Rate of Hydration of Concrete with fine aggregate replaced by 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. Productionof waste foundrysand causes environmental problemsdue toimproper disposal of foundry sand. The study iscarriedout to use maximum foundry sand with retaining the properties of the concrete, and to produce alow-cost andeco-friendly concrete.

In the present work, experimental investigations were performed to calculate comparative study of strength gain of the concrete at early stage of seven days, of 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 and 28 days curing period.

Keywords:- Foundry sand, Fine aggregates, compressive strength.

I. 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 formoulding and casting operations. Type of sand used in foundries is classifiedinto two major groups a) Greensand 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.

Moulding 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.

II. PRODUCTION OF FOUNDRY INDUSTRY IN INDIA AND WORLD

(A) The World Scenario

There are about 36,000 foundries in the world the annual production of the foundries are 90 million tonnes. China has the more number of foundries near about 9374 numbers, followed by India has nearabout 6000 numbers of foundries. Iron foundries are 56%,Steel foundries are 14% and Non-ferrous foundries are 30%. Number of foundries in Europe is 8000 numbers.

Table: No. 01 Country V/S Foundry Production : Scenario Of World

Country	2009		2010		2011	
	M.T.	R	M.T.	R	M.T.	R
China	35.3	1	39.6	1	41.26	1
US	7.4	2	8.24	3	10.01	2
Japan	4.4	4	4.76	5	5.47	4
India	7.4	3	9.05	2	9.99	3
Germany	3.9	5	4.79	4	5.46	5
Brazil	2.3	7	3.24	7	3.34	7
Italy	1.67	9	1.97	9	2.21	9
France	1.74	10	1.96	10	2.04	10
Korea	2.1	8	2.23	8	2.34	8
Russia	4.2	6	4.2	6	4.3	6

M.T. = million tons, R= Rank
Source: Census of World Casting Production

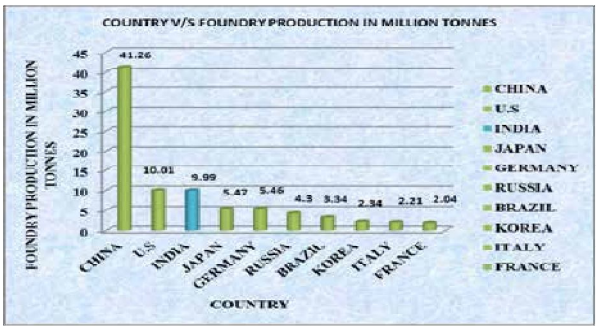

Figure 1 Foundry Production in World
Source: Census of World Casting Production

B) Beneficial Reuse Success Stories Across the Nation

- In California landfill cost is completely saved by use of foundry sand. Recycled and developed manufacturing materials are produced with the waste products.
- Kohler Co. ofWisconsin used 25,000 tons of foundry sand as construction fill material in road construction and building construction projects.
- The waste sand produced by Ford Motor Company's Cleveland Casting Plant reuses 100% waste sand in a wide variety of projects. Since 1994, they have recycled over 1,000,000 tons of spent sand.
- In southeastern Pennsylvania waste sand is used in various alternative uses. Due to this over 80,000 tons of waste sand is recycled.
- Low-strength concrete is produced with the help of waste sand in Ohio. State Environmental Protection Agency and Department of Transportation and foundries, have developed various applications for foundry sand for low strength concrete.
- A Buffalo, New York, foundry made partnership with cement manufacturer and fill manufacturerand used the waste sand of 80000 ton which in stocked on their property from many years. The disposal cost of 80000 ton waste foundry sand is $680,000, which they saved and also got profit on the waste foundry sand.
- For the Cleveland Grand Prix car race, waste sand has been used to make concrete barriers.
- The Grede Foundry plant in Michigan used concrete blocks made from foundry slag for construction of employee training facility, learning centre and lunchroom.

C) The Indian Foundry Industry

In late 19th century in India, Jute industry in Bengal and the cotton industry in Mumbai give encouragement to foundry sector . The factories such as TISCO, Bengal Iron Company and the IISCO used of castings, in domestics and industrial areas. India ranks second in the world based on the number of foundry units present. Total number of units is 4550. There are several unregistered units apart from the registered 4550 units. According to various sources unregistered units range approximately from 1500 to 5000 units. As per the IREDA- CII Report 2004, there are around 10,000 foundry units present in India including registered and unregistered units. As per experts estimation there are around 1500 unregistered foundry units across the country. This discrepancy in unregistered units is mainly due to the fact that the 5450 units included all kinds of micro and small units engaged in castings. Whereas the1500 unit's data incorporates only those foundry units that are engaged in grey iron casting. Due to non-compliance with the pollution standard set by the government several foundry units had closed. Howrah, Agra and nearby area foundry units are closed due to noncompliance of pollution standards. Automobile components, electric motor, railway parts, pipe and pipe fittings, metric weights, are produced in wide variety in foundries.

D) Exports Of Castings From India

The export of Castings from India (both sanitary and industrial combined) has doubled from the year 2001 to 2005. Year-wise break – up of exports is tabulated below: India today ranks tenth among casting exporting countries.

