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Utilization of Used Foundry Sand as a Partial Substitute for Natural Sand in Concrete Production

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Abstract – *The used foundry sand (UFS) can be replaced for river sand as it holds similar properties as that of river sand. Used foundry sand is a by-product of ferrous and non-ferrous metal industries which has high silica content. Replacement of used foundry sand can make concrete more durable and increases the strength properties. It is difficult to discover alternative material of construction which is as versatile as concrete. In present world inflation is one of the main problem faced by every country. It has become essential to lower the cost without much compromise as far as strength and durability of the structure is concerned.*

This paper presents the experimental investigation on the partial replacement of fine aggregate by used foundry sand. Compressive strength, split tensile strength, flexural strength and rapid chloride permeability test (RCPT) were conducted. The fine aggregate was replaced by 6 different percentages 0%, 5%, 10%, 15%, 20% and 25% by weight of fine aggregate. The test were performed for all replacement of UFS at the age of 3, 7, 28 and 56 days (56 days for RCPT). 15% of UFS is the optimum dosage obtained for M_{30} grade concrete. The results are graphically represented. The workability in terms of slump of concrete with UFS decreases with increase in percentage of addition of UFS. Thus, used foundry sand can be effectively used as a partial replacement of natural sand in concrete.

Key Words: *UFS, Ordinary Portland cement, compressive strength, Split tensile strength, flexural strength, RCPT*.

1. INTRODUCTION

1.1 General

Nowadays, Concrete is a most important and integral part of construction industry. Requirements of concrete increases generation to generation due to infrastructure development. Concrete is called as an artificial stone consisting cement paste, sand and coarse aggregate. Concrete is an affordable, reliable and mouldable material which solidifies and hardens when reacts with water due to chemical reaction between cement and water. This process is termed as hydration. In India alone about 170 million cubic meters of concrete is produced every year.

Foundry sand is continuously used for centuries as a moulding material because of its thermal conductivity. Foundries used the sand effectively many times in foundry. When the sand no longer to be reuse then it can removed from foundry and it is disposed of, it is termed as used foundry sand (UFS). About 15% of used foundry sand used by foundries is ultimately disposed of, amounting to millions of tons. In India, many foundries dump this waste in nearby free areas to avoid disposal cost. Which may create nuisance or pollute the nearby environment.

The restrictions by public may occur for dumping the waste foundry sand in nearby areas. In order to overcome such difficulties, industries have to self-conscious to find alternative ways to reuse the waste foundry sand. The foundry sand used as a high way application, but still it is negligible for re-utilization of used foundry sand. Recent researches were carried out on reuse of UFS in concrete and concrete related products. For the construction nearby the foundry industries may be more economical.

1.2 Used foundry sand

Foundry sand has been used as a moulding substance for decades because of its thermal conductivity. The sand was efficiently used many times by foundries in the foundry. If the sand is no longer to be reused, it can be removed from the foundry and disposed of, it is called UFS. Ultimately, 15% of the used foundry sand by foundries is disposed of, which amounts to millions of tones. In India, in order to prevent disposal costs, many foundries dump this waste in neighboring free sectors. Which may create nuisance or pollute the nearby environment.

Public restrictions on the dumping of waste foundry sand in neighboring fields may happen. To overcome these problems, companies need to be self-conscious in finding alternative methods to reuse the sand foundry waste. The foundry sand has been used as a high-way implementation, but it is still negligible for re-use of used foundry sand. Recent research on UFS, reuse in concrete and concrete associated products has been conducted. The foundry sectors can be more economical for the nearby building.

2. OBJECTIVES

1. To evaluate the durability of Used Foundry Sand Concrete by Rapid Chloride Permeability Test.
2. Investigating concrete's mechanical characteristics by partially replacing fine aggregate with used foundry sand (UFS).
3. Comparison of concrete containing used foundry sand with the conventional concrete.

To determine optimum percentage of replacement of fine aggregate with used foundry sand.

