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# Experimental Study of Concrete using Stone Slurry & Waste Foundry Sand

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**Abstract—***The bulk generation of stone slurry powder from quarries, stone mining industry, aggregate manufacturing plant and decorative stone plants is a serious problem for environment. However, stone slurry provides economical and technical suitability for concrete. In this experimental study of the check the suitability of stone slurry and waste foundry sand on fresh and hardened properties of concrete. In this research, 30% waste foundry sand (WFS) is kept constant as a partial replacement of natural river sand and cement is replaced with stone slurry (SS) in varying percentages (0%, 10%, 20% and 30%) for M40 grade concrete. For assessment of fresh properties of concrete slump cone test is conducted. similarly, compressive strength test, split tensile test and flexural strength tests are conducted to evaluation of mechanical properties of concrete as per Indian standard. This investigation to assess the quality of hardened concrete at 7and28 days curing period in normal water. According to this experiment, results show that use of stone slurry as a partial replacement of cement in concrete improves the mechanical properties of concrete up to 20% replacement. Thereafter a marginal decrease in strength shown for 30% replacement of stone slurry. Similarly, the mixes containing 20% SS exhibits better quality when compared to control mix 0% stone slurry. As a sustainable approach, use of SS up to 20% have a greater impact on reducing cost of construction and makes concrete eco-friendly.*

## INTRODUCTION

Concrete is the most widely used material in the construction industry. Main elements of the concrete are coarse aggregate, fine aggregate, cement and water. The numerous demanding applications of concrete is not readily met with Ordinary Portland cement (OPC) alone. To meet up the demand and as well as ensured the green concrete durability, it has become necessary to incorporate constituent additions with the best combination of others by-product as replacement to improve the performance without threaten the strength of concrete. In recent days, there is so many shortages of river sand due to over exploitation of natural resources. Instead of river sand we use waste material like waste foundry sand which has rich silica in high quality. In this paper we also solve the problem of economy by replacing cement with stone slurry. this research reports the experimental study of concrete using stone slurry and waste foundry sand. In this experiment 30% waste foundry sand is kept constant as partial replacement of river sand. From many literatures we get comprehensive results about waste foundry sand is as partial replacement of natural river sand. In this research, authors are considering M40 grade concrete as per IS:10262-2019 Specifications. Total five mixes (FS0SS0, FS30SS0, FS30SS10, FS30SS20 and FS30SS30) are considered for this investigation. In these mixes,30%waste foundry sand is kept constant. Similarly, cement is replaced with stone slurry (SS) in varied proportion (0%,10%,20%&30%). To improve the fluidity properties of concrete, FOSROC Conplast SP430 SNF superplasticizer is used. As mentioned earlier, fine aggregate (Natural River sand) is used in the preparation of concrete as a filler material. In general particle size passing through 4.75 mm are used as a fine aggregate in the preparation of concrete. River sand is rich in silica and provides an impaired bonding between aggregate and binding materials. It is the primary source obtained from the river. Similarly, river sand does not contain any impurities such as silt, clay, and dust, etc. use of river sand improves the strength properties over a longer period. Hence it is a widely accepted as a fine aggregate for the concrete preparation. Due to the overexploitation of river sand, it is severely impacted the environment and safety of the people residing near them. Massive demand for the clean river sand leads to scarcity of resources, and an increase in its costs and leads to scope for the development of alternate material. To reduce the usage of river sand and depletion of natural resources, researchers are busy in identifying the suitable replacement like Plastic powder, coal bottom ash , manufactured sand, copper slag, steel slag etc.

## LITERATURE REVIEW

Several authors [1–21] have reported the use of used-foundry sand in various civil engineering applications. Abichou et al. [1], MOEE [2], AFS [3], FIRST [4], Javed and Lovell [5,6], Kleven et al. [7], and Traeger [8] have reported the use of foundry sand in high way applications. Engroff et al. [9], Fero et al. [10], Ham and Boyl. T.V Reshma experimental investigated about the effect of waste foundry sand and fly ash on mechanical and fresh properties of concrete. In this research 30% fly ash is kept constant as partial replacement of cement and natural river sand is replaced with waste foundry sand (WFS) in varying percentages 0%,10%,20%,30% & 40% for M40 grade concrete. Maximum Compressive strength was

observed at the 30% replacement of sand by WFS. 28 days compressive strength of M40 is with 0%,10%,20%,30% & 40% replacement by WFS is 40.56,42.35,42.96,43.05& 41.26MPa respectively. It is also reported about workability is better obtained with increase in WFS and maximum slump value is achieved at 30%WFS. Thereafter marginal decrease in slump value and compaction factor is noticed for 40%WFS.

