# SUITABILITY OF CONCRETE BY USING CUPOLA SLAG AS PARTIAL REPLECEMENT OF COARSE AGGREGATE AND FOUNDRY SAND AS PARTIAL REPLECEMENT OF FINE AGGREGATE

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***Abstract: Now Present days, Waste materials are utilized in the preparation of Conventional Concrete. In this work, the waste materials are used cupola slag and foundry sand. The design mix for M20 grade concrete were considered for a w/c ratio of 0.55. The target mean strength was found 26.6 N/mm$^2$. Cupola slag and foundry sand was used in concrete as partially replacement of coarse aggregate and fine aggregate respectively. First of all, foundry sand used to as partial replace as 0%, 10%, 15%, 20%, 25%, 30%, 40%, 60%, 80%, and 100% of natural fine aggregate. The optimum percentage which was gave target strength. This optimum percentage used in concrete when the cupola slag was used as partial replacement as 0%, 10%, 20%, 30%, 40%, 60%, 80% and 100% of natural coarse aggregate. The experimental work is mainly concerned with the study of fresh concrete property like slump test, Mechanical properties like compressive strength, split tensile strength and flexure strength. The use of cupola slag and foundry sand could be effectively utilized as coarse and fine aggregate in concrete application and also give the better result from management of waste and protect the environment to the pollution.***

***Key Words: Cupola slag, Foundry sand, Workability, Compression test, Split tensile test, Flexure test, Durability Test***

## 1. INTRODUCTION:

Generally natural aggregates are obtained by rock quarries. Rock quarries are working from last 30 to 35 years. Properly controlled explosion is required to break the rocks which are then transported to crushers. Natural aggregates are obtained after crushing and sieving these crushed rocks. India is the second largest country in world after china in concrete consumption. As these natural resources are limited since the quantity of aggregate obtained is also limited by seeing large consumption and it grown more & more. Natural sand is obtained by the river. It is also available in limited quantity. So there is a need to replace these natural materials by alternative options which are obtained to industrial byproduct like Cupola slag and Foundry sand. Now a day, sustainable infrastructural growth demands the alternative material that should satisfy technical requirements of natural aggregate as well as it should be available great quantity. The cheapest and the easiest way of getting substitute for natural aggregates is by crushing Cupola slag to get artificial aggregates of desired size and grade and foundry sand to get silica sand of desired grade and quality.

Industry produced a large amount of by-product material during casting process. It also has environmental issues in disposal of these by product since it cannot be used anywhere expect the land filling at present. So by there is a need to replace natural aggregates by cupola slag and foundry sand to solve concrete as well as environmental and industry problem.

The present work aims to contribute at studies on the Cupola slag and foundry sand as construction material. In particular, it focuses on structural concretes, by investigating the feasibility to partially or fully replace natural aggregates by cupola slag and foundry sand.

## 2. MATERIALS:

### 2.1 CEMENT

Ordinary Portland Cement (OPC) of Sidhee Cement conforming of IS: 12269-1987 grade cement was used.

### 2.2 FINE AGGREGATE AND COARSE AGGREGATE

Fine aggregate used for study as conforming to zone II of Is: 383 1987. Fine aggregate size is less than 4.75mm. Coarse aggregate size is maximum 20mm used for study as conforming to IS: 383 1970.

### 2.3 WATER

Potable Water available in the site was used in casting and curing of concrete. The water used in concrete shall Confirms the requirements of IS 10500, the code of portable water.

### 2.4 CUPOLA SLAG

Cupola slag is by-product material which is gathered from cast iron manufacturing unit. It is produced during melting of cast iron in cupola furnaces. The slag occurs as a molten liquid which solidifies upon cooling. Cupola slag is a complex solution of silicates and oxides. Cupola furnace is cylindrical shaped melting device which is used in steel industries for melting of cast iron ranging from 0.5 to 4 m in diameter. Bottom of furnace having a door which can swing in and out. Top of the furnace is kept open. Air vent is arranged to supply the air in Furnace. Shells of furnace are made up of steel, refractory bricks. There is one slag hole from which slag comes out at higher temperature with low viscosity that solidifies in black colored lumps upon cooling. Lumps size varied from 100 mm to 450 mm. Cupola slag is tends to be dense solid material that varies in color from Grey to black. Physical properties of cupola slag to be used as compared with natural coarse aggregates and IS 383-1970 requirements for material to be used as aggregates.

