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**APPLICATION OF WASTE FOUNDRY SAND FOR EVOLUTION OF LOW COST CONCRETE**

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***Abstract***

*The operation of waste foundry sand for the development of low- cost concrete involves incorporating discarded foundry sand as a partial relief for conventional fine summations in concrete mixture. This approach aims to address both environmental enterprises related to waste disposal and cost- effectiveness in construction accoutrements. The application of waste foundry sand in concrete product offers a sustainable result by reducing tip waste and conserving natural coffers. Through applicable engineering and blend design, the performing low- cost concrete maintains needed structural and continuity properties while also contributing to a further Eco-friendly construction assiduity. An experimental disquisition is carried out on a concrete containing waste foundry sand in the range of 0, 20, 30, 40, 50 and 60 by weight for M- 30 grade concrete( PPC). Material was produced, tested and compared with conventional concrete in terms of plasticity and strength. These tests were carried out on standard cell of 150 \* 150 \* 150 \* mm for 7 and 28 days to determine the mechanical properties of concrete. Through experimental result we conclude that the compressive strength increases with increase in partial relief of waste foundry sand and split tensile strength decreases with increases in chance of waste foundry sand. So foundry sand can be safely used in concrete for continuity and strength purpose.*

***Keywords:*** *MPa, concrete mixtures, foundry eco-friendly, pumpable.*

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# INTRODUCTION

## Foundry sand is high quality silica sand with invariant physical characteristics. It's a by- product of ferrous and non-ferrous essence casting diligence, where sand has been used for centuries as a molding material because of its thermal conductivity. It's a by- product from the product of both ferrous and non-ferrous essence castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the assiduity sector from which it originates..(5, 6) In ultramodern foundry practice, sand is generally reclaimed and reused through numerous product cycles. Assiduity estimates that roughly 100 million tons of sand is used in product annually of that 6- 10 million tons are discarded annually and are available to be reclaimed into other products and in assiduity..(2) The automotive diligence and its corridor are the major creators of foundry sand. Foundries buy high quality size-specific silica sand for use in their molding and casting operations.

## The objectification of waste foundry sand into construction accoutrements, similar as concrete, presents a promising avenue to address both environmental and profitable enterprises. This innovative approach not only contributes to waste reduction but also has the implicit to enhance the properties of construction accoutrements while reducing product costs.( 1,3) The application of waste foundry sand in concrete mixture is an active area of exploration and development, aiming to unlock its eventuality as a functional and sustainable component in the construction assiduity.

# 1. WASTE FOUNDRY SAND

**1.1 Physical Properties**

## Typical physical properties of spent foundry sand from green sand systems are given in Table-1.1. The grain size distribution of spent foundry sand is veritably invariant, with roughly 85 to 95 of the material between0.6 mm and0.15 mm (No. 30 and No. 100) sieve sizes. 5 to 12 of foundry sand can be anticipated to be lower than 0.075 mm (No. 200 sieve). The flyspeck shape is generally sub angular to round. Waste foundry sand gradations have been set up to be too fine to satisfy some specifications for fine total.

**Table 1.1** Typical physical properties of spent green foundry sand

|  |  |  |
| --- | --- | --- |
| **Property** | **Results** | **Test Methods** |
| Specific Gravity | 2.34 | ASTM D854 |
| Fineness Modulus | 1.8 | ASTM C136 |
| Absorption, % | 0.45 | ASTM C128 |
| Moisture Content, % | 0.1-10.1 | ASTM D2216 |
| Plastic Limit/Plastic Index | Non-plastic | AASTHO T90/ASTM D4318 |

**1.2 Chemical Composition**

## Chemical Composition of the foundry sand relates directly to the essence moldered at the foundry. This determines the binder that was used, as well as the combustive complements. Generally, there's some variation in the foundry sand chemical composition from foundry to foundry. Montmorillonite is also present in foundry sand. (7) Sands produced by a single foundry, still, won't probably show significant variation over time. Also, amalgamated sand produced by colleges of foundries frequently produce harmonious sand. The chemical composition of the foundry sand can impact its performance. Spent foundry sand consists primarily of silica sand, carpeted with a thin film of burnt carbon, residual binder (betonies, ocean coal, and resins) and dust.

