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MODIFICATION OF PLAIN CONCRETE BY REPLACEMENT OF FINE AGGREGATE WITH FOUNDRY SAND

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Abstract: *In the last 20 years the growth of construction industry is increasing very fast due to increase in population. The natural sand required for construction work is decreasing as natural sand available is limited in quantity. The decreasing of natural sand is the global problem. As urbanisation is increasing the natural sand is also empting in the same rate. The new deposits are found underground and access to these deposits are more difficult. The environmental concerns are opposing the vast and uncontrolled excavation of natural sand from river beds, as it act as filter for ground water. Above fact diverts construction industry to look for alternative material which is waste from other industries. In most of the countries natural sand is replaced by crushed sand, foundry sand and various by products. Due to use of above waste material, cost of construction is also reduced and this also solve problem of disposal of this waste material. Production of waste foundry sand causes environmental problems due to improper disposal of foundry sand. The study is carried out to use maximum foundry sand with retaining the properties of the concrete, and to produce a low-cost and eco-friendly concrete. In the present work, experimental investigations were performed to calculate comparative study of properties of fresh concrete using replacement of fine aggregate with foundry sand. Foundry sand is replaced by 10%, 20%, 22%, 24%, 26%, 28%, 30% & 40% by weight of fine aggregates.M20 grade of concrete is designed & test are taken for compressive strength, Flexural strength & Split tensile strength for 7 & 28 days curing period.*

Keywords*: Foundry sand, Fine aggregates, compressive strength, flexural strength, split tensile strength.*

1. INTRODUCTION

Concrete is a composite construction material, made by mixing of cement, aggregate plus fine aggregate such as sand, water and admixtures (if required)). The property of concrete is affected by proportionate quantity of each material. Due to need for energy conservation, research works have been directed to use the various waste materials. High quality raw sand is used for moulding and casting operations. Type of sand used in foundries is classified in to two major groups a) Green sand and b) Chemically bonded sand. In greensand binding material used is Bentonite clay. While chemically bonded sand consists of silica sand and Chemical binder and catalysts Molding sands are recycled and reused many times till they lose their characteristic properties and become unsuitable for further use in the manufacturing. When this sand became unsuitable for moulding they are broken and thrown in the stock piles and are disposed off.

Fig.1. Foundry Sand

1.1 Physical Characteristics of Foundry Sand

Typical physical properties of spent foundry sand from green sand systems are given in Table-1.1. The grain size distribution of waste foundry sand is very uniform, with approximately 85 to 95 percent of the material between 0.6 mm and 0.15 mm (No. 30 and No. 100) sieve sizes. 5 to 12 percent of foundry sand can be expected to be smaller than 0.075 mm (No. 200 sieve). The particle shape is typically sub angular to round. Waste foundry sand gradations have been found to be too fine to satisfy some specifications for fine aggregate. Waste foundry sand has low absorption and is non plastic. Reported values of absorption were found to vary widely, which can also be attributed to the presence of binders and additives. The content of organic impurities (particularly from sea coal binder systems) can vary widely and can be quite high. This may preclude its use in applications where organic impurities could be important (e.g., Portland cement concrete aggregate). The specific gravity of foundry sand has been found to vary from 2.39 to 2.55. This variability has been attributed to the variability in fines and additive contents in different samples .In general, foundry sands are dry, with moisture contents less than 2 percent. A large fraction of clay lumps and friable particles have been reported, which are attributed to the lumps associated with the molded sand, which are easily disintegrated in the test procedure. The variation in permeability, listed in Table-1.1, is a direct result of the fraction of fines in the samples collected.

Property	Results	Test Method
Specific Gravity	1.64	ASTM D854
Bulk Density, kg/m 3	1346	ASTMC48/AASTHO T84
Absorption, %	0.40	ASTM C128
Moisture content, %	0.1-10.	ASTM D2216
Clay Lumps and Friable Particles	1-44	ASTM C142/AASTHO T112
Plastic Limit/Plastic Index	Non plastic	AASTHO T90/ASTM D4318

[American Foundry man's Society, 1991]

Table 1 Direct result of the fraction of fines in the samples collected.