**Fig -1**: Lump sized of Cupola Slag aggregate
(**Source:** Image Capture)

**Fig -2**: 20mm sized of Cupola Slag aggregate
(**Source:** Image Capture)

**2.4.1 PHYSICAL PROPERTIES OF CUPOLA SLAG**

| PROPERTIES | CUPOLA SLAG |
|---|---|
| Abrasion value | 20.8 |
| Impact value | 13.79 |
| Crushing value | 25.47 |
| Specific Gravity | 3.28 |
| Fineness Modulus | 4.65 |
| Water absorption | 0.44 |

**Table 1: Physical properties of Cupola Slag**

**2.4.2 CHEMICAL PROPERTIES OF CUPOLA SLAG**

| SR NO. | ELEMENT | VALUE (%) |
|---|---|---|
| 1 | $Al_2O_3$ | 9.65 |
| 2 | MnO | 2.92 |
| 3 | $SiO_2$ | 45.03 |
| 4 | MgO | 2.48 |
| 5 | $TiO_2$ | 1.17 |
| 6 | CaO | 14.29 |
| 7 | $Fe_2O_3$ | 23.58 |
| 8 | $Cr_2O_3$ | 0.34 |
| 9 | $Na_2O$ | 0.54 |

**Table 2: Chemical Properties of Cupola Slag**

**2.5 FOUNDRY SAND**

Foundry sand is the fine aggregate to be used in concrete, other than normal sand. Metal foundries use large amounts of natural sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is throwing anywhere. So it is known as "foundry sand". For the preparation of the mould, there is used one type of silica sand and that also known as "foundry sand". Now in days, generally Foundry sand is used for earth filling. Physical properties of foundry sand to be used as fine aggregate was found and compared with natural fine aggregates and IS 383-1970 requirements for material to be used as fine aggregates.

**Fig -3**: Foundry Sand
(**Source:** Image Capture)

There are mainly two types of foundry sand available, which are

1) Green Sand (Referred to as molding sand material)
2) Chemically bonded sand

Green sand or molding sand uses clay as the binder material in foundry and chemically bonded sand that uses polymers to bind the sand grains together. It is a one type of silica sand.

**2.5.1 PHYSICAL PROPERTIES OF FOUNDRY SAND**

| PROPERTIES | FOUNDRY SAND |
|---|---|
| Fineness Modulus | 3.14 |
| Specific Gravity | 2.38 |
| Water absorption | 0.39 |
| Silt content | 2.4% |

**Table 3: Physical Properties of Foundry Sand**

**2.5.2 CHEMICAL PROPERTIES OF FOUNDRY SAND**

| ELEMENT | VALUE (%) |
|---|---|
| $SiO_2$ | 97.67 |
| $Al_2O_3$ | 1.14 |
| $Fe_2O_3$ | 0.48 |
| CaO | 0.24 |
| MgO | 0.16 |
| LOI | 0.31 |

**Table 4: Chemical Properties of Foundry Sand**

## 3. EXPERIMENTAL SETUP AND METHODOLOGY:

### 3.1 CONCRETE MIX PROPORTION

The mixture proportioning was done according the Indian Standard Recommended Method IS 10262- 2009 and with reference to IS 456-2000. Concrete for M20 grade were prepared as per I.S.10262:2009 with w/c 0.55. The target mean strength was 26.60MPa for the OPC control mixture, the total binder content was 358.47 Kg/m$^3$, fine aggregate was taken 708.98 Kg/ m$^3$ and coarse aggregate was taken 1117.28Kg/m$^3$. The water to binder ratio was kept constant as 0.55.

**Mix Proportion:**

| Cement | FA | CA | Water |
|---|---|---|---|
| 358.47 kg | 708.98 kg | 1117.28 kg | 197.16 kg |
| 1 | 1.97 | 3.11 | 0.55 |

### 3.2 WORKABILITY TEST:

#### 3.2.1 SLUMP TEST:

Workability is one of the physical parameters of concrete which affects the strength and durability as well as the cost of labor and appearance of the finished product. Concrete is said to be workable when it is easily placed and compacted homogeneously i.e. without bleeding or Segregation. Unworkable concrete needs more work or effort to be compacted in place, also honeycombs &/or pockets may also be visible in finished concrete.

**Fig -4**: Slump
(**Source:** Image Capture)

### 3.3 HARDENED CONCRETE TEST:

#### 3.3.1 COMPRESSION TEST

The strength of concrete is usually defined and determined by the crushing strength of 150mm x 150mm x 150mm, at an age of 7, 28 and 56days. It is most common test conducted on hardened concrete as it is an easy test to perform and also most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. It also stated in IS 516-1959 that the load was applied without shock and increased continuously at the rate of approximately 140 Kg/sq. cm/ min until the resistance of specimen to the increasing loads breaks down and no greater load can be sustained. The maximum load applied to the specimen was then recorded as per IS: 516-1959.

The compressive strength was calculated as follows:

Compressive strength (MPa) = Failure load / cross sectional area.

**Fig -5**: Compression Testing

(**Source:** Image Capture)

#### 3.3.2 SPLIT TENSILE TEST:

The test was conducted as per IS 5816:1999 [23]. For tensile strength test, cylindrical specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank wherein they were allowed to cure for 7 and 28 days. In each category, three cylinders were tested and their average value was reported.