E) Advantages of Foundry Sand

Following are the areas where foundry sand is being successfully used

- Construction Fill / Road Sub base
- Grouts and Mortars
- Cement Manufacturing
- Precast Concrete Products
- Highway Barriers
- Pipe Bedding
- Asphalt
- Brick and Pavers
- Landfill Daily Cover

Table No.2. COUNTRYV/SFOUNDRYPRODUCTIONS: SCENARIOOF WORLD

Year	Sanitary Castings	Industrial Casting	Total
2001-02	524	880	1,404.00
2002-03	609	1,038.00	1,647.00
2003-04	867	1,058.00	1,925.00
2004-05	1,242.00	1,383.00	2,652.00
2005-06	1,530.00	1,467.00	2,997.00
Predicted 2011-12	2,536.00	2,054.00	4,590.00

Sources: Census of World Casting Production

F) Other Engineering Application

- Portland cement manufacturing
- Mortars
- Agriculture /soil amendments
- Verification of hazardous materials
- Smelting
- Rockwool manufacturing
- Fiberglass manufacturing
- Landfill cover or hydraulic barriers.

III. METHODOLOGY OF RESEARCH

Foundry sand is a by-product after casting mould in the casting industries. Highly heighted molten metals are poured in these moulds. 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 hydration rate by evaluating and comparing 7 days and 28 days strengths of various combinations. Therefore M20 grade mix cubes are casted by varying % replacement of sand for 10%, 20%, 22%, 24%, 26%, 28%, 30% and 40%.

Figure No. 02 shows variation of compressive strength of cubes after 7 days and 28 days of curing. It has been found that at 10% replacement of sand, strength results are higher than that of 20%, but as per previous research the results obtained for 20% are higher than 10% as well as 30%.

The change in the result may be due to the quality of foundry sand, quality of binders in the foundry sand before moulding, also it may depend on the heat for which the sand is exposed and the metal for which the sand is used. The foundry sand used in this research was from foundry located in the Chakan MIDC (Dist. Pune, Maharashtra).The casting Industry is manufacturing Automobile spare parts of aluminium alloy. The aluminium is heated to 7100c (+/- 200c) temperature. And the molten material is poured in the dies made up of this sand. After single cycle of casting, the sand is a waste product for the industry and they dispose it off.

Table No.03 Compressive Strength (7& 28 days)

% Replacement by Foundry sand	Compressive Strength (N/mm²)		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

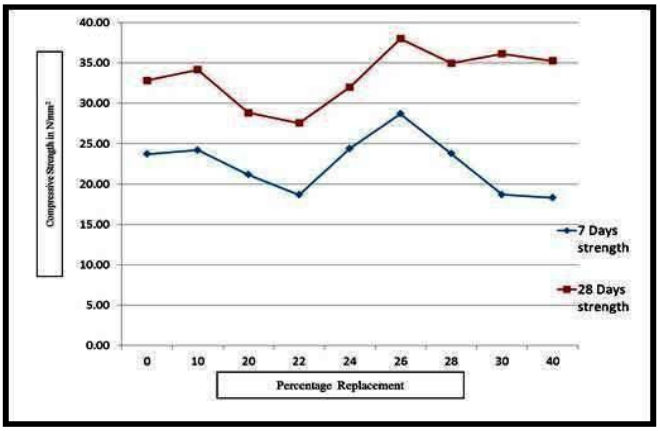

Figure 2: Compressive Strength (7& 28 days)

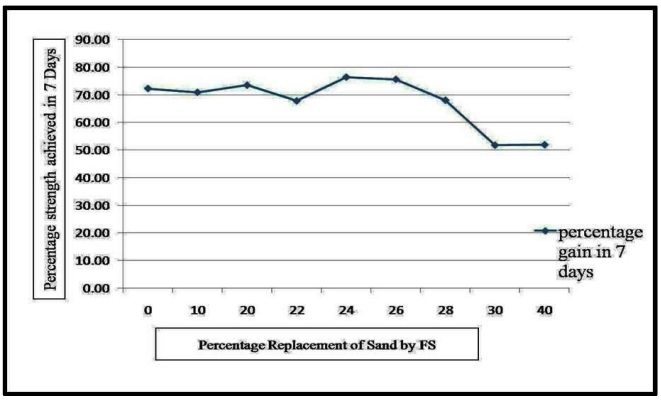

Figure 3: Compressive Strength gain in 7 days curing (7& 28 days)

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.

As the sand is one of the major contributors in the concrete having volume percentage about 35 to 40 % of the

total volume, any change in the properties of 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 compositions, 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 particles 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 6.2.

Generally it is observed in 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 achives 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 prcess 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 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.

IV. CONCLUSION

Sand is an important contributor in the strength of concrete, it is required for effective bonding of cement also for the proper interlocking with coarse aggregate. Therefore the variation of percentage or grading of fine aggregate highly affect the strength of concrete. In the present study following conclusions are highlighted.

- The hydration process at early stage of curing is highly affected at the increased volume percentage of foundry sand in the concrete.
- 26% replacement of sand is effectively possible to increase the strength as well as cost of concrete may also be reduced. 30% of cost of concrete is governed by the cost of sand, Therefore replacement of sand by 26% may reduce the cost of concrete by 5% to 8%.

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