1.2 Chemical Composition

Chemical Composition of the foundry sand relates directly to the metal molded at the foundry. This determines the binder that was used, as well as the combustible additives. The chemical composition of the foundry sand can impact its performance. Waste foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust. Silica sand is hydrophilic and consequently attracts water to its surface. This property could lead to moisture-accelerated damage and associated stripping problems in an asphalt pavement. Depending on the binder and type of metal cast, the pH of waste foundry sand can vary from approximately 4 to 8 . It has been reported that some waste foundry sands can be corrosive to metals.

1.3 Mechanical Properties

Typical mechanical properties of waste foundry sand are listed in Table 1.2. Waste foundry sand has good durability characteristics as measured by low Micro-Deval abrasion and magnesium sulphate soundness loss tests. The Micro-Deval abrasion test is an attrition/abrasion test where a sample of the fine aggregate is placed in a stainless steel jar with water and steel bearings and rotated at 100 rpm for 15 minutes. The percent loss has been determined to correlate very well with magnesium sulphate soundness and other physical properties. Recent studies have reported relatively high soundness loss, which is attributed to samples of bound sand loss and not a breakdown of individual sand particles. The angle of shearing resistance (friction angle) of foundry sand has been reported to be in the range of 33 to 40 degrees, which is comparable to that of conventional sands.

Property	Results	Test Method
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

[American Foundryman 's Society, 1991]

Table 2 Typical mechanical properties of spent foundry sand

2. METHODOLOGY OF RESEARCH

Foundry sand is a by-product after casting mould in the casting industries. Highly heighted molten metals are poured in these molds. Therefore the properties of the sand definitely get enhanced due to heat. Also due to binders the binding properties or bond strength may also increase when the same sand is used in the concrete. To know variation in strength of concrete in compression, Tension and Flexure, for various percentage replacement of sand in the concrete, the past results showed that, when the foundry sand replaced by 10%, 20%, 30% and 40 %, for 20% replacement of sand the maximum strength was achieved. The focus of present study was to find the maximum strength between 20% and 30% to evaluate the % reduction in cost of concrete. Therefore M20 grade mix cubes are casted by varying % replacement of sand for 10%, 20%, 22%, 24%, 26%, 28%, 30% and 40%.

3. RESULT ANALYSIS

3.1 Result of Compressive strength

When we compare the results of compressive strength of the cubes replaced with foundry sand, it is seen that, for smaller percentage replacement of sand by foundry sand, the 28 days strength and 7 days strength variation, with the percentage replacement of FS, is similar in both the graphs (7 and 28 days) see figure 2.

% Replacement by Foundry sand	Compressive Strength (N/mm^2)		Percentage strength gain in 7 days
	7 Days	28 Days	
0	23.70	32.83	72.19
10	24.22	34.15	70.93

20	21.19	28.81	73.55
22	18.67	27.63	67.57
24	24.44	32.07	76.21
26	28.67	38.07	75.31
28	23.78	34.96	68.02
30	18.89	36.15	52.25
40	18.52	35.26	52.52

Table 3 Compressive Strength (7& 28 days)

