

# USE OF USED FOUNDRY SAND IN CONCRETE: A STATE OF ART REVIEW

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## Abstract

*This state of art review represents the development in the field of utilization of used foundry sand in cementitious concrete. The paper reviews the utilization of foundry sand as the concrete constituent and the noticeable and important findings from the experimental works of various researchers. The historical development is also discussed as a part of introduction in the review. After a careful study of large number of research papers on the topic it was felt by the authors to integrate all the important results for streamlining the potential of this area of research. The paper summarizes conclusions of experiments conducted for the properties like strength and durability. It was observed the results have shown positive changes and improvement in strength and durability properties of the conventional cementitious concrete due to the addition or replacement of fine sand with used foundry sand in different proportions. However in couple of cases such addition has reported reduction in the values of properties. From the review of past research works it could be concluded that utilizing the used foundry sand holds a great potential towards the development of environment friendly and sustainable cementitious concretes.*

**Key Words:** foundry waste, foundry sand, concrete, strength, durability, utilization

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## 1. INTRODUCTION

The Waste generated from the industries cause environmental problems. Hence the reuse of this Waste material can be emphasized. Foundry sand is high quality silica sand that is a byproduct from the production of both ferrous and nonferrous metal casting Industries.

Foundry sand used for the centuries as a molding casting material because it's high thermal conductivity. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates.

In the casting process, molding sands are recycled and reused multiple times. Eventually, however, the recycled sand degrades to the point that it can no longer be reused in the casting process. At that point, the old sand is displaced from the cycle as byproduct, new sand is introduced, and the cycle begins again.

Two general types of binder systems are used in metal casting depending upon which the foundry sands are classified as: clay bonded systems (Green sand) and chemically- bonded systems. Both types of sands are suitable for beneficial use but they have different physical and environmental characteristics.

Over the last decades, much research has been conducted on the mechanical, chemical and durability aspects of foundry sand [10]. But inadequate research focus is given to the study of the strength and durability aspects of foundry sand concrete.

## 2. LITERATURE REVIEW

Several authors have reported the use of used foundry sand in various civil engineering applications. Tarun Naik [1] and their fellows investigated the performance of fresh and hardened concrete containing discarded foundry sand in place of fine aggregate. Concrete mixes were proportioned to replace 25% and 35% by weight of regular concrete sand with clean/new foundry sand and used foundry sand. The results of this investigation showed that mix containing 25% discarded foundry sand showed about 10% higher compressive strength at 28 days than the mix containing 35% discarded foundry sand. However, the compressive strength of the control mix was about 20-30% higher than the mixes containing discarded foundry sands. They added that no marked difference was observed in the density of fresh and hardened concrete.

Han-Young [3] investigated two types of Foundry Sands like clay bonded sand (CLW) and silicate bonded sand (COW) as a fine aggregate for concrete and basic properties such as air contents, setting time, bleeding, workability and slump loss of the fresh concrete with WFS were tested and compared with those of the concrete mixed without WFS. Also compressive strength and tensile strength of hardened concrete of 28 days were measured. The results showed that (i) flow value and compressive strength of mortar is very rapidly decreased with increasing the replacement ratio of COW and CLW; (ii) Bleeding of concrete with COW, CLW are decreased according to increasing replacement ratio of COW and CLW; (iii) concrete mixed with COW of 30%, compressive and tensile strengths of concrete are higher than those of any other concrete without COW, whereas concrete mixed with CLW, compressive and tensile

strengths of concrete are a bit smaller than that of control concrete. Rafat Siddique [4] investigated the mechanical properties of concrete mixtures in which fine aggregate was partially replaced with used foundry sand with three percentages 10%, 20% and 30% by weight. Tests were performed for the properties of fresh concrete, compressive strength, splitting tensile strength, flexural strength and modulus of elasticity were determined at 28, 56, 91 and 365 days. Test results showed that increase in compressive strength varied between 8% and 19% depending upon UFS percentage and testing age, whereas it was between 6.5% and 14.5% for splitting tensile strength, 7% and 12% for flexural strength and 5% and 12% for modulus of elasticity.

Saveria [5] investigated the properties of mortars and concretes containing different dosages of used foundry sand (UFS) as partial replacement of sand. The results showed that (i) UFS addition gives low slump; (ii) mortars containing UFS at water cement ratio equal to 0.5 show a compressive strength lower by about 20-30% compared to that of the reference mix; (iii) the modulus of elasticity doesn't vary significantly; (iv) Drying shrinkage increases with the decrease of mechanical performances.

Khatib and Baig [6, 7] investigated fresh and hardened properties of concrete containing waste foundry sand (WFS) replaced with 0 to 100% with fine aggregate. The water to cement for all mixes was kept constant. Testing on hardened properties was mainly conducted at 14, 28 and 56 days. The results show that the incorporation of waste foundry sand in concrete causes a systematic decreases in workability, ultrasonic pulse velocity and strength and an increase in water absorption and shrinkage of concrete. They also reported that an acceptable concrete strength can be achieved using foundry sand.

