTROL CONCRETE (1:1.47:1.9) | 75 | 26.22Mpa | 32.148Mpa | 36.296Mpa |
| Cement replacement(30:10:10) CEMENT 50% | 65 | 14.22Mpa | 24.59Mpa | 29.8Mpa |
| Cement replacement (10:30:10) CEMENT 50% | 80 | 17.77Mpa | 20.00Mpa | 29.55Mpa |
| Cement replacement (10:10:30) CEMENT 50% | 75 | 12.00Mpa | 20.11Mpa | 29.5Mpa |

B. Cement replacement with 50% give optimum result at (30%g:10%f:10%si) replacement i.e. 29.8mpa

COST OF INGREDIENTS PER KG AS PER MARKET RATE IN ASANGAON

G.G.B.S - 2.90 RS / KG

FLY-ASH - 2.75 RS/ KG

SILICA - FUME - 25 RS/ KG

CEMENT - 8.00 RS/ KG

as silica –fume is too much costly hence avoid the maximum replacement of silica-fume

C. Strength of concrete having cement constant i.e. 60%

Comparison of control concrete strength with constant cement (60%) replacement strength

Table 4.3. Strength of control concrete with replacement of constant cement

| DAYS / STRENGTH(Mpa) | SLUMP(MM) | 3 DAYS | 7DAYS | 28 DAYS |
|--|-----------|-----------|-----------|-----------|
| NORMAL CONCRETE (CONTROL CONCRETE (1:1.47:1.9) | 75 | 26.22 Mpa | 32.148Mpa | 36.296Mpa |
| Cement replacement(20:10:10) CEMENT 60% | 70 | 22.88Mpa | 29.77Mpa | 34.00Mpa |
| Cement replacement(10:20:10) CEMENT 60% | 65 | 14.66Mpa | 20.00Mpa | 33.33Mpa |
| Cement replacement(10:10:20) CEMENT 60% | 75 | 13.688Mpa | 19.11Mpa | 30.33Mpa |

D. Cement Replacement with 60% give optimum result at (20%G:10%F:10%Si) Replacement i.e. 34.51mpa

Cost of Ingredients Per kg as per Market Rate in Asangaon

G.G.B.S - 2.90 RS / KG

FLY-ASH - 2.75 RS/ KG

SILICA - FUME - 25 RS/ KG



CEMENT - 8.00 RS/ KG

AS SILIKA –FUME IS TOO MUCH COSTLY HENCE AVOID THE MAXIMUM REPLACEME OF SILICA-FUME

E. Comparison of control concrete strength with constant cement (70%) replacement strength

Table 4.Strength of control concrete with replacement of constant cement.

| DAYS / STRENGTH (Mpa) | SLUMP(MM) | 3 DAYS | 7DAYS | 28 DAYS |
|--|-----------|-----------|-----------|-----------|
| NORMAL CONCRETE (CONTROL CONCRETE (1:1.47:1.9)) | 75 | 26.22 Mpa | 32.148Mpa | 36.296Mpa |
| Cement replacement (10:10:10) CEMENT 70% | 70 | 17.185Mpa | 32.07Mpa | 34.00Mpa |
| Cement replacement (10:10:10) CEMENT 70% | 70 | 17.085Mpa | 24.07Mpa | 34.00Mpa |
| Cement replacement (10:10:10) CEMENT 70% | 70 | 17.19Mpa | 20.11Mpa | 34.00Mpa |

F.

Cement replacement with 70% give optimum result at (10%G:10%F:10%Si) replacement ie 34.00mpa

Cost of Ingredients Per kg as per Market Rate in ASANGAON

G.G.B.S - 2.90 RS / KG

FLY-ASH - 2.75 RS/ KG

SILICA - FUME - 25 RS/ KG

CEMENT - 8.00 RS/ KG

AS SILIKA –FUME IS TOO MUCH COSTLY HENCE AVOID THE MAXIMUM REPLACEME OF SILICA-FUME

1) Quantity & cost for nine (09) cube for the testing(20g:10f:10si) ie 60% constant cement

Total quantity = 0.0513 m³

CEMENT IN KG = 16.77 KG

SAND IN KG = 24.65 KG

AGGRIGATE IN KG = 15.93 KG(M1)

15.93 KG(M2)

TOTAL AGGRIGATE =31.86KG

COST FOR THE SAND = 24.65 X 1.32= 32.53 Rs. Ie 33.00 Rs

COST FOR THE AGGRIGATE = 31.86 X 1.1 = 35.046 Rs. Ie 36 Rs.

COST FOR CEMENT IN (20:10:10) CASE ie 60% constant cement.

