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DURABILITY STUDY OF CONCRETE USING FOUNDRY WASTE SAND

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A B S T R A C T

Today's metal casting businesses in India discharge a lot of foundry sand as waste, which is leading to hazardous environmental issues. On the other side, we are dealing with a sand shortage in the building industry. In order to address these two issues, we have sought to evaluate the strength and durability of concrete using foundry sand as a replacement for 100% of the sand. Reusing water is increasingly being seen as a crucial part of managing water resources and promoting sustainable development, not just in dry and water-scarce locations but also in areas with plenty of water. Use of reclaimed water in place of potable water for agriculture, environmental restoration, cleaning, toilet flushing, and industrial processes are a few instances of successful water reuse initiatives.

Keywords: Foundry waste sand (Burnt black sand and Weathered sand), Porosity and Water absorption, Permeability, Compressive strength, Acid attack etc

1. Introduction

Federal and state environmental authorities began to pay for pollution in the 1970s and 1980s.growing focus on waste management, safety, and industrial pollution control. As a result, the foundry sector was forced to reconsider its established procedures for getting rid of used sands. The necessity to cut back on landfill upkeep and disposal costs has been one of the key issues facing the foundry sector. Currently, disposal expenses range from Rs. 10 to Rs. 20 per tonne. Due to new laws, it is anticipated that costs will rise by 5 to 10 times over the following ten years. Also, old landfills are reaching capacity while new landfills will not be coming to market in sufficient numbers as desired by industries. This was mostly due to the nationwide programme that governs and oversees by-product disposal, Public Law 94-580, the Federal Resource Conservation and Recovery Act of 1976. (Naik, 1987). Used foundry sand has been rejected by landfill operators due to its huge volume and "special waste" categorization due to the global shortage of landfill space. According to Murarka (1987), foundries typically manufacture metal castings at a rate of 227 to 2270 kg of total by-product material per tonne. The states in the east and the midwest have the most foundries per state. In a batch of normal weight concrete, the American Foundrymen's Society advised (33% of the utilised foundry sand should be substituted with fine aggregate; AFS report, 1991) following thorough testing. This research served as the basis for the decision to replace 25 and Foundry sand was utilised in 35% of the fine aggregates to test the impact of various replacement amounts.

This is because India produces more than 300 million tonnes of industrial trash each year as a result of its agricultural and industrial processes. The problem caused by continuous industrial and technical advancement is waste disposal. Not only can the cost of development be reduced if any of the waste materials are found to be adequate for concrete manufacture, yet it is also possible to dispose of waste fabric safely. Concrete made with excessive energy typically has a high cement content, which frequently causes greater shrinkage and greater disparity in the rate of hydration with the exception of cost.

2. Objectives

1. Determination of compressive strength of concrete for 28days curing period and 56days (i.e., 28days for curing and other 28 days exposed to atmosphere).
2. Effect of accelerated curing on compressive strength (440C, 550C).
3. Determination of porosity and water absorption.
4. Permeability test.
5. Determination of strength after heating and cooling.
6. Determination of strength after alternate wetting and drying.
7. Acid attack test (sulphate attack test).

3. Literature survey

[1]Merve Basar. H and Nuran DeveciAksoy (2012) In order to produce ready mixed concrete (RMC), investigated the potential re-use of waste foundry sand (WFS). Five percentages of WFS by weight and the solidification/stabilization (S/S) procedure were used in place of the normal sand.

was used on each and every concrete mixture. For the WFS-based-RMC's certification, three factors—the mechanical, leaching, and microstructural properties—were examined. The results of this study indicate that WFS can be used to produce high-quality RMC as a partial replacement for fine aggregates without having a negative influence on mechanical, environmental, or microstructural properties; however, the partial replacement shouldn't be more than 20%. [1]

[2]Pathariya Saraswati C, Ranajay krushnaK(2013) studied the compressive strength of the concrete by replacement of the local sand by foundry waste sand by 0%, 20%, 40% and 60% and they found that for 60% replacement of local sand by waste foundry sand they had obtained maximum compressive strength values.[2]