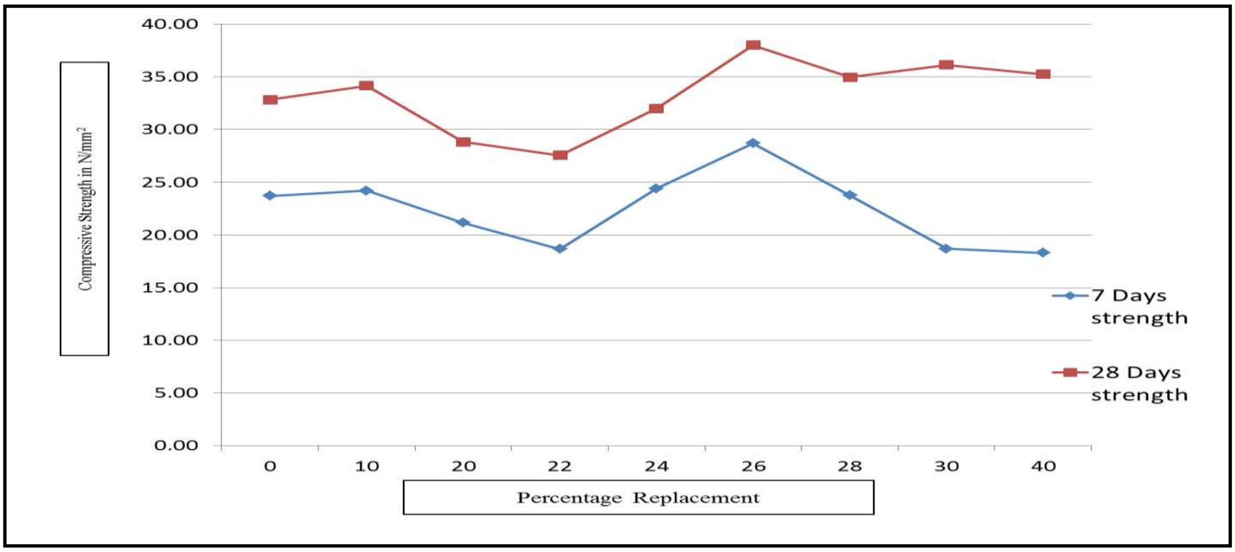

Fig. 2 Compressive Strength Variation for Various Replacement Level of Foundry Sand After 7 and 28 Days Curing

As the sand is one of the major contributor in the concrete having volume percentage about 35 to 40 % of the total volume, any change in the sand will definitely affect the hydration process of the concrete. Moreover the sand is replaced by foundry sand and it is very clear that foundry sand is made of certain chemical composition, some binders are added to the foundry sand so that it can resist the load and heat of the metal poured in the sand. Also when molten metal is poured in the sand the metal particals may also react and precipitated in the sand. Therefore it is needed to see the effect of such sand when used as the replacement to the natural sand, on the hydration process of the concrete. Therefore for each percentage replacement of sand the percentage strength gained at early stage of curing i.e. 7 Days, is evaluated and the results are compared as shown in the Fig 2.

Generally it is observed by the previous data that, concrete attains average 67 to 70 % of its total strength at 7 days curing, Here in this study, the average percentage compressive strength gained in 7 days is seen to be 72 % of that of the 28 days curing for normal concrete with 0 % replacement. While as we replace the sand by FS, it is observed that, from 10 % to 22% replacement of sand with FS, the of the 7 days strength which is ranges between 67 to 73% of the total strength, which shows that there is minor or negligible change in the hydration process, but suddenly for percentage replacement of 24 %, the hydration process is seen to be accelerated and the concrete achieves strength of more than 76%, for 26% replacement, also the strength at early stage is highly accelerated and reaches to 75.51% showing the hydration process is boosted, this may be because certain binders used in the FS. But after 26 % replacement, strength gain at 7 days curing is started reducing as the volume of FS increases, for high volume percent of 30% and 40 %, the hydration process at early stage of curing i.e. for 7 days curing, the strength gain is reduced to around 50 % of the total strength. Also it is to be noted that, the strength at this stage is accelerated after 7 day and increased by almost 50% between 7 to 28 days of curing.

The maximum strength was observed for the replacement of foundry sand by 30% and 26% for 28 days strength and the 7 days strength was seen to be more for 26% and seen to be less for 30 % replacement by foundry sand. This shows that the maximum strength was for the replacement of 26-40% by foundry sand.

3.2 Results for Split Tensile Strength

The variation of the tensile strength for various percentage replacement of sand with FS shows the similar results for the Tensile strength at 7 and at 28 Days curing. The maximum strength was observed for the replacement of foundry sand by 10% for 28 days strength as well as for the 7 days. The strength drops down after 10 % and then increase after 26 % replacement and reaches to high of 3.16 MPa at 28 %, then falls down gradually at 30% and 40%, at 40% replacement the tensile strength is the lowest of all the results showing strength less than the normal mix without Replacement. From these results we can conclude that for better tensile strength and economy, we can use the FS from 26 to 30% as a replacement to the river sand.