Split tensile strength was calculated as follows:

Spilt Tensile strength (MPa) = 2P / π DL

Where, P = Failure Load (KN)
D = Diameter of Specimen (150 mm)
L = Length of Specimen (300 mm)

**Fig -6**: Split Tensile Testing

(**Source:** Image Capture)

#### 3.3.3 FLEXURAL TEST:

The flexural tensile strength test was performed on 100*100*500 mm prismatic specimens by using the beam method according to IS 516:1959 at which load is applied at one third points of the specimen. Two prismatic specimens were produced for each series. The tests were carried out by using a closed loop deflection-controlled loading frame of 250 KN capacity and loading rate was 0.5 mm/min. The deflections at the mid-span of bottom surface and the supports of beams were simultaneously recorded during the test. The net mid-span deflection of the beam was obtained by taking the difference between mid-span deflection and the average of the support deflections. Load–deflection curves for each specimen were also obtained graphically.

Flexural strength was calculated as follow:

Flexural strength (MPa) = PL/BD2

Where, P = applied load, L = length of beam, B = width of beam, D = depth of beam.

**Fig -7**: Flexure Testing

(**Source:** Image Capture)

### 3.6 DURABILITY TEST

#### 3.6.1 ACID ATTACK

Acid attack is an important aspect for consideration when we deal with the durability of concrete. Acid attack is particularly important because it causes corrosion of reinforcement. Cube specimens were immersed in storage tank for normal curing for 28 days after casting. After 28 days, cubes were taken out and put on the dry place or on dry cloth and the dry cube specimens were weighed. Then the specimens were immersed in acid curing storage tank up to 28 days from the casting. The specimens were weighed again and the weight difference before acid curing and after acid curing was measured.

**Fig 8:** Acid Attack

#### 3.6.2 SULPHATE ATTACK

Most soil contains some sulphate in the form of calcium, sodium, potassium and magnesium. The term sulphate attack denote an increase in the volume of the cement paste in concrete or mortar due to the chemical action between the products of hydration of cement and solution containing sulphates.

**Fig 9:** Sulphate Attack

### 3.6.3 SEA WATER ATTACK

To investigate the effect of sea water on compressive strength of concrete, concrete cubes were made. The Specimens size measuring 150 x 150 x 150 mm dimension was used. The batching of the concrete was carried out by weight. Mix was proportioned for target cube strength of 26.6 N/mm2. After Casting of Concrete Cube with fresh water then cubes were immersed in fresh water tank for 28 days. After 28 days, cubes were immersed in sea water for next 28 days.

## 4. SPECIMENS:

### 4.1 USE OF FOUNDRY SAND

| MIX NAME | %REPLACEMENT OF F.A. BY FOUNDRY SAND | CUBES | | CYLINDERS | | BEAMS |
|---|---|---|---|---|---|---|
| | | 7 DAY | 28 DAY | 7 DAY | 28 DAY | 28 DAYS |
| A | 00 | 3 | 3 | 3 | 3 | 3 |
| B | 10 | 3 | 3 | 3 | 3 | 3 |
| C | 15 | 3 | 3 | 3 | 3 | 3 |
| D | 20 | 3 | 3 | 3 | 3 | 3 |
| E | 25 | 3 | 3 | 3 | 3 | 3 |
| F | 30 | 3 | 3 | 3 | 3 | 3 |
| G | 40 | 3 | 3 | 3 | 3 | 3 |
| H | 60 | 3 | 3 | 3 | 3 | 3 |
| I | 80 | 3 | 3 | 3 | 3 | 3 |
| J | 100 | 3 | 3 | 3 | 3 | 3 |
| Total | - | 30 | 30 | 30 | 30 | 30 |

**Table 5: No of Specimens casting of using Foundry Sand**

- Total numbers of cubes (150mm*150mm*150mm) are 60 casted.
- Total numbers of cylinders (150mm*300mm) are 60 casted.
- Total numbers of beams (100mm*100mm*500mm) are 30 casted.

### 4.2 USE OF CUPOLA SLAG AND FOUNDRY SAND

| Mix Name | % of Replacement | | Cubes | Cylinders | Beams |
|---|---|---|---|---|---|
| | Cupola Slag | Foundry Sand | | | |
| K | 00 | 30 | 12 | 12 | 9 |
| L | 10 | 30 | 12 | 12 | 9 |
| M | 15 | 30 | 12 | 12 | 9 |
| N | 20 | 30 | 12 | 12 | 9 |
| O | 25 | 30 | 12 | 12 | 9 |
| P | 30 | 30 | 12 | 12 | 9 |
| Q | 40 | 30 | 12 | 12 | 9 |
| R | 60 | 30 | 12 | 12 | 9 |

**Table 6: No of Specimens casting of using Cupola Slag and Foundry Sand**

- Total numbers of cubes (150mm*150mm*150mm) are 96 casted.
- Total numbers of cylinders (150mm*300mm) are 96 casted.
- Total numbers of beams (100mm*100mm*500mm) are 72 casted.