## Table-1.2. Chemical Composition of Foundry Sand

|  |  |
| --- | --- |
| **Constituent** | **Value (%)** |
| SiO2 | 83.93 |
| Al2O3 | 0.02 |
| Fe2O3 | 0.950 |
| CaO | 1.03 |
| MgO | 1.77 |
| SO3 | 0.057 |
| LOI | 2.19 |

**1.3 Mechanical Properties**

## Typical mechanical Properties of spent foundry sand are listed in Table –1.3. Spent foundry sand has good continuity characteristics as measured by lowMicro-Deval bruise and magnesium sulphate soundness loss tests. TheMicro-Deval bruise test is a waste/ bruise test where a sample of the fine total is placed in a pristine sword jar with water and sword comportments and rotated at 100 rpm for 15 twinkles. The percent loss has been determined to relate veritably well with magnesium sulphate soundness and other physical Properties. Recent studies have reported fairly high soundness loss, which is attributed to samples of set sand loss and not a breakdown of individual sand patches. The angle of shearing resistance (disunion angle) of foundry sand has been reported to be in the range of 33 to 40 degrees, which is similar to that of conventional sand.

**Table-1.3.** Typical mechanical properties of waste foundry sand

|  |  |  |
| --- | --- | --- |
| **Property** | **Results** | **Test Methods** |
| Micro-Devil Abrasion Loss,% | <2 | - |
| Magnesium Sulphate Soundness Loss,% | 5-15  6-47 | ASTM C88 |
| Friction Angle (deg) | 33-40 | - |
| California Bearing Ratio,% | 4-20 | ASTM D1883 |

**2. Foundry Sand Engineering Characteristics**

Since foundry sand has nearly all the properties of natural or cultivated sand, it can typically be used as a sand relief. It can be used directly as a filler material in dikes. It can be used as a sand relief in hot blend asphalt, flow suitable stuffings, and Portland cement concrete. It can also be blended with either coarse or fine summations and used as a road base or sub base material.

**3. LITERATURE REVIEW**

**Eknath P Salokhe and D B Desai**, **2013** performed experimental investigations to evaluate the comparative study of the properties of fresh and hardened concrete containing ferrous and nonferrous foundry waste sand as fine aggregate replacement. Fine aggregates replaced with four percentages of foundry sand 0%, 10%, 20% and 30% by weight of fine aggregate for M-20 grade concrete at the curing periods of 7 days and 28 days. Compressive strength at 28 days increases with the increase in ferrous FWS and at 30% addition.

**Dushyant Rameshbhai Bhimani et al., 2013** performed experimental investigation on strength of concrete and optimum percentage of the partial replacement by replacing fine aggregate via 0%, 10%, 30%, and 40% by weight for M-20 grade concrete. As a result, the compressive increased up to 40% addition of used foundry sand. Compressive strength increase when replacement of used foundry sand percentage increases when compare to traditional concrete.

**Yogesh Aggarwal et al., 2014** investigate properties of concrete with waste foundry sand and bottom ash as a replacement of fine aggregate in various percentages (0-60%) at 28, 90 and 365 days of curing period. They observed that the greatest increase in compressive, tensile strength, and flexural strength compared to that of the conventional concrete was achieved by substituting 30% of the natural fine aggregates with industrial by-product aggregates. It was observed that the greatest increase in compressive, splitting tensile strength, and flexural strength compared to that of the conventional concrete was achieved by substituting 30% of the natural fine aggregates with industrial by-product aggregates. The inclusion of waste foundry sand and bottom ash as fine aggregate does not affect the strength properties negatively as the strength remains within limits except for 60% replacement.

**Mr.P.Sivasankar, M.E.,Mr.P.KaruppasamyM.E. 2020** Experimental investigation on waste foundry sand with recon fiber in reinforced cement concrete, they got a result the Compressive strength, Split tensile strength and Flexural strength of the Conventional concrete with waste improved holding of cement aggregates, Tensile strength. Hence in future it is advised to use 60% replacement of waste foundry sand and 1% of Recron fibre for M30 grade concrete to get good results also reduce environmental disposal problems of waste foundry sand.