3. METHODOLOGY

Towards fulfilment of objectives of present study, the Mix design was done as per IS 10262:2009 and the following methodology has been set for present experimental investigation. Following tests were carried out.

1. Slump cone test.
2. Compressive strength test.
3. Split tensile Strength test.
4. Flexural strength test.
5. Rapid chloride permeability test.

4. MATERIAL PROPERTIES

4.1 Cement:

Cement used in this study is ordinary Portland cement of grade 43. OPC 43 grade cement confirmed according to IS: 8112-1989. Various tests were conducted on cement and the results were tabulated below:

Table 1: Test results on cement.

Name of tests	Results	Units
Initial setting	51	Minutes
Final setting	463	Minutes
Specific gravity	3.12	Unit less

Figure 1: Cement.

4.2 Fine aggregate:

The size of natural sand lies between 4.75 mm to 150 microns. In this study specification of natural and confirms IS: 383:1970. The test were conducted on natural sand in laboratory and tabulated:

Table 2: Test results on Natural Sand.

Name of tests	Results	Units
Specific gravity	2.66	Unit less
Bulk Density	1645	Kg/m3
Fineness	4.57	Percentage
Zone	I	Unit less

Figure 2: Fine aggregate.

4.3 Used foundry sand:

For this study, UFS is collected from Belgaum foundry cluster which is located in Santi Bastwad. The size of UFS varies from 4.75 mm to 150 microns. But 35% of UFS retained in 300 micron sieve and 60% of UFS retained in 150 micron sieve. The test results on used foundry sand were tabulated below:

Table 3: Test results on used foundry sand.

Name of tests	Results	Units
Specific gravity	2.41	Unit less
Bulk density	1676	Kg/m3
Fineness	2.338	Percentage
Zone	III	Unit less

Figure 3: Used foundry sand.

4.4 Coarse Aggregate:

In this study coarse aggregate is collected from popular aggregate crushing plant, Kinaye. The aggregate size is 20mm. This can be categorized as round, cubical and uniformly graded. Laboratory tests were conducted on coarse aggregate. The results were tabulated below:

Table 4: Test results on coarse aggregate.

Name of Tests	Results	Units
Specific gravity	2.82	Unit less
Water absorption	0.55	Percentage
Bulk density	1560	Kg/m3

Figure 4: Coarse aggregate.

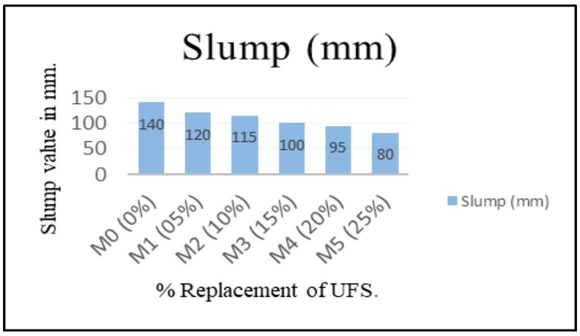
5. RESULTS AND DISCUSSIONS

5.1 Slump test

The workability of M30 concrete grade was determined for M_0 (0%), M_1 (5%), M_2 (10%), M_3 (15%), M_4 (20%) and M_5 (25%). The slump value gradually reduces with a rise in the amount of used foundry sand added. Because of its greater fineness and ability to absorb water. The decrease in slump statistics shown in the graph below.

Table 5: Slump values of concrete for different % of UFS.

Mix Designation	Initial reading (mm)	Final reading (mm)	Slump (mm)
M_0 (0%)	300	160	140
M_1 (05%)	300	180	120
M_2 (10%)	300	185	115
M_3 (15%)	300	200	100
M_4 (20%)	300	205	95
M_5 (25%)	300	220	80



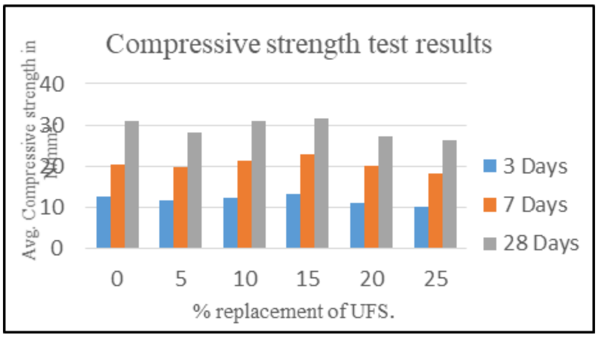
Graph 1: Representation of variation in slump value.