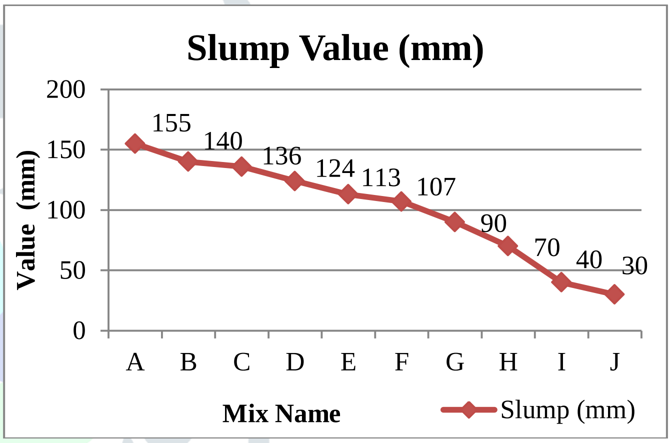
## 5 RESULT ANALYSES:

### 5.1 SLUMP TEST RESULT

### 5.1.1 FOR USING FOUNDRY SAND

| Mix No. | Mix Name | Slump (mm) |
|---|---|---|
| 1 | A | 155 |
| 2 | B | 140 |
| 3 | C | 136 |
| 4 | D | 124 |
| 5 | E | 113 |
| 6 | F | 107 |
| 7 | G | 90 |
| 8 | H | 70 |
| 9 | I | 40 |
| 10 | J | 30 |

**Table 7: Slump Test Result for Using Foundry Sand**

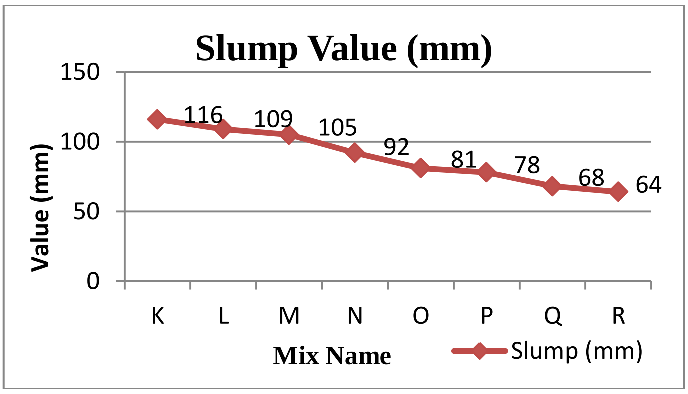



**Graph 1: Slump Test Result for Using Foundry Sand**

### 5.1.2 FOR USING CUPOLA SLAG AND FOUNDRY SAND

| Mix No. | Mix Name | Slump (mm) |
|---|---|---|
| 1 | K | 116 |
| 2 | L | 109 |
| 3 | M | 105 |
| 4 | N | 92 |
| 5 | O | 81 |
| 6 | P | 78 |
| 7 | Q | 68 |
| 8 | R | 64 |

**Table 8: Slump Test Result for Using Cupola Slag and Foundry Sand**



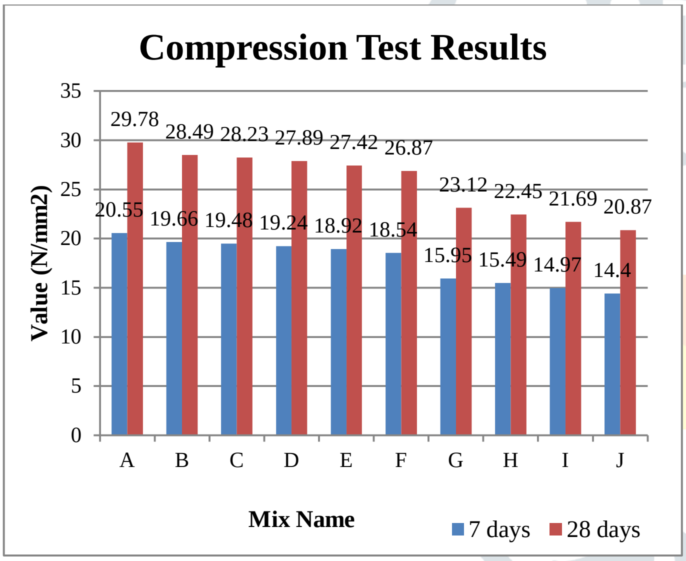

**Graph 2: Slump Test Result for Using Cupola Slag and Foundry Sand**

### 5.2 TEST RESULTS OF USING FOUNDRY SAND

#### 5.2.1 COMPRESSION TEST RESULT:

| Mix Name | % Replacement of F.A. by Foundry sand | Average Compression Value | |
|---|---|---|---|
| | | 7 days | 28 days |
| A | 0 | 20.55 | 29.78 |
| B | 10 | 19.66 | 28.49 |
| C | 15 | 19.48 | 28.23 |
| D | 20 | 19.24 | 27.89 |
| E | 25 | 18.92 | 27.42 |
| F | 30 | 18.54 | 26.87 |
| G | 40 | 15.95 | 23.12 |
| H | 60 | 15.49 | 22.45 |
| I | 80 | 14.97 | 21.69 |
| J | 100 | 14.40 | 20.87 |