[3]Sohail Md, Arfath Khan Md, and Abdul Wahab (2013) conducted experimental studies to evaluate the durability and strength of concrete compositions that contain natural sand. replaced in part with (WFS).0%, 15%, and 35% of WFS by weight were substituted for regular M sand, and all of the concrete through the solidification/stabilization (S/S) procedure. mixtures. At ages 7, 28, and 56 days, each test was administered. According to test results, waste foundry sand can be used successfully in place of traditional river sand as fine aggregate in concrete.demonstrated an increase in plain concrete's compressive strength of up to 90% before a slight decline.[3]

[4]Siddique, R., and Dhanoa, G. (2014) Experimental studies were conducted to assess the strength and durability of concrete mixtures in which M sand was partially replaced with (WFS). In place of fine aggregate, 0, 5, 10, 15, and 20% of WFS by mass were used. The age and length of each test were both 28 and 365 days. According to test results, (1) replacing fine aggregate with WFS improved concrete's strength characteristics as WFS concentration increased at all ages. (2) By substituting 15% of the fine aggregate with WFS, maximum strength was attained.

Although it starts to decline after 15% replacement, it was still greater than control concretes. (3) Waste foundry sand concrete mixes developed compressively and split tensile at a faster rate than control samples.

[5]Rafat Siddique and Ravinder Kaur Sindhu (2015) In order to study resistance, they tested the concrete for sulphate attack and found that the 10% FWS mix had greater strength than the control mix even after submerging the cubes in Solution of magnesium sulphate. However, after immersion in the sulphate solution, at all ages, a reduction in strength is seen for both the 15% and 20% replacement levels when compared to the comparable concrete mix's typical 28-day strength.

[6] G. Ganesh Prabhu, Jin Wook Bang, Byung Jae Lee, Jung Hwan Hyun, and Yun Yong Kim(2016) examined the usage of foundry sand as a replacement for natural sand in the manufacturing of concrete using the material's mechanical and durability qualities. The results of the in-depth testing performed on the six mixes led to the following conclusion. The chemical examination of foundry sand revealed that it can be a very good component for making concrete. Although the effect was significant beyond the 30% substitution rate, the fineness and high water absorption of FWS increase the water requirement of the concrete by water absorption, limiting the workability of the concrete.

4. Experimental work

Cement: The choice of cement content is determined by the mix's minimum fine aggregate requirement, exposure classes for durability, and strength needs. In this study, regular Portland cement of grade 43 was used.

Fine Aggregate: The sand is river sand that has been filtered and cleaned to eliminate any possible organic and inorganic materials. Sand is obtained from nearby suppliers of building supplies and sieved using a 4.75mm sieve.

Coarse Aggregate: The coarse aggregates used in concrete have an angular shape and a maximum size of 20 mm.

Foundry Sand: The Badger Mining Corp. supplied both fresh and old foundry sand, and Falk Corporation provided the discarded foundry sand. All of the used sands underwent ASTM C33 testing.

Materials tests -

Material Tests:

Properties cement determined by the following tests in table

Particulars	**Results Obtained**	**Requirements As Per Is 12269-1970**
Fineness of cement (%)	**4.3**	**3-7**
Specific gravity	**3.1**	**3.1-3.15**
Normal consistency (%)	**32**	**30-35**
Initial setting time (min)	**31**	**30**
Final setting time (hrs)	**8 hours**	**10 hours**

Properties fine aggregate determined by the following tests in Table

Particulars	**Results Obtained**	**Requirements As Per Is 12269-1970**
Specific gravity	**2.58**	**2.60-2.90**
Fineness modulus	**2.88**	**2.80-2.90**
Water absorption (%)	**0.8 %**	**1%**

Properties of fresh concrete Workability by slump test Table

Replacement level	**Value**	**Degree of Workability**
20 %	**55**	**Medium**
25 %	**50**	**Medium**
30 %	**45**	**Low**
35 %	**41**	**Low**

Methodology -

Materials which are used to conduct the above tests are Cement (OPC), Locally availablesand, Foundry waste sand, Basalt Aggregates and Water.

