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# Experimental Analysis of M-25 Grade Concrete with Usage of Waste Foundry Sand as Partial Replacement of Fine Aggregate

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**Abstract -** *Concrete is a mixture of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time and is used as a construction material. Fine Aggregates which is usually taken as sand is a natural resource and its prices fluctuate with weather, climate and availability. In lieu of making a more eco-friendly and cost efficient concrete, we have done experimental analysis of concrete with partial replacement of sand with Used Foundry Sand. Various properties of hard and fresh concrete are analyzed in order to determine the feasibility of the material to be used as replacement and also to establish that the resulting concrete formed is cheaper, eco-friendly and has the same strength as that of conventional concrete.*

*An M-25 grade of concrete is made with partial replacement (0%, 10%, 20%, 30%, 40%, 50%, and 60%) of fine aggregates with used foundry sand for water cement ratios 0.5. After experimental analysis we conclude that compressive strength of concrete increases and then beyond a certain percentage of used foundry sand, it starts decreasing. Also, it can be concluded that split tensile strength decreases with increase in percentage of used foundry sand.*

***Key Words***: Concrete, Eco- Friendly Concrete, Used Foundry Sand, Fine Aggregates

## 1. INTRODUCTION

In this era, where world is so rapidly progressing, infrastructure has turned out to be the new benchmark for development. To enable the fascinating concrete jungles that we witness today, construction industry has played the most prominent role. To feed the ever-growing demand of infrastructure, it's essential that the raw materials must be always available in ample quantity to the construction industries. The vital organ of construction industries is the concrete of which most of the construction is done.

Concrete is composed of gravels or crushed stones, sand and hydrated cement etc. it has been used over a century in all construction work. As a result, we owe almost all of the best constructions around the world to concrete. Concrete is one of the most prominent inventions in construction industry. One of the main constituents of concrete is fine aggregate which is being used in large quantity all over the world. The Worldwide consumption of fine sand is very high and thus this demand is increasing day by day. The main challenge that our construction industries can face in the near future is to satisfy this ever growing demand of constituents of concrete.

While on the other hand, another relevant issue that one of our other leading industries is facing today is the safe dumping of their waste products. Metal industry is one of such industry that generates a huge amount of waste product and the disposal of these waste products is usually the main problem. The waste generated is dumped to the ground which can pose a serious threat to the environment. So the best possible option to deal with these two relevant issues i.e. the dumping of waste products and that of scarcity of fine aggregates for construction industries can be successfully dealt if we can use the by-product from the metal industries as the constituent in concrete. One such waste generated from metal industry is the 'FOUNDRY SAND'. In this study, experimental investigation is done to determine the suitability of used foundry sand as a substitute of fine aggregates.

## 2. MATERIAL SPECIFICATION

### 2.1 Cement

Cement act as a binding material in concrete which hardens with addition of water and binds together the aggregates to provide desired strength in concrete. In this experimental investigation ordinary Portland cement, Grade 53, manufactured by Aditya Birla Plus is used.

**Table 1** – Properties of Cement

| S.N | Name of the properties | Value |
|---|---|---|
| 1 | Specific Gravity | 3.2916 |
| 2 | Consistency (%) | 33% |
| 3 | Initial setting time (min) | 140 |
| 4 | Final setting time (min) | 490 |
| 5 | Compressive Strength after 7 days(MPa) | 27.33 |
| 6 | Compressive Strength after 28 days(MPa) | 54.91 |

### 2.2 Coarse-Aggregates

Aggregate is a prime constituent of concrete. Aggregates not only act as structural filer, but also occupy most of the

volume of concrete. Coarse aggregates are aggregates with particle size greater than 4.75mm. The usual range lies between 9.5mm and 37.5mm in diameter.

**Table 2** – Properties of Coarse aggregates

| S. N. | Name of the properties | Value |
|---|---|---|
| 1 | Specific Gravity | 2.84 |
| 2 | Water Absorption (%) | 0.4004% |
| 3 | Aggregate Impact Value (%) | 23.66% |
| 4 | Fineness Modulus | 7.29 |

## 2.3 Fine Aggregates

Aggregates with most particles passing through a 3/8-inch sieve are called fine aggregates. Generally, the fine aggregates comprise of natural sand or crushed stone.