**Table 9: Compression Test Results of Using Foundry Sand**

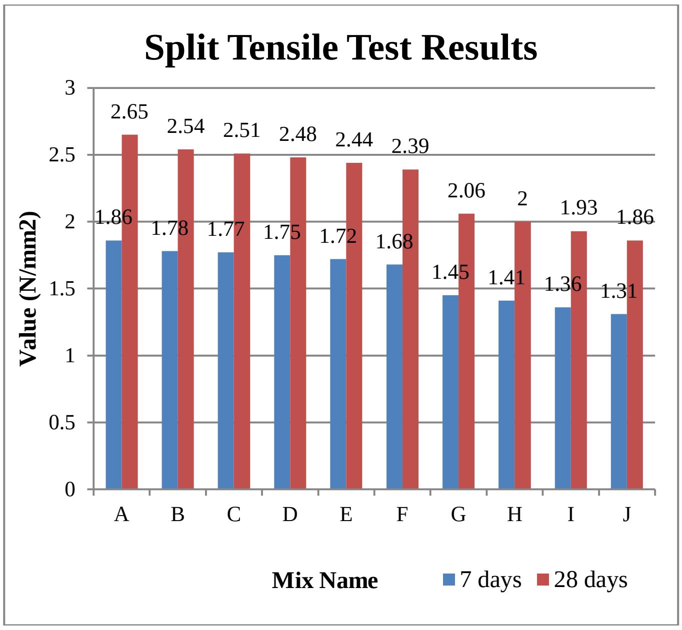



**Graph 3: Compression Test Results of Using Foundry Sand**

#### 5.2.2 SPLIT TENSILE TEST RESULT:

| Mix Name | % Replacement of F.A. by Foundry sand | Average Split Tensile Test Value | |
|---|---|---|---|
| | | 7 days | 28 days |
| A | 0 | 1.86 | 2.65 |
| B | 10 | 1.78 | 2.54 |
| C | 15 | 1.77 | 2.51 |
| D | 20 | 1.75 | 2.48 |
| E | 25 | 1.72 | 2.44 |
| F | 30 | 1.68 | 2.39 |
| G | 40 | 1.45 | 2.06 |
| H | 60 | 1.41 | 2.00 |
| I | 80 | 1.36 | 1.93 |
| J | 100 | 1.31 | 1.86 |

**Table 10: Split Tensile Test Results Of Using Foundry Sand**

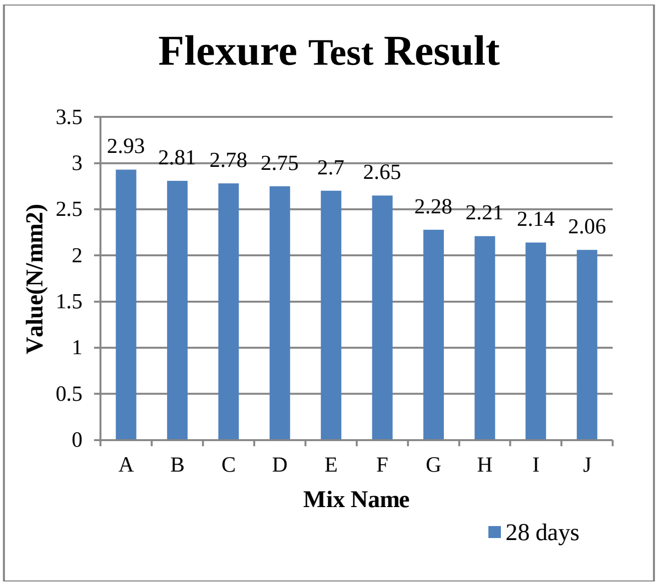



**Graph 4: Split Tensile Test Results Of Using Foundry Sand**

#### 5.2.3 FLEXURE TEST RESULT:

| Mix Name | % Replacement of C.A. by Cupola Slag | Average Flexure Test value |
|---|---|---|
| | | 28 days |
| A | 0 | 2.93 |
| B | 10 | 2.81 |
| C | 15 | 2.78 |
| D | 20 | 2.75 |
| E | 25 | 2.70 |
| F | 30 | 2.65 |
| G | 40 | 2.28 |
| H | 60 | 2.21 |
| I | 80 | 2.14 |
| J | 100 | 2.06 |