**Research significance**

There is a large-scale production/availability of used/spent foundry sand from foundry industries in the world. Though used/ spent foundry sand has been extensively investigated as constituent's materials for controlled low-strength materials (CLSM), its possible utilization in concrete has not been investigated thoroughly. In this work, effects of utilization of used-foundry sand as partial replacement for regular sand (fine aggregate) in concrete was investigated. The data obtained in this investigation will be used to establish mixture proportions for concrete and construction. Stone slurry is a fine powdered form of quarry dust which is obtained by quarrying of stone blocks. It is obtained by suspension process after regular supply of water in quarry. This is formed throughout the aggregate manufacturing process which is often found as waste material in quarries and expelled out by channel drainage so that we accumulate and dispose of stone slurry. In stone slurry has large volume of lime stone fines present. In this experiment 30% waste foundry sand is kept constant as partial replacement of river sand and cement is replaced with stone slurry in varying percentages (0%, 10%,20%&30%) for M40 grade concrete. From many literatures we get comprehensive results about waste foundry sand is as partial replacement of natural river sand.

## EXPERIMENTAL DETAIL

### Material

#### *Cement*

To prepare M40 grade concrete, a combination of OPC 43 grade cement is used as a binding material, conforming to Indian standard IS:12269-2013. The physical and chemical properties of cement. tabulated in Tables.

**Table 1: Physical Properties of Cement**

| Type & grade | OPC 43 |
|---|---|
| Consistency | 31 |
| Initial setting time | 34 min |
| Specific gravity | 3.1 |
| 90-micron sieve fineness | 7.2 |
| Surface area($cm^2$/gm) | 3780 |
| Final setting time | 530 min |
| Color | gray |

#### *Aggregate*

Coarse aggregates are particles larger than 4.75 mm in size and are typically made of crushed stone, gravel, or recycled concrete. The use of crushed angular shape of 20 mm nominal size coarse aggregates is common for the preparation of concrete, as it provides good workability, strength, and durability. The Indian standard IS:383–1970 specifies the requirements and methods of testing for coarse aggregates used in concrete. The proportion of coarse aggregates used in concrete can vary depending on the specific requirements of the project. In this case, the proportion used is 40% of 12.5 mm and 60% of 20 mm size. The physical properties of coarse and fine aggregates used are tabulated in Table3.

#### *Waste foundry sand (WFS)*

Waste foundry sand is a by-product of the foundry industry, which produces large amounts of castings made of ferrous metals such as cast iron and steel, as well as nonferrous metals like aluminium, copper, brass, and bronze. Foundries typically use high-quality, specific size silica sand for their moulding and casting processes. During the casting process, the sand is used repeatedly until it can no longer be reused in the foundry, at which point it is removed from the manufacturing unit and considered waste foundry sand (WFS). In this experiment a fixed constant of 30% waste foundry sand is kept constant as a partial replacement of river sand. The physical and chemical is shown in table by SEM & EDS test.

#### *Stone slurry (SS)*

Stone slurry is a fine powdered form of quarry dust which is obtained by quarrying of stone blocks. It is obtained by suspension process after regular supply of water in quarry. This is formed throughout the aggregate manufacturing process which is often found as waste material in quarries and expelled out by channel drainage so that we accumulate and dispose of stone slurry. In stone slurry has large volume of lime stone fines present. For this experiment stone slurry as a partial replacement of cement in varying 0%, 10%, 20% and 30%.the physical & chemical properties

#### *Superplasticizer*

Superplasticizers are chemical admixtures that are commonly used in concrete preparation to improve the fresh and fluid properties of concrete. They can increase the workability and flowability of concrete without compromising its strength or durability. Superplasticizers work by dispersing the cement particles, which reduces the water-to-cement ratio and allows for more efficient hydration of the cement. In this experimentation, FOSROC Conplast SP430 SNF superplasticizer is used as a chemical admixture. This superplasticizer conforms to the Indian standard specification IS:516–1959, which specifies the requirements and methods of testing for superplasticizers used in concrete. The dosage of superplasticizer used in this research is 1.5% by weight of the binding material.

#### *Mix proportion*

For this research, authors used M40 grade concrete as per Indian standard IS:10262–2019 [39]. Totally four mixes (MIX1, MIX2, MIX3, and MIX4) are considered for the

investigation of fresh and mechanical properties of M40 grade concrete. In these mixes, 30% waste foundry sand is kept constant. Similarly, fine aggregate is replaced with waste stone slurry in varying percentages such as 0% MIX1, 10% MIX2, 20% MIX3, and 30% (MIX4). To improve the fluidity properties of concrete, authors used sulfonated naphthalene formaldehyde (SNF) superplasticizers as a chemical admixture. 1.5% of SNF superplasticizer by weight of binding material (cement + stone slurry) is considered for all the mixes. The mixtures are mainly studied for the concrete's fresh and hardened properties, thereby looking at its workability and strength aspects for economical usage. Totally, 180 specimens are casted to determine the mechanical properties of concrete at different age of curing. Out of these, 48number of cube specimens, 48 number of cylindrical specimens and 48 beam specimens.