Casting and curing - Cube specimen of size 15cm×15cm×15cm were cast using the mix proportion given in Table3.4as per IS:516- 1959.The cubes were de-moulded after 24 hours of casting. The cubes were kept for curing under water immersion at laboratory temperature 27±2˚C. Water is being changed at regular intervals.

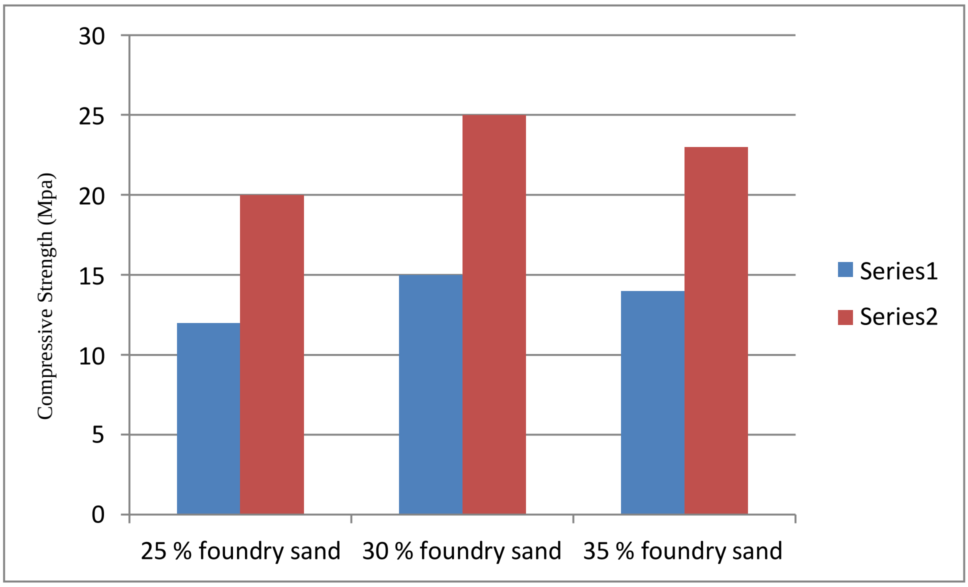
Finalized mix proportions for locally available sand (Natural Sand), and FoundryWaste Sand for M20 grade concrete

Sr. No.	**Mix Combination**	**Cement**	**Fine Aggregate**	**Course Aggregate 12.5 mm**	**Course Aggregate 20 mm**	**W/Cratio**
1	**Basalt + Natural Waste**	**1**	**2**	**2**	**1.32**	**0.56**
2	**Basalt + Foundry Waste Sand**	**1**	**1.80**	**2.20**	**1.36**	**0.56**

Test Procedure-

1. Compressive strength test:

Compressive strength testing was done after both 28 and 56 days (after being exposed to the environment for a total of 28 days following the curing phase of 28 days).the combinations comprising used foundry sands had reduced strengths at all test ages, according to the findings of compressive strength tests. At 28 days old, concrete with 25% used foundry sand has a 23% lower compressive strength than control mix. The value of concrete with 35% utilised foundry sand is 30% less than that of the control mix. However, in 28 days, the compressive strength of 25% and 35% is lower by 11% and 19%, respectively, than the design strength of 38 Mpa. However, at all ages, concrete containing 25% and 35% clean/new foundry sand in place of ordinary concrete sand demonstrated nearly the same compressive strength as control mix.



Compressive Strength (Mpa) of Concrete with Various Levels of Replacement of foundry waste

2. Accelerated curing method (warm water method): As per IS 9013-1978 the specimens after casting were kept for drying for a period of 2 and ½ hours and then sealed, after sealing they are kept in accelerated curing tank at a temperature of 550C for a period of 20± ½ hours, after this period they are taken out and wiped and later checked for its compressive strength. • The same procedure is repeated for 440C (Prevailing temperature in our city).

3. Water absorption test: The test was carried out as per ASTM C-640.
% water absorption=[(Ww-Dw)/Dw]x100
Where, Ww=wet weight of the cube,
Dw=dry weight of the cube.