% Replacement by Foundry sand	Split Tensile Strength (N/mm^2)	
	7 Days	28 Days
0	1.56	2.85
10	2.64	3.50
20	1.56	2.72
22	2.37	2.67
24	2.17	2.45
26	2.44	2.89
28	2.39	3.16
30	1.77	2.88

40	1.51	2.25

Table 4 Split Tensile Strength (7& 28 days)

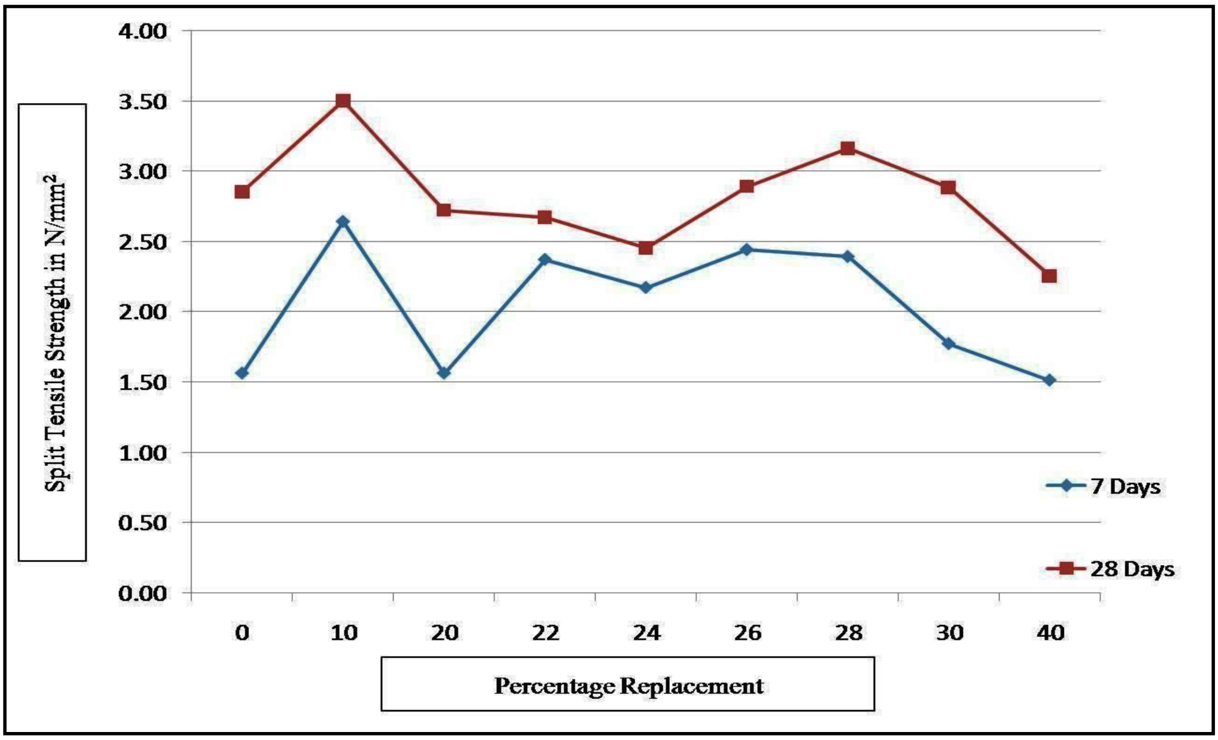

Fig. 3 Split Tensile Strength Variation for Various Replacement Level of Foundry Sand after 7 Days and 28 Days Curing

3.3 Result of Flexural Strength

The maximum strength was observed for the replacement of foundry sand by 28% for 28 days strength and the 7 days strength was seen to be less than 30 % replacement by foundry sand. This shows that the maximum strength was for the replacement of 28-30% by foundry sand.