5.2 Compressive strength

The average compressive strengths of M_{30} grade concrete were determined for 0%, 5%, 10%, 15%, 20% and 25% replacement of natural sand by used foundry sand at the age of 3, 7 and 28 days of curing period. Among these concrete with 15% of UFS gives the maximum strength. 15% of UFS is the optimum percentage of replacement.

Table 6: Average compressive strength at 3, 7 and 28 Days.

Sl. No	Percentage of replacement	Average Compressive strength in N/mm²		
		3 Days	7 Days	28 Days
1	0	12.44	20.44	30.82
2	5	11.56	19.71	28.15
3	10	12.29	21.18	30.82
4	15	13.17	22.82	31.56
5	20	11.11	20.15	27.26
6	25	10.07	18.07	26.31



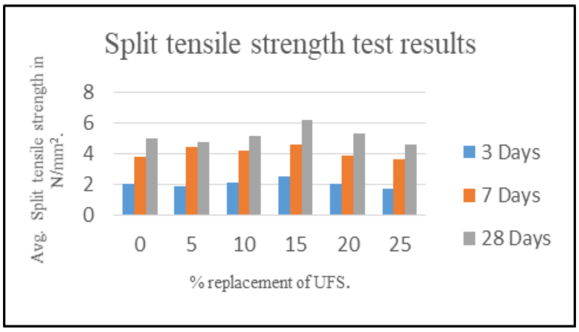
Graph 2: Compressive strength results.

5.3 Split tensile strength

Average split tensile strength of M30 grade concrete were determined for 0%, 5%, 10%, 15%, 20% and 25% replacement of natural sand by used foundry sand at the age of 3, 7 and 28days of curing period. Among these concrete with 15% of UFS shows maximum strength. The optimum percentage of replacement is 15% of UFS.

Table 7: Average Split tensile strength at 3, 7 and 28 Days.

Sl. No	Percentage of replacement	Average Split tensile strength in N/mm²		
		3 Days	7 Days	28 Days
1	0	2.03	3.82	5.00
2	5	1.89	4.44	4.76
3	10	2.12	4.19	5.18
4	15	2.50	4.62	6.17
5	20	2.07	3.91	5.28
6	25	1.70	3.63	4.62



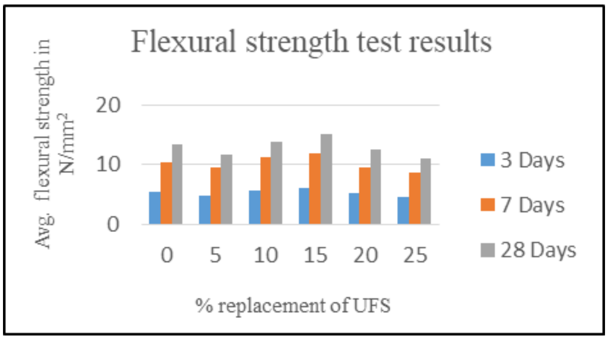
Graph 3: Split tensile strength results.

5.4 Flexural strength

Average flexural strength of M30 grade concrete were determined for 0%, 5%, 10%, 15%, 20% and 25% replacement of natural sand by used foundry sand at the age of 3, 7 and 28days of curing period. Among these 15% of UFS shows maximum strength. The optimum percentage of replacement is 15% of UFS.

Table 8: Average flexural strength at 3, 7 and 28 Days.