4. Porosity-The specimens are poured in accordance with the mix design, then cured in a curing tank for 28 days. Next it is taken out of the curing tank, the surface is cleaned, and the weight is recorded. The samples were then dried in an oven for 24 hours at 65 °C before being weighed once more. It is once more kept in For the following 24 hours, the weight is recorded again in the oven. The weight is maintained constant by repeating this process. The porosity is determined by the variation in sample weight

5. Permeability Test: Concrete specimens measuring 150x150x150 mm were subjected to the test in accordance with German Standard DIN 1048, and their depth of penetration was recorded by breaking them.similarly subject to UTM.

6. Alternate heating and cooling: The specimens are cast and allowed to cure for 28 days. Then, to test their durability, the specimens are heated and cooled simultaneously for 20 days (20 cycles). The specimens are warmed throughout the day at the ambient temperature and chilled at night. The strength of the specimens is e valuated after this process has proceeded for 20 days.

7. Alternate wetting and drying : After being cast and curing for 28 days, the specimens are put through 20 days of alternate wetting and drying to test their durability. After 20 days of this cycle, the strength of the specimens is evaluated to determine the impact of alternating heating and cooling on concrete. The specimens are retained for wetting in the curing tank for 1 day and then allowed to dry the next day.

8. Sulphate attack test was performed in accordance with Leonardo journal of science ISSN 1583-0233.Concrete's sulphate resistance is assessed using a 50g/l magnesium sulphate solution.

Future work

Corrosion of reinforcement embedded in RCC member using foundry waste sand is to be carried out.

Conclusions

The compressive strength values for concrete with regular sand substitutions of 25% and 35% in place of foundry sand are nearly identical to those for concrete without replacement. In comparison to previous replacements, the concrete made with a 25% and 35% replacement of foundry sand waste has higher flexural strength. The test findings show that the modulus of elasticity rises with ageing.

1. Water absorption of weathered sand is more as compared to foundry sand waste and locally available sand hence workability is reduced.
2. Higher workability is recorded for concrete containing locally available sand compared to concrete containing weathered sand and foundry sand waste.
3. Porosity of concrete decreases in the order of concrete containing weathered sand (17.9%), concrete containing foundry sand waste (16%) and control mix (13.6%). Similarly decreasing
4. trend is observed for water absorption i.e., concrete containing weathered sand (2.2%), concrete containing foundry sand waste (1.9%) and control mix (1.6%).
5. Concrete containing weathered sand and concrete containing foundry sand waste has resulted in lower strength at 28 days of curing i.e., 27.76N/mm2 and 28.05 N/mm2 respectively compared to control mix of strength 42.292N/mm2 , this is due to higher water absorption of foundry waste sand. At 56 days age of concrete (moist cured for 28 days and exposed to ambient temperature for 28 days) control concrete (40N/mm2) and concrete containing foundry sand waste (39.385N/mm2) has recorded nearly the same strength but concrete containing weathered sand has recorded lower strength (31.68N/mm2). All the three concrete for both the ages have satisfied the requirement of M20 grade concrete.
6. To study the effect of heat curing warm water method (550C) is used, compressive strength of control mix and concrete containing foundry sand waste registered nearly the same strength i.e., 42.292N/mm2 and 40.380N/mm2 respectively but concrete containing weathered has recorded lower strength of 33.94N/mm2 compared to control mix, this is due to higher water absorption of weathered sand.
7. Permeability is measured in terms of depth of penetration of water in concrete, concrete containing weathered sand, control mix and concrete containing foundry sand waste recorded depth of penetration 4.38cm, 2.86cm, 1.85cm respectively. Concrete containing weathered sand is more permeable which is clear from higher porosity result in 4th conclusion and lower compressive strength in 5th conclusion.
8. Heating and cooling effect has not much influence on concrete using locally available sand and foundry sand waste, but increase in strength was observed for concrete containing weathered sand (17.31%) compared to control mix, this is due to enhanced hydration.

9. Effect of alternate wetting and drying is marginal for concrete using locally available sand and weathered sand. But concrete using black sand has resulted in higher strength (27.47%), it is due to enhanced hydration.
10. Decrease in strength is observed due to sulphate attack on concrete using locally available sand and weathered sand but for concrete containing foundry sand waste increase in strength was observed (25.19%), it may be due to formation of ettringite (tri calcium alumina sulphate).

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