% **Replacement by Foundry sand**	**Flexural Strength (N/mm^2)**	
	7 Days	**28 Days**
0	2.93	3.95
10	2.82	4.75
20	3.47	6.21
22	2.56	5.84
24	3.79	6.85

26	2.97	5.51
28	5.88	7.15
30	4.85	6.33
40	4.63	6.40

Table 5 Flexural Strength (7& 28 days)

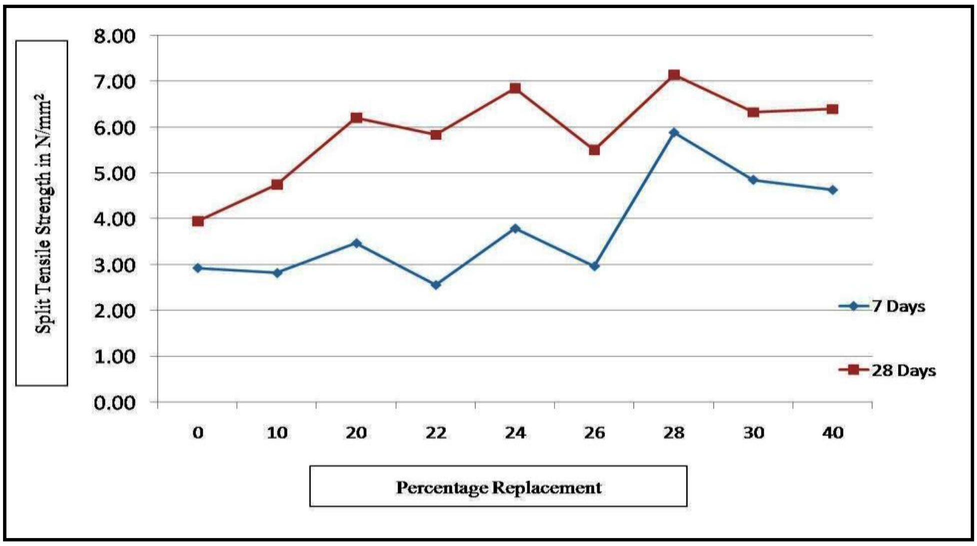

Fig. 4 Flexural Strength Variation for Various Replacement Level of Foundry Sand After 7 Days and 28 Days Curing

4. CONCLUSIONS & FUTURE SCOPE

It is found that the use of foundry sand in the concrete decreases the workability of the fresh concrete to some extent. Though the workability decreases, the strength parameters have shown very promising results. Following are the conclusive findings of the Tests.

4.1 Compressive Strength

By using the foundry sand, the compressive strength is found to be increased by 16% at the 26% replacement level. Though, at high percentage replacement, the strength gain at early stage is slowdown, there is not much effect on the final 28 days strength. The samples are seen be reddish in colour due to the use of foundry sand.

Results are very promising and are very encouraging, it can be concluded that, there is defiantly scope for using the waste foundry sand in the concrete. It is advisable to use the foundry sand between 26 to 30%.

4.2 Tensile Strength

The tensile strength for various percentage replacement of sand by using Foundry Sand shows the similar results for the Tensile strength at 7 and at 28 Days curing. The maximum strength was observed for the replacement of foundry sand by 10% for 28 days strength as well as for the 7 days. The strength decreases after 10 % and then increases after 26 % replacement and reaches to high of 3.16 MPa at 28 % level, then again falls down gradually at 30% and 40%, at 40% replacement the tensile strength is the lowest of all the results showing strength less than the normal mix without Replacement. From these results we can conclude that for better tensile strength and economy, we can use the FS from 26 to 30% as a replacement to the river sand.

4.3 Flexural Strength

The maximum strength was observed for the replacement of foundry sand by 28% for 28 days strength and the 7 days strength was seen to be less than 30 % replacement by foundry sand. This shows that the maximum strength was for the replacement of 28-30% by foundry sand.

4.4 Future Scope

Though the results are positive for most of the combinations, According to various reasons the use of river is increased which increases the over use of natural sand which leads to ageing of river. As we use the foundry sand in percentage variation up to 40%, which reduces the use of river sand which avoids ageing and proper flow of river, and as foundry is a waste product which gives the benefits of using wastage from mechanical industries, and which also reduces the cost of work. Study of chemical properties of concrete with foundry sand can also be done to check chemical attack on concrete

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