Total weight of cement =16.77 kg

But 60% cement =0.6x16.77 = 10.062 kg

Hence cost of cement (20:10:10) = 10.062 x 8 = 80.496 Rsie 81.00 Rs.

REMAINING 40% HAVE (20% GGBS, 10% FLY-ASH, 10% SILIKA- FUME)

20% GGBS = 0.2 X16.77 = 3.354 KG

COST FOR GGBS = 3.354 x 2.90 = 9.7266 Rs.

10% FLY-ASH = 0.1 X 16.77= 1.677 KG



COST FOR FKY- ASH = $1.677 \times 2.75 = 4.611$ Rs.
 10% SILIKA- FUME = $0.1 \times 16.77 = 1.677$ KG
 COST FOR SILIKA- FUME = $1.677 \times 25 = 41.92$ Rs.
 Hence total cost for material for (20:10:10) replacement
 = $33+36.00+ 81.00 + 9.7266 + 4.611 + 41.92$
 = 206.2626 Rs. (for 20:10:10)
 Hence total cost / m³
 4020.66 Rs. / m³

2) *Quantity & Cost For Nine (09) Cube For The Testing (10g:10f:10si) ie70% Constant Cement.*

TOTAL QUANTITY = 0.0513 M³
 CEMENT IN KG = 16.77 KG
 SAND IN KG = 24.65 KG
 AGGRIGATE IN KG = 15.93 KG(M1)
 15.93 KG(M2)
 TOTAL AGGRIGATE =31.86KG
 COST FOR THE SAND = $24.65 \times 1.32 = 32.53$ Rs. ie 33.00 Rs
 COST FOR THE AGGRIGATE = $31.86 \times 1.1 = 35.046$ Rs. ie 36 Rs.
 COST FOR CEMENT IN (20:10:10) CASE ie 70%constant cement
 Total weight of cement =16.77 kg
 But 70% cement = $0.7 \times 16.77 = 11.739$ kg
 Hence cost of cement (10:10:10) = $11.739 \times 8 = 93.912$ Rsie 94.00 Rs.
 REMAINING 30% HAVE (10% GGBS, 10% FLY-ASH, 10% SILIKA- FUME)
 10% GGBS = $0.1 \times 16.77 = 1.677$ KG
 COST FOR GGBS = $1.677 \times 2.90 = 4.8633$ Rs.
 10% FLY-ASH = $0.1 \times 16.77 = 1.677$ KG
 COST FOR FKY- ASH = $1.677 \times 2.75 = 4.611$ Rs.
 10% SILIKA- FUME = $0.1 \times 16.77 = 1.677$ KG
 COST FOR SILIKA- FUME = $1.677 \times 25 = 41.92$ Rs.
 Hence total cost for material for (10:10:10) replacement
 = $33.00 + 36.00 + 94 + 4.8633 + 4.611 + 41.92$
 = 214.3943 Rs.
 Hence total cost / m³
 4179.22 Rs./ m³

VI. RESULT

| Sr. no. | Description of sample | Grade of concrete | Slump (mm) | Compressive Strength at 28 days | Tensile strength (N/mm ²) | Flexural strength (N/mm ²) | Cost (Rs.)/m ³ |
|---------|--|-------------------|------------|---------------------------------|---------------------------------------|--|--------------------------------|
| 01 | 60% constant cement Remaining 40% Have (20% Ggbs, 10% Fly-Ash, 10% Silica- Fume) (60% constant cement) (20%G : 10%F : 10%Si) | M30 | 70mm | 34.00 Mpa | 2.053 (N/mm ²) | 3.28 (N/mm ²) | 4020.66 Rs./ m ³ |

| | | | | | | | |
|----|--|-----|-------|--------------|----------------------------------|----------------------------------|------------------------------------|
| 02 | 70% constant cement Remaining 40% Have (10% Ggbs, 10% Fly- Ash, 10% Silica- Fume) (70% constant cement) (10%G : 10%F : 10%Si) | M30 | 70 mm | 34.00 Mpa | 2.92 (N/mm ²) | 2.88 (N/mm ²) | 4179.22 Rs./ m ³ |
|----|--|-----|-------|--------------|----------------------------------|----------------------------------|------------------------------------|

Comparing Both (20G:10F:10Si) & (10G:10F:10Si) the Replacement cost and strength.

- Hence Preferably (20%Ggbs : 10%Fly-Ash : 10%Silica-Fume) are accepted.
- Having 60% Constant Cement Replacement In The Presence Of GGBS, Fly-Ash And Silica-Fume Is Optimum.
- Since The Cost Is Less And Strength Is Very much acceptable, Also cost saving of 158.56 Rs / M³

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