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**Shubham S. Amritkar 1 , Sanket N. Chandak 2 , Sagar S. Patil 3 , Rahul A. Jadhav 4 2015** performed experimental investigation,Effect of Waste Foundry Sand (WFS) on the Mechanical properties of concrete with artificial sand as Fine Aggregate, they found the conclusion, Compressive strength increases on increase in percentage of waste foundry sand as compared to traditional concrete. And maximum compressive strength is obtained at 15% replacement of fine aggregate by waste foundry sand. Also fined Split tensile strength decrease on increase in percentage of waste foundry sand.

**Sarita Chandrakanth1 , Ajay.A.Hamane2 2016** performed experimental investigation, Partial Replacement of Waste Foundry Sand and Recycled Aggregate in Concrete Depending upon results and methodology adopted conclusion were made regarding properties of concrete incorporating waste foundry sand and recycled aggregate.

It is found that compressive strength of concrete mix is increases with increase in percentage of waste foundry sand and recycled aggregate as compare to normal concrete. It was maximum for 40% replacement after that it reduces. It is also found that split tensile strength increases with increase in percentage of waste foundry sand and recycled aggregate up to 40%replacement after that it reduces. It is also found that flexural strength increases with increase in percentage of waste foundry sand and recycled aggregate up to 40%replacement after that it reduces

**Gurpreet Singh, 2Ankush Thakur 2018** Experimental investigation of Durability of concrete made with foundry sand. They got a result, Shrinkage ratio of WFS mixes was found higher at initial age of concrete but leveled out to other concretes after 28 days. Modulus of elasticity of concretes with WFS was found similar to compressive strength results. Upto 30% WFS level, improvements in modulus of elasticity have been reported. Improvement in abrasion resistance of concrete with WFS is reported attributable to dense matrix due to addition of fine WFS. Waste foundry sand addition had positive influence on sulphate resistance of concrete at up to 30% replacement ratio. At higher substitution the resistance degraded which is attributed to traces of SO3 present in WFS. Similarly beyond 30% substitution led to increase in carbonation depth in concrete with WFS which is attributed to poor workability which led to poor compaction.

**MIX PROPORTION AND PREPARATION OF SPECIMENS**

The admixture was prepared according to [6] to get the 28- day compressive strength of 30 MPa. The ratio of concrete design blend was12.032.66(C S A). Five relief situations and 60 of foundry sand were used in trial mixture. Water/ cement ratio of all mixture is kept invariant with a value of0.40. Plasticizer was used to get keep lower water/ cement ratio. Details of mixture, unit weight of different ingredients are shown in Table

**Table -1.4** Proportion of M-30 Grade Concrete

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Mix** | **Cement**  **(Kg/m3)** | **Sand**  **(Kg/m3)** | **Coarse Aggregate**  **(Kg/m3)** | **Foundry sand**  **(Kg/m3)** | **Water**  **(Kg/m3)** | **Plasticizer**  **(Kg/m3)** | **Plasticizer**  **(%)** |
| M-1 | 394 | 799.17 | 1111.86 | 0 | 157.60 | 1.97 | 0.5 |
| M-2 | 394 | 639.34 | 1111.86 | 159.83 | 157.60 | 1.97 | 0.5 |
| M-3 | 394 | 559.42 | 1111.86 | 239.75 | 157.60 | 3.94 | 1 |
| M-4 | 394 | 479.50 | 1111.86 | 319.67 | 157.60 | 7.88 | 2 |
| M-5 | 394 | 399.58 | 1111.86 | 399.58 | 157.60 | 7.88 | 2 |
| M-6 | 394 | 319.67 | 1111.86 | 479.50 | 157.60 | 7.88 | 2 |

**Material Specification**

**Cement**

IS mark 53 grade cement (Brand-Ambuja cement) was used for all concrete mixes. The cement used was fresh and without any lumps. Testing of cement was done as per IS: 8112-1989. The various tests results conducted on the cement are reported in Table 3.1.

