AN EXPERIMENTAL STUDY OF GYPSUM AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

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Abstract—Gypsum which has a pozzolanic property and silica fume is an industrial by – product which is partially mixed with cement and comparative study is studied in this project. In this project gypsum, silica fume, fine aggregate and coarse aggregate will be used in proportions to the cement concrete mixture. The investigation is carried out with compressive strength test and flexural strength test for cube and beam. The percentage of gypsum in partial replacement cubes is 63%, 73% , 83% and silica fume is 2% i.e.,( 63% of gypsum + 2% of silica fume, 73% of gypsum + 2% of silica fume , 83% of gypsum + 2% of silica fume). And for partial replacement of cement in concrete beams, the percentage of gypsum is 63%, 73%, 83% and silica fume is 2% i.e.,( 63% of gypsum + 2% of silica fume, 73% of gypsum + 2% of silica fume + 83% of gypsum + 2% of silica fume). The overall percentage of gypsum and silica fume is 65%, 75% and 85% on the strength criteria M25 concrete. The comparative study is carried out between conventional and partial replacement beams. The flexural strength tests for beam have to be done and the result will be submitted after the test.

Keywords—cement – gypsum and silica fume, fine aggregate, coarse aggregate.

I. INTRODUCTION

The entire construction industry is in search of suitable and effective waste product that would considerably minimize the cost and the use of cement. Gypsum plays a very important role in controlling the hardening of the cement. Gypsum which has the pozzolanic properties and in this study the comparative study of gypsum when partially mixed with silica fume is studied. Silica fume is a industrial by - product and it refines pore structure and produces concrete of improved mechanical strength. In this project, gypsum and silica fume will be used in proportions as concrete mixture with cement, fine and coarse aggregate.

The conventional concrete along with gypsum and small quantity of silica fume as the partial replacement of cement in concrete. After the casting process the cubes and beams were produced in a tank for 28 days. By this study, the high strength is achieved in gypsum and silica fume as partial replacement of cement in concrete mixture with the percentage 83%, 73% and 63% of gypsum and 2% of silica fume. The overall percentages of gypsum and silica fume in cube and beam is 65%, 75% and 85%.
1.2 SCOPE OF THE PROJECT

➢ Usage of gypsum helps in quick setting of cement in concrete.
➢ Gypsum and silica fume acts as an effective replacement of cement because of its pozzolanic and mechanical strength.
➢ Control hardening of cement.
➢ To achieve the better replacement of cement.

1.3 OBJECTIVE

➢ To study the durability effects when mineral admixtures of higher fineness is used as cement replacement in concrete.
➢ To study the effectiveness of gypsum waste as a mineral admixtures as it is one of the industrial waste and its usage can reduce the environmental pollution.

II. MATERIAL USED

The materials used in the project are,

2.1 Cement
Ordinary Portland Cement of 53 grade cement is required to conforming specification IS 12269 – 1987. The specific gravity of OPC is 3.15

2.2 Fine aggregate
Natural sand is used for this investigation which is conforming to IS:383 – 1970 and specific gravity of fine aggregate is 2.65.

2.3 Coarse aggregate
Crushed stone is used as coarse aggregate of 20 mm which is available in nearby area was used for this project.

2.4 Gypsum
Gypsum powder is a industrial waste used as a by- product of cement. It is useful in hardening of the cement and quick setting of cement. Gypsum is calcium sulphate dihydrate (CaSO4.2H2O). The white color gypsum powder is used for this investigation of the project.

![Gypsum](image1.jpg)

Fig1.Gypsum

2.5 Silica fume
Silica fume also known as microsilica, is an amorphous polymorph of silicon dioxide (SiO2), silica. It is an ultrafine powder collected as a by- product of the silicon. The main field of application is as pozzolonic material for high performance concrete.
III. MIX DESIGN

The procedure of mix design recommended by American concrete institute IRC – road no: 4 and IS mix design are widely used and adopted. The mix design are given below,

- Grade designation – M25
- Type of cement – OPC – 53 grade
- Maximum water cement ratio – 0.45
- Workability – 50 to 70 mm slump
- Exposure condition – good
- Type of aggregate – crushed angular aggregate
- Specific gravity of cement – 3.15
- Specific gravity of fine aggregate – 2.7
- Specific gravity of coarse aggregate – 2.9

Refer from IS 456 - 2000, mix design for 1 m³ is calculated
- Cement content - 435.409 kg
- Fine aggregate - 653.384 kg
- Coarse aggregate - 1173.782 kg
- Water content - 203.430 litres.

For beam size – 1.5 m * 150 mm * 200 mm
- Cement = 19.59 kg
- Fine aggregate = 29.40 kg
- Coarse aggregate = 52.82 kg
- Water = 9.15 litres

For replacement of 65% (63% of gypsum + 2% of silica fume)
- Cement = 35% = 6.8 kg
- Fine aggregate = 29.4 kg
- Coarse aggregate = 52.82 kg
- Gypsum = 12.34 kg
- Silica fume = 0.39 kg

For replacement of 75% (73% of gypsum + 2% of silica fume)
- Cement = 25% = 4.89 kg
- Fine aggregate = 29.40 kg
- Coarse aggregate = 52.82 kg
- Gypsum = 14.30 kg
- Silica fume = 0.39 kg
For replacement of 85% (83% of gypsum + 2% of silica fume)
Cement = 15% = 3 kg
Fine aggregate = 29.40 kg
Coarse aggregate = 52.82 kg
Gypsum = 16.25 kg
Silica fume = 0.39 kg
Total amount of cement required = 34.18 kg (including conventional)
Total amount of gypsum required = 42.89 kg
Total amount of silica fume required = 1.17 kg

TEST FOR MATERIALS
1. Slump cone test
2. Compressive strength test
3. Flexural strength test

3.1 Slump cone test

The concrete slump test is a method used to for the measurement of a property of fresh concrete. The test is an empirical test that measures the workability of fresh concrete. It specially, measures consistency between batches. Clean the inner surface of the mould and apply oil. Place the mould with the prepared concrete mix in 4 approximately equal layers. Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For all the layers the tamping should penetrate into the underlying layer. Remove the excess concrete and level the surface with a trowel. Clean away the mortar or water leaked out between the mould and the base plate. Raise the mould from the concrete immediately and slowly from the vertical direction. Measure the slump as the difference between the height point of the specimen being tested.