**Table 3** - Properties of Fine aggregates

| S.N. | Name of the properties | Value |
|---|---|---|
| 1 | Specific Gravity | 2.525 |
| 2 | Water Absorption (%) | 0.67% |
| 3 | Moisture Content (%) | 1.729% |
| 4 | Fineness Modulus | 2.418 |
| 5 | Zone to which sand belongs | 3 |

## 2.4 Foundry Sand

Foundry sand is uniform sized, high quality silica sand which is bound to form a mould for casting of ferrous and nonferrous metal. In foundry, the ferrous metal casts are cast iron and steel, non ferrous metal are aluminum, copper, brass and bronze. High quality specific size silica sand is used for their molding and casting process. This sand is successfully recycled and reused in foundry. When this sand can no longer be reused it is removed from the foundry. The removed sand is termed as 'Waste Foundry Sand'. The waste foundry sand is black in color and contain large amount of fines.

**Table 4** - Properties of Foundry sand

| S.N. | Name of the properties | Value |
|---|---|---|
| 1 | Specific Gravity | 2.57 |
| 2 | Water Absorption (%) | 0.33% |
| 3 | Moisture Content (%) | 0.17% |
| 4 | Fineness Modulus | 2.42 |
| 5 | Zone to which sand belongs | 3 |

**Figure 1 –** Waste Foundry sand

## 3. EXPERIMENTAL PROCEDURE

### 3.1 Mix Design

The mix proportion for pumpable concrete mix of M-25 grade for water-cement ratio 0.5 is 1:0.5:1.86:2.84. The mix design is done as per IS 10262-2009.

### 3.2 Batching, Mixing and Casting of test cubes

The cement, water, coarse aggregates and fine aggregates are mixed as per the mix design for various percentages (0%, 10%, 20%, 30%, 40%, 50%, and 60%) of substitution of fine aggregates with waste foundry sand. The concrete mix is filled in moulds (size 150mmX150mmX150mm) and is vibrated on vibrating table. The top surface of mold is finished and leveled properly. After being kept for 24 hours the set cubes are removed from molds and are kept in curing tank for 7 and 28 days.

### 3.3 Testing of cubes

The cubes are taken out of the curing tank after desired amount of time and are tested in universal testing machine for compressive strength.

### 3.4 Batching, Mixing and Casting of test cylinders

The readings of compressive strength was analyzed and the cylinders(size 300mm X 150mm diameter) were casted for the percentages (0%, 30%, 40% and 50%) of replacement of fine aggregate with used foundry sand, at which we got the most satisfactory outcome. The casted cylinders were then put in the curing tank for 28 days.

### 3.5 Testing of cylinders

The cylinders were taken out after 28 days and are tested in universal testing machine for tensile strength.

## 4. EXPERIMENTAL RESULTS-

Various properties of fresh concrete for various percentage of waste foundry sand are listed below.

**Table 5** – Slump & Compaction Factor

| Percentage of waste Foundry Sand in Mix | Slump (mm) | Compaction Factor |
|---|---|---|
| **0%** | 102mm | 0.871 |
| **10%** | 80mm | 0.874 |
| **20%** | 65mm | 0.853 |
| **30%** | 57mm | 0.83 |
| **40%** | 40mm | 0.769 |
| **50%** | 20mm | 0.747 |
| **60%** | 10mm | 0.729 |