**Table 11: Flexure Test Results of Using Foundry Sand**



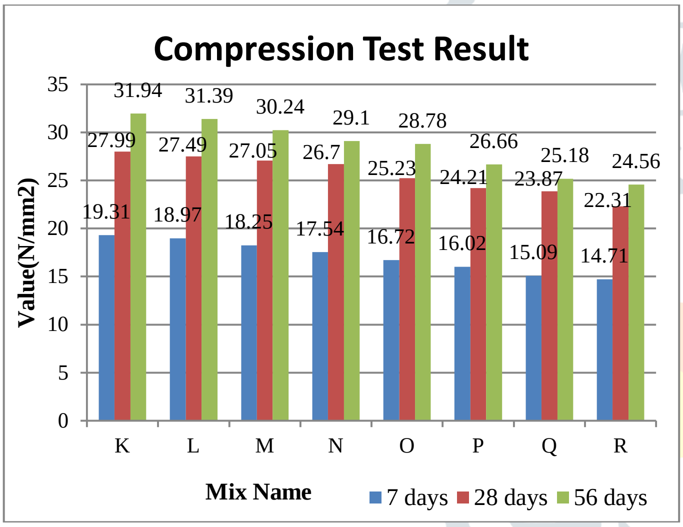

**Graph 5: Flexure Test Results of Using Foundry Sand**

## 5.3 TEST RESULTS OF USING CUPOLA SLAG AND FOUNDRY SAND:

### 5.3.1 COMPRESSION TEST RESULT:

| Mix Name | % Replacement of C.A. by Cupola Slag | % Replacement of F.A. by Foundry Sand | Average Compression Test Value | | |
|---|---|---|---|---|---|
| | | | 7 days | 28 days | 56 days |
| K | 0 | 30 | 19.31 | 27.99 | 31.94 |
| L | 10 | 30 | 18.97 | 27.49 | 31.39 |
| M | 20 | 30 | 18.25 | 27.05 | 30.24 |
| N | 30 | 30 | 17.54 | 26.70 | 29.10 |
| O | 40 | 30 | 16.72 | 25.23 | 28.78 |
| P | 60 | 30 | 16.02 | 24.21 | 26.66 |
| Q | 80 | 30 | 15.09 | 23.87 | 25.18 |
| R | 100 | 30 | 14.71 | 22.31 | 24.56 |

**Table 12: Compression Test Results of Using Cupola Slag and Foundry Sand**

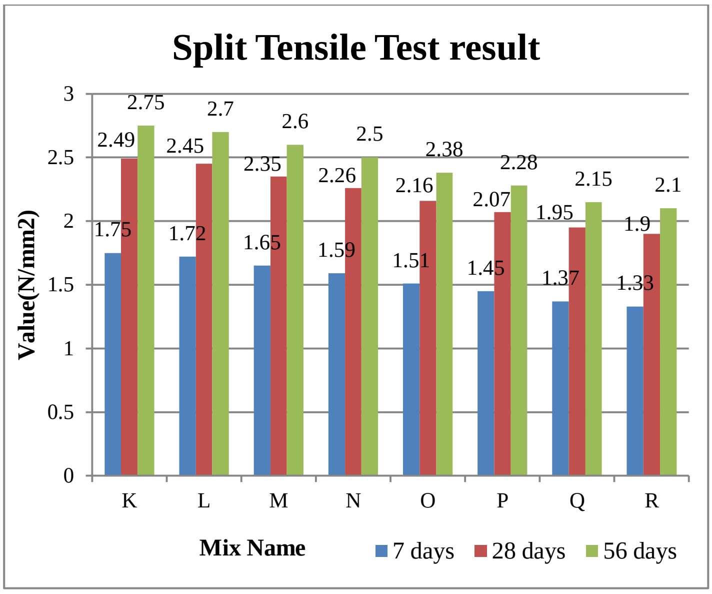



**Graph 6: Compression Test Results of Using Cupola Slag and Foundry Sand**

### 5.3.2 SPLIT TENSILE TEST RESULT:

| Mix Name | % Replacement of C.A. by Cupola Slag | % Replacement of F.A. by Foundry Sand | Average Split Tensile Test Value | | |
|---|---|---|---|---|---|
| | | | 7 days | 28 days | 56 days |
| K | 0 | 30 | 1.75 | 2.49 | 2.75 |
| L | 10 | 30 | 1.72 | 2.45 | 2.70 |
| M | 20 | 30 | 1.65 | 2.35 | 2.60 |
| N | 30 | 30 | 1.59 | 2.26 | 2.50 |
| O | 40 | 30 | 1.51 | 2.16 | 2.38 |
| P | 60 | 30 | 1.45 | 2.07 | 2.28 |
| Q | 80 | 30 | 1.37 | 1.95 | 2.15 |
| R | 100 | 30 | 1.33 | 1.90 | 2.10 |