**Table 2: Mix Designation**

| | | |
|---|---|---|
| MIX1 | WFS Replaced With 30%Natural River Sand | WS30SS0 |
| MIX2 | SS Replaced10% with cement | WS30SS10 |
| MIX3 | SS Replacement 20% with cement | WS30SS20 |
| MIX4 | SS Replacement 30% with cement | WS30SS30 |

### *Test Procedure*

For concrete preparation, authors used drum type concrete mixers of capacity 0.1 m3. First dry mixing concrete is done by adding all the materials (cement, fly ash, WFS, fine aggregate and coarse aggregate), followed by wet mixing of concrete is done by adding super plasticizer and water to the mixer. After wet mixing of concrete, fresh properties of concrete such as compaction factor test and slump cone test is carried out as per the Indian standards IS:1199–2018 [41]. After wet mixing, prepared mixes are filled in standard cube, cylinders and beam molds to investigate the strength and quality of concrete. Mechanical properties of concrete such as flexural strength test, split tensile strength and compressive strength test is conducted for all the mixes as per Indian standard IS:516–1959 [42]. Flexural strength test is carried out by using test beams of specimen 100x100x500 mm size at 7- and 28-days curing period as per Indian standard IS:516–1959. Similarly, split tensile strength test is conducted for all the mixes by using cylinder specimens of size 150 mm diameter and 300 mm height at 7and28 days curing period as per Indian standard IS:516–1959. Likewise, compressive strength test is performed for all the mixes by using standard concrete cubes of size 150x150x150 mm at 7- and 28-days curing period as per Indian standard IS:516–1959.

## RESULT AND DISCUSSION

### Compressive strength

This test is performed by a cube size of 150 mm x 150 mm x150 mm mold where the compressive load is acted on a smooth levelled surface using compression testing machine (CTM) till the specimen fails. This test is performed based on the guidelines of Indian standard IS: 516–1959 at 7- and 28-days curing period. The results of this test shown below:

**Table 2: Result of Compressive Strength**

| MIX | 7 Days (MPa) | 28 Days (MPa) |
|---|---|---|
| MIX1 | 36.55 | 44.7 |
| MIX2 | 37.8 | 47.4 |
| MIX3 | 40.27 | 50.25 |
| MIX4 | 34.5 | 44.41 |

### *Splitting-tensile strength*

The tensile test is carried out with a cylindrical specimen of diameter 150 mm and height 300 mm. The test procedure is followed as per Indian standard IS: 516–1959. As concrete is strong in compression and brittle in nature, we will apply a compressive load on the longitudinal axis, which splits the cylindrical specimen into two halves along the vertical plane after failure.

**Table 3: Result of split tensile strength test**

| MIX | 7 Days (MPa) | 28 Days (MPa) |
|---|---|---|
| MIX1 | 2.4 | 4.84 |
| MIX2 | 3.35 | 5.19 |
| MIX3 | 4.2 | 5.35 |
| MIX4 | 2.33 | 4.34 |

**Flexural strength**

As per the guidelines of Indian standard IS:516–1959 [42], flexural strength test is examined using 100x100x500 mm sized specimen. The test results are represented in Table 4 at different ages of concrete. Test values indicate that flexural strength increases marginally with increased SS content at 20% optimum dosage of stone slurry.

## CONCLUSIONS

- In most cases, partial replacement of sand with waste foundry sand (up to 30%) enhances the strength properties (compressive strength, splitting tensile strength, and modulus of elasticity) of concrete.
- Waste foundry sand replacement of up to 30% has a positive influence on sulphate resistance, but beyond 30% substitution leads to a decrease in resistance, which is attributed to traces of SO3 present in WFS. Similarly, beyond 30% substitution leads to an increase in carbonation depth in concrete.
- Non-destructive testing such as ultrasonic pulse velocity of concrete is found to be positively influenced by the percentage of waste foundry sand used as a replacement for natural river sand.
- The use of waste industrial by-products like fly ash, stone dust, and waste foundry sand in concrete reduces disposal challenges, and it is advantageous in making green concrete and promoting a healthy environment.
- The slump of concrete decreases, and water absorption capacity of the concrete increases with an increase in WFS content.
- Rapid chloride permeability test results show that chloride ingress decreases with WFS addition up to 30%, and freezing and thawing resistance, and salt scaling resistance of concrete improve with 20%.
- The addition of fine waste foundry sand improves the abrasion resistance of concrete by contributing to a dense matrix.
- Based on all experimental investigations in the literature, it is concluded that 30% waste foundry sand is the optimum replacement for sand in concrete, exhibiting maximum strength and workability.
- This review recommends further studies on the durability performance of concrete with partially substituted WFS, as less information is available on this topic.
- Finally, this review concludes that WFS up to 20 to 30% can be used as a fine aggregate in concrete production without any negative effects on the mechanical and durability performance of concrete. Up to 30% replacement of waste foundry sand shows that the mechanical performance of the concrete is comparable to control concrete.

In this paper partial replacement of stone slurry with cement 20% is optimum dose for compressive strength, split tensile strength & flexure strength.

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