Kumbhar [8] investigated the various mechanical properties of concrete containing used foundry sand. Concrete was produced by replacing natural sand with UFS in various percentages (10%, 20%, 30% and 40%). Based on the test results they concluded that (i) workability goes on reducing with increase in UFS content; (ii) At 28-days, Compressive strength, splitting tensile strength and flexural tensile strength for different replacement levels of UFS is increased whereas flexural tensile strength goes on reducing for UFS content more than 20%; (iii) At 28-days, the modulus of elasticity values increases with replacement of UFS up to 20%. They also concluded that the UFS can be utilized as a replacement to regular sand in concrete up to about 20%.

L Da Silva and their team [11] investigated the influence of the use of foundry sand waste (FSW) on concrete properties. The properties on the fresh state were evaluated by means of flow table test and the determination of the incorporated air content. On the hardened state, compressive strength tests were performed. Their initial results have shown that the use of FSW leads to an increase in the air content and cracking, caused by expansive reactions. As a result of that, a reduction in the compressive strength has been noticed. They added that the application of mixtures made with FSW

becomes risky as to the structural and durability requirements. However they also added that their work may not be generalized, because the FSW composition varies according to the manufacturing process and in all cases it is advisable to carry out preliminary tests in order to verify the effects caused by the use of FSW in the concrete production.

Gurpreet Singh and Rafat Siddique [12, 13] investigated the strength and durability properties of concrete mixtures, in which natural sand was replaced with five percentage (0%, 5%, 10%, 15% and 20%) of waste foundry sand (WFS) by weight. Compression test and splitting tensile strength test were carried out at the age of 7, 28 and 91 days and Modulus of elasticity, ultrasonic pulse velocity and Rapid Chloride Permeability test were conducted at the age of 28 and 91 days. The abrasion resistance of concrete containing WFS was also investigated. Based on the results obtained they concluded that (i) Maximum increase in compressive strength, splitting tensile strength and modulus of elasticity of concrete was observed with 15% WFS, both at 28 and 91 days; (ii) WFS increases the ultrasonic pulse velocity values and decreased the chloride ion penetration in concrete; (iii) Abrasion resistance of concrete increased with the increase in WFS content. They also added that WFS can be suitably used in making structural grade concrete, as well as for applications where abrasion is also important parameter.

Khatib and Herki [16] investigated the concrete produced by replacing the fine aggregates with 0%, 30%, 60% and 100% WFS. The water content, coarse aggregate, cement and the water to cement ratio remained constant. The properties investigated at 7, 28 and 90 days curing times. The results indicate that there is systematic increase in water absorption by capillary action, a decrease in compressive strength and Ultrasonic pulse velocity with increasing amounts of WFS in concrete. They also reported that adequate strength can be achieved using an appropriate replacement level of foundry sand.

Eknath [17] investigated the comparative study of the properties of fresh & hardened concrete containing ferrous & non-ferrous foundry waste sand replaced with four (0%, 10%, 20% and 30%) percentage by weight of fine aggregate & tests were performed for M20 grade concrete. Result showed that (i) addition of both foundry sand gives low slump mainly due to the presence of very fine binders; (ii)

Compressive strength at 7 days of both ferrous & nonferrous mixtures increases and maximum increase was observed with 20% WFS of both types of sand, at 28 days 30% addition of ferrous WFS & 10% addition of nonferrous WFS gives same strength as ordinary concrete and goes on decreasing for higher percentages of replacement; (iii) Split tensile strength gives maximum values with 20% WFS for both types of sand; (iv) water absorption is minimum with 20% ferrous WFS & with 10% nonferrous WFS. They also reported that both ferrous & nonferrous WFS can be suitably used in making structural grade concrete.

### 3. DISCUSSION

Based on various researchers, it is observed that 20% replacement generally gives higher strength compared to normal concrete. All the researchers noticed fresh concrete behavior with foundry sand that workability is decreases with the increase of foundry sand content by slump test or flow table test. Most of the researchers noticed positive changes in the concrete containing foundry sand in terms of compressive strength and tensile strength where there is not much change occurs in modulus of elasticity. Also, Water absorption increases as replacement of foundry sand increases. Also it shows that foundry sand decreases the chloride ion penetration in concrete. However all researchers have noticed that concrete incorporation with foundry sand can be suitably used in making structural or nonstructural grade concrete. It could also be noted that the effects of concrete containing foundry sand shall be differs as the foundry sand changes its characteristics according to its manufacturing process and source.

### 4. CONCLUSION

Based upon above literature review it could be concluded that all researchers gave their findings with concrete up to 30-40% replacement of fine aggregate with foundry sand in which compressive and tensile strength is increased up to 20% whereas not much change occurs in modulus of elasticity. Also workability is decreases with the increase of foundry sand content because of very fine particles. However all researchers noted that concrete made with foundry sand can be suitably used in making structural grade concrete. But, very few researchers go up to 100% replacement where strength and durability criteria needed to be studied further effectively in future.

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