**Table 13: Split Tensile Test Results of Using Cupola Slag and Foundry Sand**

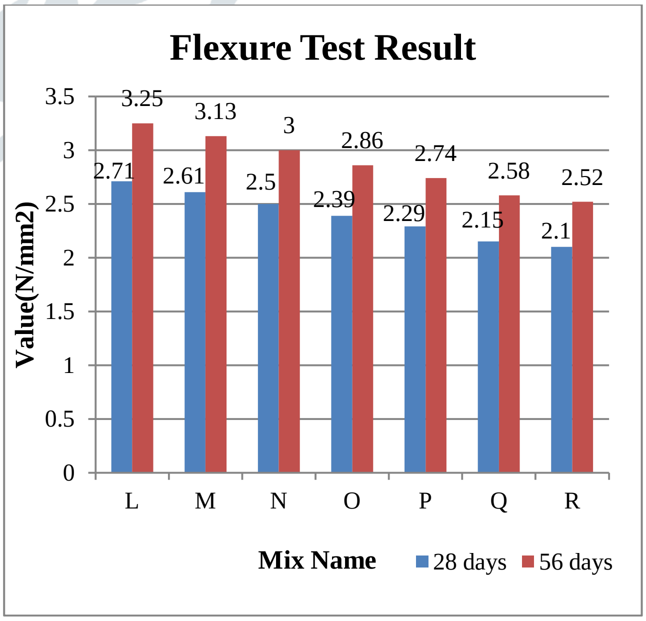



**Graph 7: Split Tensile Test Results of Using Cupola Slag and Foundry Sand**

### 5.3.3 FLEXURE TEST RESULT:

| Mix Name | % Replacement of C.A. by Cupola Slag | % Replacement of F.A. by Foundry Sand | Average Flexural Test Value | |
|---|---|---|---|---|
| | | | 28 days | 56 days |
| K | 0 | 30 | 2.76 | 3.31 |
| L | 10 | 30 | 2.71 | 3.25 |
| M | 20 | 30 | 2.61 | 3.13 |
| N | 30 | 30 | 2.50 | 3.00 |
| O | 40 | 30 | 2.39 | 2.86 |
| P | 60 | 30 | 2.29 | 2.74 |
| Q | 80 | 30 | 2.15 | 2.58 |
| R | 100 | 30 | 2.10 | 2.52 |

**Table 14: Flexure Test Results of Using Cupola Slag and Foundry Sand**

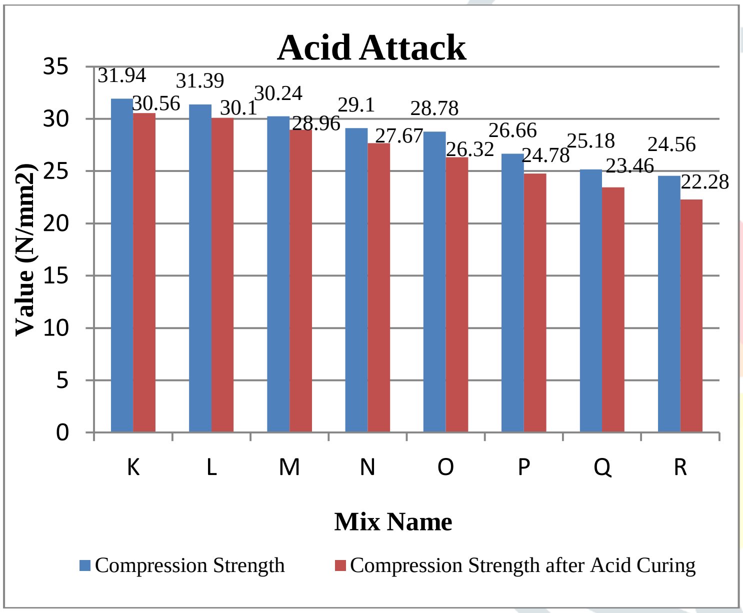



**Graph 8: Flexure Test Results of Using Cupola Slag and Foundry Sand**

**5.3.4 ACID ATTACK:**

| Mix Name | Compressive Strength (MPa) | Compressive Strength after Acid Attack (MPa) | Avg. Loss of Compressive Strength (%) |
|---|---|---|---|
| K | 31.94 | 30.56 | 4.32 |
| L | 31.39 | 30.10 | 4.11 |
| M | 30.24 | 28.96 | 4.23 |
| N | 29.10 | 27.67 | 4.91 |
| O | 28.78 | 26.32 | 8.55 |
| P | 26.66 | 24.78 | 7.05 |
| Q | 25.18 | 23.46 | 6.83 |
| R | 24.56 | 22.28 | 9.28 |