**Table 3.1** Properties of cement

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Characteristics** | **Values obtained** |
| 1. | Normal consistency | 34% |
| 2. | Initial setting time (minutes) | 30 min. |
| 3. | Final setting time (minutes) | 600 min. |
| 4. | Fineness (%) | 3.5% |
| 5. | Specific gravity | 3.15 |

**Coarse Aggregate**

Locally available coarse aggregates having the maximum size of 10 mm and 20mm were used in the present work. Testing of coarse aggregates was done as per IS: 383-1970. The 10mm aggregates used were first sieved through 10mm sieve and then through 4.75 mm sieve and 20mm aggregates were firstly sieved through 20mm sieve. They were then washed to remove dust and dirt and were dried to surface dry condition. The results of various tests conducted on coarse aggregate are given in Table 3.2

**Table 3.2** Properties of Coarse aggregates

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Characteristics** | **Value** |
| 1. | Type | Crushed |
| 2. | Specific gravity | 2.7 |
| 3. | Water absorption (%) | 1.14 |
| 4. | Moisture content (%) | 0.33 |
| 5. | Fineness modulus | 6.35 |

**Fine Aggregate**

The sand used for the experimental programme was locally procured and conformed to grading zone II as per IS: 383-1970.[11] The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and then was washed to remove the dust. Properties of the fine aggregate used in the experimental work are tabulated in Table 3.3

**Table 3.3** Properties of fine aggregates

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Characteristics** | **Value** |
| 1. | Type | Natural |
| 2. | Specific gravity | 2.68 |
| 3. | Water absorption (%) | 1.2 |
| 4. | Moisture content (%) | 0.16 |
| 5. | Fineness modulus | 3.2 |

**Foundry Sand**

Investigations were made on waste foundry sand procured from Aurangabad Foundries, Chikalthana, Aurangabad, Maharashtra. The chemical and physical properties of the foundry sand used in this investigation are listed in Table 3.4 and Table 3.5 respectively.

**Table 3.4** Physical Properties of Foundry Sand

|  |  |  |
| --- | --- | --- |
| **Property** | **Results** | **Test Methods** |
| Specific Gravity | 2.34 | ASTM D854 |
| Fineness Modulus | 1.8 | ASTM C136 |
| Absorption, % | 0.45 | ASTM C128 |
| Moisture Content, % | 0.1-10.1 | ASTM D2216 |
| Plastic Limit/Plastic Index | Non-plastic | AASTHO T90/ASTM D4318 |

**Table 3.5** Foundry sand sample chemical oxide composition

|  |  |
| --- | --- |
| **Constituent** | **Value (%)** |
| SiO2 | 83.93 |
| Al2O3 | 0.02 |
| Fe2O3 | 0.950 |
| CaO | 1.03 |
| MgO | 1.77 |
| SO3 | 0.057 |
| LOI | 2.19 |

**Water**

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Potable tap water was used for the concrete preparation and for the curing of specimens.

**Superplasticizer**

Sulphonated Naphthalene Formaldehyde Polymers based super plasticizer is used, which confirming the specification of IS 9103 – 1999. The superplasticizer is of the brand Sika India Pvt. Ltd. having product name as Sikament – 610. The dosage of superplasticizer varied from 0.5% to 2% by weight of cement in plain concrete, concrete incorporating foundry sand. Technical data of Superplasticizer are listed in Table 3.6

**Table 3.6** Technical data of Super plasticizer

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Characteristics** | **Details** |
| 1. | Color | Dark Brown liquid |
| 2. | Chemical Base | Modified Naphthalene Formaldehyde Sulphonate |
| 3. | Relative Density | ~ 1.20 kg/l at 30°C |
| 4. | pH value | Min 6 |
| 5. | Chloride content | 0.2% Max. |
| 6. | Air entrainment | Nil |
| 7. | Nitratio content | Nil |

**Specimen Preparation and Casting**

For compressive strength concrete cubes of size 150mm X 150mm X 150mm [7] were casted, and also for splitting tensile strength and modulus of elasticity 150 mm diameter 300 mm high cylinders were prepared [5] [6] Specimens were removed from molds after 24-h of casting and were placed into a water-curing room till the time of testing.