Slump for the given sample = \(65\) mm

Fig 3. Slump cone test
3.2 Compressive strength test
3.2.1 Casting and testing process

![Fig 4. Gypsum and silica fume cubes](image)

The size of the cube specimen are 150 mm*150 mm *150 mm. From this project, gypsum and silica fume is the partial replacement of cement in concrete. So the mixture of concrete according to the project is 63%, 73% and 83% of gypsum and 2% of silica fume as partial replacement of cement in concrete cube. And it is poured into the mould and tampered properly so as to neglect any voids. The top surface of the specimen should be made even and smooth. This is done putting the concrete paste and spreading smoothly on whole area of specimen. And after 24 hours these moulds are removed and test specimen are put in water for curing.

For testing, the specimen should be removed from the water after specified curing time (i.e., 7, 14 and 28 days) and wipe out excess water from the surface. Clean the surface of the testing machine. Place the specimen in the machine in such a manner that the load shall be given to the opposite side of the cube. Then, align the specimen centrally on the base plate of the machine. Rotate the moveable portion gently by hand so it touches the top surface of the specimen. Apply the load gradually and continuously at the rate of 140 kg/cm$^2$/minute till the specimen fails. Record the maximum load and note any unusual features in the type of failure.

Tabulation 1. For 7, 14 and 28 days the compressive strength test for conventional cubes,

<table>
<thead>
<tr>
<th>S. No</th>
<th>Days</th>
<th>Average compressive strength test(N/mm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>37.85</td>
</tr>
<tr>
<td>2</td>
<td>14</td>
<td>46.7</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
<td>54.7</td>
</tr>
</tbody>
</table>
Chart 1. Graph for conventional cube at 7, 14 and 28 days

Tabulation 2. For consolidated strength of concrete for different replacement @ different curing days

<table>
<thead>
<tr>
<th>S. No</th>
<th>specimen</th>
<th>Compressive strength for 7 days in N/m$^2$</th>
<th>Compressive strength for 14 days in N/m$^2$</th>
<th>Compressive strength for 28 days in N/m$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sp1</td>
<td>38.2</td>
<td>47.5</td>
<td>56</td>
</tr>
<tr>
<td>2</td>
<td>Sp2</td>
<td>40.4</td>
<td>50.5</td>
<td>58.08</td>
</tr>
<tr>
<td>3</td>
<td>Sp3</td>
<td>39</td>
<td>48.1</td>
<td>56.9</td>
</tr>
</tbody>
</table>

Sp1 = 63% of gypsum + 2% of silica fume + 35% of cement.
Sp2 = 73% of gypsum + 2% of silica fume + 25% of cement.
Sp3 = 83% of gypsum + 2% of silica fume + 15% of cement.

Chart 2. For 65%, 75% and 85% replacement cubes at 7, 4 and 28 days

3.3 Flexural strength test

3.3.1 Casting and testing process

For the cement concrete beam with gypsum and silica fume in partial replacement of cement is casted. The size of the beam is 1.5m * 150 mm * 200mm and determine the proportions of materials including cement, sand, aggregate, gypsum, silica fume and water. Mix the materials and place moulds on horizontal surface and lubricate inside surface with proper lubricant material and excessive lubricant should be prevented. Pour the concrete of conventional and partial replacement concrete into the moulds. The casting of partial replacement of cement with gypsum and silica fume
should be casted quickly because the gypsum has the quick setting capacity. Compact each layer with tamping rod and apply 25 strokes for each layer or fill the mould completely and compact concrete using vibration table. Remove excess concrete from the top of the mould. Cover top of the beam in the moulds and store them in a temperature room. Remove the moulds and moist cure specimen till the time of testing. The test of the conventional and partial replacement beam should be after 28 days.

Fig 5.Reinforcement of beam

![Reinforcement of beam](image)

Fig 6.Concrete mix with cement, sand, aggregate, gypsum and silica fume

![Concrete mix](image)

Fig 7.Casting of conventional concrete

![Casting of conventional concrete](image)

Fig 8.Casting of partial replacement of cement in concrete with 65%
Fig 9. Casting of partial replacement of cement in concrete with 75%

Fig 10. Casting of partial replacement of cement in concrete with 85%

Fig 11. Flexural strength testing of beam
Graph 1. Load to deflection graph for 65%
In 65% cracking load at 0.66mm and ultimate load at 4.12mm

Graph 2. Load to deflection graph for 75%
In 75% the cracking load at 1.63mm and ultimate load at 4.16 mm.

Graph 3. Load to deflection graph for 85%
In 85% the cracking load at 0.79 mm and ultimate load at 4.25
IV. CONCLUSION AND RESULT

➢ The conclusion arrived in this project is achieved by finding the cement replacement percentages of 65%, 75% and 85% of compressive strength test and flexural strength test in M25 strength criteria.

➢ It was observed that in compressive strength test the result was achieved in 75% and decreases in 85%.

➢ In flexural strength test the result was achieved in 75% as there is a decreased value in 85%.

➢ As the partial replacement of cement by gypsum and silica fume in various percentages in 7, 14 and 28 days curing the high strength were studied in 75%.

REFERENCES


IS CODES