Sl. No	Percentage of replacement	Average flexural strength in N/mm²		
		3 Days	7 Days	28 Days
1	0	5.47	10.27	13.47
2	5	4.73	9.47	11.73
3	10	5.53	11.20	13.73
4	15	6.00	11.87	15.00
5	20	5.07	9.47	12.47
6	25	4.47	8.73	11.07



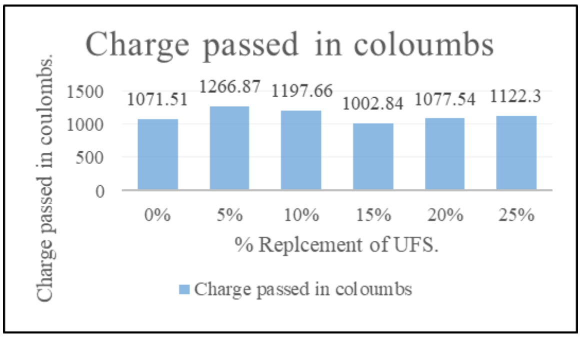
Graph 4: Flexural strength results.

5.5 Durability of concrete by Rapid Chloride Permeability test

The influence of UFS on the permeability of chloride-ion concrete mixtures reduced with the rise in UFS content. At 56 days, the coulomb value of combinations M_0 (0% UFS), M_1 (5% UFS), M_2 (10% UFS), M_3 (15% UFS), M_4 (20% UFS) and M_5 (25% UFS) reduced in combination M_3 with a rise in UFS material of up to 15 % UFS, indicating a denser concrete. The compressive strength experimental results of the concrete mixture produced with UFS up to 15 % UFS also reflected this aspect. However, the coulomb value is mildly increased at 20 % UFS (M_4) with references to 15 % UFS. All concrete mixes have Low Permeability as per ASTM C1202 (coulombs between 1000 and 2000). It can be seen that with the rise in UFS content (%) the RCPT results decreased. Maximum decrease of the RCPT value at 15 % UFS was indicated. Concrete mix M3 showed more chloride-ion penetrability resistance at 15 percent UFS than control mix M1 (0 percent UFS). According to ASTM C 1202, all concrete mixtures have low chloride ion penetration. At 56 days, the M3 mixture (15% UFS) falls underneath the very small penetrability of chloride ions.

Table 9: Charge passed through specimen in coulombs.

% Replacement of UFS	Charge (Q) passed in coulombs
0%	1071.51
5%	1266.87
10%	1197.66
15%	1002.84
20%	1077.54
25%	1122.30



Graph 5: Charge (Q) passed through different % of UFS.

6. CONCLUSIONS

In the present study, evaluation of compressive strength, split tensile strength, flexural strength and rapid chloride permeability test of concrete with partial replacement natural sand by used foundry sand are investigated. The results of concrete with used foundry sand and conventional concrete are compared. The optimum dosage of used foundry sand is obtained for M30 grade concrete. The results are graphically represented. The following are the conclusions.

1. All concrete specimen shows low chloride ion permeability, but concrete (M_3) with 15% replacement shows very low amongst all specimen. Among all M_3 is more durable.
2. Used foundry sand in concrete shows an increase in the compressive strength up to 15% of addition. After 15% of addition of UFS, the compressive strength starts decreasing. i.e, the maximum compressive strength is obtained when 15% of UFS is added.
3. Used foundry sand in concrete shows an increase in the split tensile strength up to 15% addition. After 15% of addition of UFS, the split tensile strength starts decreasing. i.e the maximum split tensile strength is obtained when 15% of UFS is added.
4. Used foundry sand in concrete shows an increase in the flexural strength up to 15% addition. After 15% of addition of UFS, the flexural strength starts decreasing. i.e the maximum split tensile strength is obtained when 15% of UFS is added.
5. The workability in terms of slump of concrete with used foundry sand decreases with increase in percentage of addition of UFS.

Thus, used foundry sand can be effectively used as a partial replacement of natural sand in concrete.

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BIOGRAPHIES

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