**EXPERIMENTAL AND TESTING**

* **Slump Test**
* **Compressive strength test**
* **Split tensile test**

1. **Slump Test**

Slump test was performed on fresh concrete to check the workability of concrete. Slump was measured as per ASTM standards. Fresh concrete after mixing is poured in the standard cone in three layers. Each layer was compacted with 25 blows of tamping rod and the drop in height is noted. It is observed that the slump value decreases with increase in percentage replacement of natural sand with WFS for the same w/c ratio.

1. **Compressive Strength Test**

Compressive strength tests were performed on compression testing machine. In this test six cubes from each mix were tested. The test was carried at the end of 7 and 28 days of curing. The compressive strength of any mix was taken as the average of strength of three cubes.

1. **Split Tensile Strength Test**

Cylinder specimens were tested for splitting tensile strength. The test was carried out according to IS: 5816-1970(10). In this test compressive line loads were applied along a vertical symmetrical plane, which causes splitting of specimen. The test was carried at the end of 7 and 28 days of curing. The tensile strength of any mix was taken as the average of strength of three cubes.

**RESULTS AND DISCUSSION**

In this research the values of compressive strength for different replacement levels of foundry sand contents (0%, 20%, 30%, 40%, 50% and 60%) at the end of different curing periods (7 days, 28 days) are given in Table 4.1

**Table 4.1:** Compressive Strength (MPa) of Concrete with Foundry Sand

for M30 Grade

|  |  |  |  |
| --- | --- | --- | --- |
| **Foundry Sand**  **Content, %** | **Designation** | **Compressive Strength, MPa** | |
| **7 days** | **28 days** |
| 0 | M-1 | 32.50 | 40.10 |
| 20 | M-2 | 37.25 | 48.10 |
| 30 | M-3 | 37.33 | 47.46 |
| 40 | M-4 | 37.91 | 48.05 |
| 50 | M-5 | 36.83 | 46.88 |
| 60 | M-6 | 29.50 | 37.28 |

There is a considerable improvement in the compressive strength of concrete with inclusion and increase in the percentage of waste foundry sand up to 60%. The maximum compressive strength was achieved with 50% replacement of fine aggregate with waste foundry sand.

**Split Tensile Strength**

It was found that split tensile strength of concrete incorporating foundry sand (using 0 %, 20 %, 30 %, 40 %, 50 % and 60 % replacement levels with fine aggregate and a w/c of 0.4) depended on the percentage of foundry sand used. The variation of split tensile strength was shown in Table 4.2.

**Table 4.2:** Split Tensile Strength (MPa) of Concrete with Foundry Sand for M30 Grade

|  |  |  |
| --- | --- | --- |
| **Foundry Sand**  **Content, %** | **Designation** | **Split Tensile Strength, MPa**  **28 days** |
| 0 | M-1 | 4.38 |
| 20 | M-2 | 4.77 |
| 30 | M-3 | 5.01 |
| 40 | M-4 | 5.81 |
| 50 | M-5 | 5.74 |
| 60 | M-6 | 4.50 |

There is a considerable improvement in the split tensile strength of concrete with inclusion and increase in the percentage of waste foundry sand up to 60%. The maximum strength was achieved with 40% replacement of fine aggregate with waste foundry sand.

**CONCLUSIONS**

According to the results of this study, the following conclusions can be drawn.

1. The fresh concrete data shows that addition of foundry waste sands gives low slump mainly due to the presence of very fine binders, therefore use of super plasticizer is essential in order to maintain a good workability.
2. Compressive strength of concrete increased with the increase in sand replacement with different replacement levels of foundry sand. However, at each replacement level of fine aggregate with foundry sand, an increase in strength was observed with the increase in age.
3. In this study, maximum compressive strength is obtained at 50% replacement of fine aggregate by waste foundry sand. At 60% replacement it goes on decreasing but still higher than ordinary concrete.
4. Split Tensile Strength also showed an increase with increase in replacement levels of Foundry Sand with fine aggregate. Split Tensile Strength also increased with increase in age.

Thus, sand replaced with waste foundry sand up to 60% is suitable in the construction works.

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