**Table 15: Acid Attack Test Results of Using Cupola Slag and Foundry Sand**

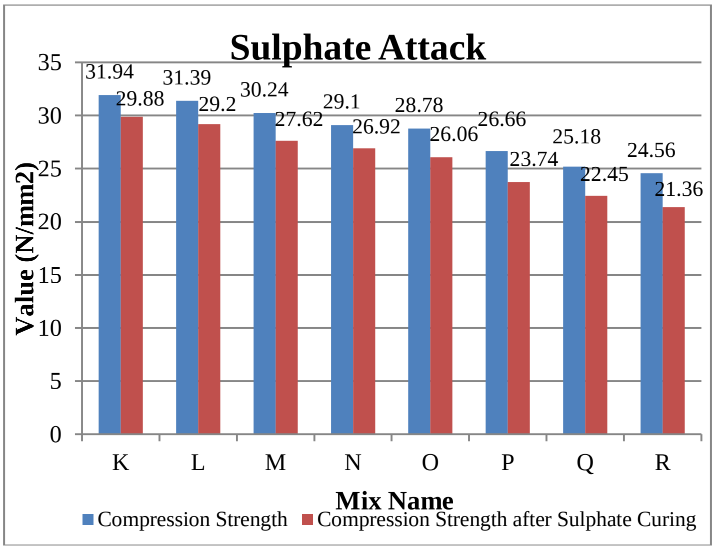



**Graph 9: Acid Attack Test Results of Using Cupola Slag and Foundry Sand**

**5.3.5 SULPHATE ATTACK:**

| Mix Name | Compressive Strength (MPa) | Compressive Strength after Sulphate Attack (MPa) | Avg. Loss of Compressive Strength (%) |
|---|---|---|---|
| K | 31.94 | 29.88 | 6.45 |
| L | 31.39 | 29.20 | 6.98 |
| M | 30.24 | 27.62 | 8.66 |
| N | 29.10 | 26.92 | 7.49 |
| O | 28.78 | 26.06 | 9.45 |
| P | 26.66 | 23.74 | 10.95 |
| Q | 25.18 | 22.45 | 10.84 |
| R | 24.56 | 21.36 | 13.03 |

**Table 16: Sulphate Attack Test Results of Using Cupola Slag and Foundry Sand**

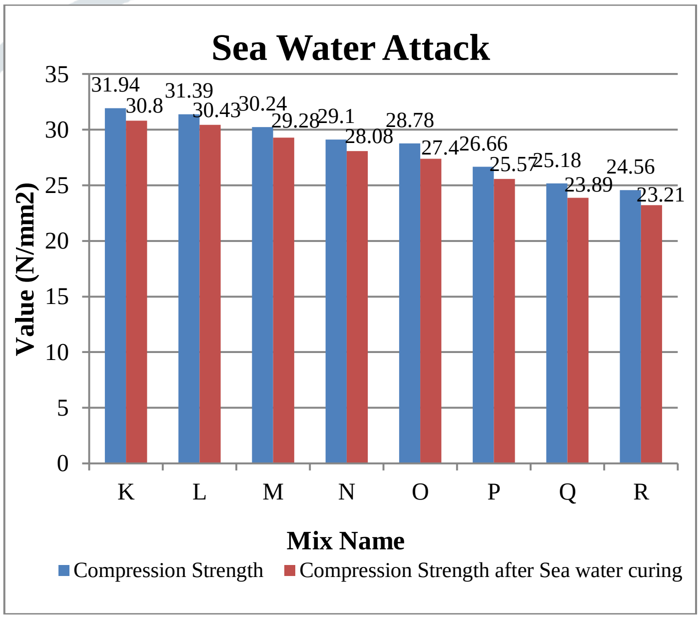



**Graph 10: Sulphate Attack Test Results of Using Cupola Slag and Foundry Sand**

**5.3.6 SEA WATER ATTACK:**

| Mix Name | Compressive Strength (MPa) | Compressive Strength after Sea Water Attack (MPa) | Avg. Loss of Compressive Strength (%) |
|---|---|---|---|
| K | 31.94 | 30.80 | 3.57 |
| L | 31.39 | 30.43 | 3.06 |
| M | 30.24 | 29.28 | 3.17 |
| N | 29.10 | 28.08 | 3.51 |
| O | 28.78 | 27.40 | 4.79 |
| P | 26.66 | 25.57 | 4.09 |
| Q | 25.18 | 23.89 | 5.12 |
| R | 24.56 | 23.21 | 5.50 |

**Table 17: Sea Water Attack Test Results of Using Cupola Slag and Foundry Sand**




**Graph 11: Sea Water Attack Test Results of Using Cupola Slag and Foundry Sand**

## 6. CONCLUSION:

Based on the experiments performed in the laboratory, the following conclusions can be drawn with respect to M20 concrete mix

- The physical properties of Cupola Slag and Foundry Sand are satisfying the requirements of coarse aggregate and fine aggregate.
- At 30% replacement of coarse aggregate with Cupola Slag and fine aggregate with Foundry Sand, There is no reduction in compressive strength with required target strength.
- At 30% replacement of coarse aggregate with Cupola Slag and fine aggregate with Foundry Sand that also shown the required strength in split tensile strength and flexural strength was observed.
- At 30% replacement of both waste materials gave a sufficient durability for concrete cubes after 56 days.
- Based on this experimental investigation, it is found that Cupola Slag can be used as an alternative material to the natural coarse aggregate and Foundry Sand can be used as an alternative material to the natural fine aggregate up to 30% percentage.
- The cost of concrete made with Cupola Slag and Foundry Sand is less than conventional concrete because the Cupola Slag and Foundry Sand which were less cost because of these waste material has no Cost, only transportation charges apply.
- Hence, it could be recommended that slag aggregate could be effectively utilized as coarse and fine aggregate in all concrete applications either as partial or full replacements of normal crushed coarse and natural fine aggregates.

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