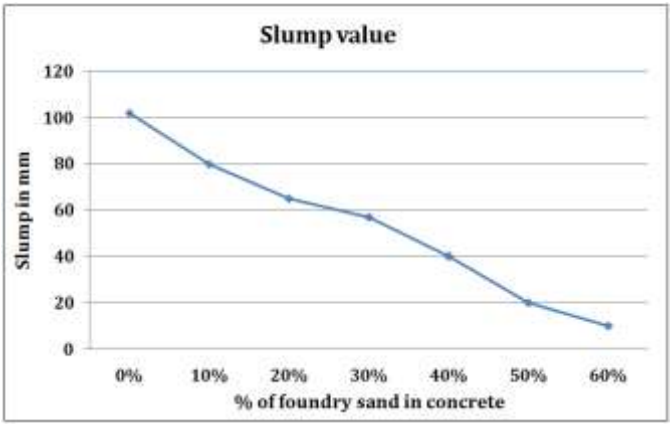


**Fig. 2** – Graph of slump value VS various percentages of foundry sand

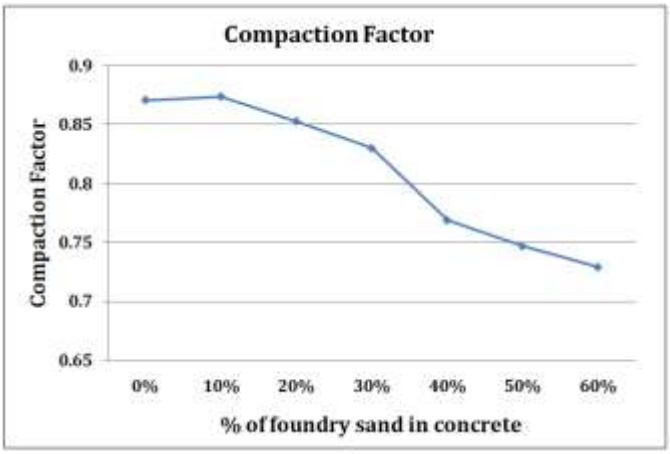


**Fig. 3** – Graph of compaction factor VS various percentages of foundry sand

**Table 6** – Ultimate compressive strength of cubes after 7 and 28 days curing

| Percentage of waste foundry sand in concrete | Average ultimate compressive strength at 7 days (MPa) | Average ultimate compressive strength at 28 days (MPa) |
|---|---|---|
| **0%** | 29.47 | 37.39 |
| **10%** | 26.66 | 32.95 |
| **20%** | 28.03 | 36.05 |
| **30%** | 28.04 | 36.22 |
| **40%** | 29.73 | 37.5 |
| **50%** | 24.77 | 33.29 |
| **60%** | 24.15 | 31.24 |

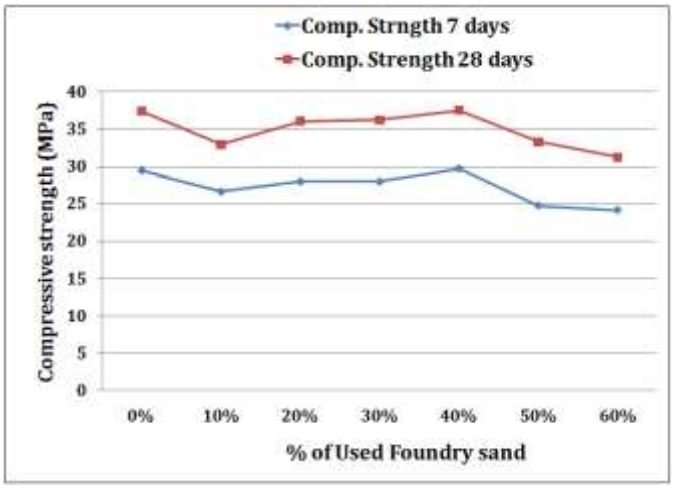


**Fig. 4 –** Graph of compressive strength of concrete VS various percentages of foundry sand

**Table 7 -** Split Tensile Strength at 28 days

| % of waste foundry sand in concrete | Average split tensile Strength after 28 days (MPa) |
|---|---|
| **0%** | 3.15 |
| **30%** | 3.02 |
| **40%** | 2.76 |
| **50%** | 2.616 |

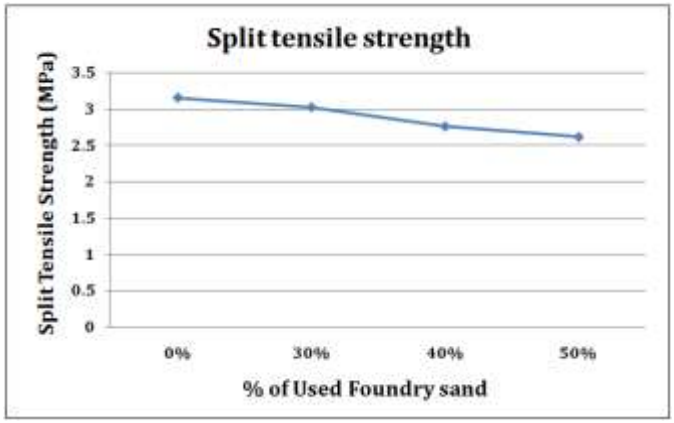


**Fig. 5 –** Graph of split tensile strength VS % of used foundry sand in concrete

## 5. Cost Analysis

The cost of foundry sand is nearly 20 times lesser then the same quantity of normal sand.

**Table 8** – Cost comparison of normal sand and waste foundry sand

| Type of Sand | Quantity (in cubic metres) | Cost (in Rupees) |
|---|---|---|
| Normal Sand | 7.6-10 | 8000 |
| Waste Foundry Sand | 7.6-10 | 400 |

## 6. Conclusion

- On addition of used foundry sand in concrete, the compressive strength of concrete first decreases and then increases for 40% replacement of fine aggregate.
- For this experiment, we get maximum compressive strength at 40% replacement of fine aggregate with waste foundry sand.
- Split tensile strength decreases with increase in percentage of waste foundry sand in concrete.
- Value of slump and compaction factor decreases on increasing the percentage of replacement of waste foundry sand.
- Waste foundry sand is 20 times cheaper than normal sand. Thus the concrete formed using waste foundry sand is quite economical.
- Usage of waste foundry sand provides a solution to disposal problem of foundry industries. So the concrete formed is eco-friendly.
- The cost of disposal and maintenance of waste product of metal and foundry industries is reduced.

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