A Study on Utilization of Used Foundry Sand: Opportunities for Economical and Sustainable Concrete

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Abstract- *Used foundry sand is the byproduct from metal casting foundries. In Metal foundries huge numbers of the metal casting processes have been done. In Foundries they strongly reuse and recycle the sand number of times in a foundry, the remaining sand that is defined as foundry sand which is removed from foundry. Foundry sand is uniform in size, rich quality silica sand that is combined with a binder and used to configure molds for ferrous and nonferrous castings. Due to the various types of equipments used for foundry processing, used foundry-sand properties may vary. The huge number of times the sand is reused. In the concrete production industry, the most fruitful examples have been using coal fly ash to form durable, high-quality concrete and recycling old; destroy concrete as aggregate for new concrete. This analysis presents the knowledge about the favorable circumstances for economical and sustainable concrete. Uses of used foundry sand, which is technically, sound, environmentally safe for feasible development. Use of used foundry sand in different engineering applications can solve the problem of disposal of used foundry sand and other functions. Foundry sand exists primarily of silica sand, coated with a thin film of burnt carbon, residual and dust. To enhance the strength and other durability factors foundry sand can be used in concrete. Foundry Sand can be used as a partial replacement of as a partial replacement of fine aggregates, cement or total replacement of fine aggregate to achieve different properties of concrete.*

Keywords- foundry sand, foundry waste, concrete, strength, industrial waste, utilization

I. INTRODUCTION

Foundry sand contains rich quality silica sand with consistent physical characteristics. Because of its thermal conductivity property sand has been used for centuries as a molding material ,foundry sand is a by- product of ferrous and nonferrous metal casting industries. It is a byproduct which we found from the production of ferrous and nonferrous metal castings .The Main characteristics like, physical and chemical characteristics of foundry sand will rely on the form of casting process and the industry from which it come from . In modern foundries, through many production cycles, sand is basically recycled and reused. Industry calculates that yearly approximately 100 million tons of sand is used in manufacturing processes out of which only 6 - 10 million tons are discarded yearly and are available to be recycled into other works. Major generators of foundry are automobile industries. Foundries buy good quality size-specific silica sands for use in their molding and casting processes. The raw sand is usually of a good quality than the natural sands used in construction sites. These sands generally depend upon a slight quantity of bentonite clay to perform as the binder material. Chemical binders are also useful to produce sand "cores". Rely upon the geometry of the casting, sands cores are introduced into the mold cavity to make internal passages for the molten metal.

The casting is separated from the molding and core sands in the shakeout process, once the metal has solidified.

Molding sands are recycled and reused number of times, in the casting process. Ultimately, the recycled sand weakens to the point that it cannot reused longer in the casting processes. Now the time comes where, the old sand is displaced from the cycle as byproduct and new sand is received, and the cycle starts again.

II. MANUFACTURING OF FOUNDRY INDUSTRY IN INDIA AND WORLD

A. The World Scenario

Annual production of 90 million tons in 35,000 foundries in the world. China has highest number of foundries (9374), followed by India (6000). There are maximum Iron foundries 56% followed by steel with 14%and then the non-ferrous with 30%. The upcoming environmental issues like globalization of recession have led to a closure of almost8000 foundries in Europe. These countries have been intended to

shift their business to the low labour cost countries like China and India.

Table I. 1COUNTRY V/S FOUNDRY PRODUCTION: SCENARIO OFWORLD

COUNTRY	M.T. (million tons)	R (Rank)	M.T. (million tons)	R (Rank)	M.T. (million tons)	R (Rank)
China	35.3	1	39.6	1	41.26	1
US	7.4	2	8.24	3	10.01	2
India	7.4	3	9.05	2	9.99	3
Japan	4.4	4	4.76	5	5.47	4
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

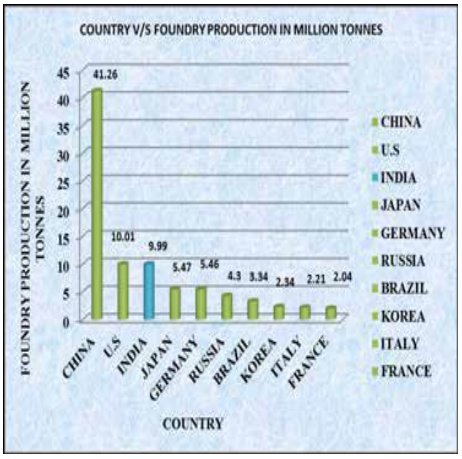

Figure 1: World Foundry Production
Source: Census of World Casting Production

B. Foundry Industries In The INDIA

The Jute industry gives the motivation for foundry sector in India in Bengal and in late 19th century cotton industry in Mumbai. The organizations of TISCO, Bengal Iron Company and the IISCO manage some notable new uses of castings, in industrial as well as domestic areas. Based on the number of foundry units in the world India ranks second with (4550 units) - after China – and stands fourth in terms of total production (7.8 million tons) (According to 42nd Census of World Casting Production - 2007). There are several unregistered units, apart from the registered 4550 units which according to different sources range approximately from 1500 to 5000 units. As per the IREDA- CII Report 2004, presently in India there are around 10,000 foundry units including registered and nonregistered units. By considering, there are 4550 units which are registered, and there are 5450 units are unregistered. As per Calculation by the experts of the foundries, there are around 1500 unregistered foundry units which are scattered across the India. This variation in nonregistered units is because of the 5450 units included all sort of micro and small units taking parts in castings. In fact the1500 units data includes only those foundry units that are matched use conventional cupola and in grey iron casting and excludes those units that are too micro in nature and use crucible for melting of metals. Various foundry units had closed due to refusal with the pollution parameters set by the Government of INDIA for example Agra, Howrah .Actually foundry manufactures a huge range of variety of castings like pipe and pipe fittings ,manhole covers, automobile components, sanitary wares, tube well body, railway parts, electric motor etc.

C. Exports Of Castings Scenario From India

The export of castings scenario from the country like India (both industrial and sanitary)has observed a linear growth year after year .In 2001-02 total export is Rs.1,404crores to Rs.2,997 crores in 2005-06, scenario was satisfactory as it gets almost doubled in the considered five years. Today India ranks tenth between the casting exporting countries.

Table 2: Country V/S Foundry Productions Scenario Of World

Year	Sanitary Castings	Industrial Casting	Total
2001-02	524.00	880.00	1,404.00
2002-03	609.00	1,038.00	1,647.00
2003-04	867.00	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

D. Foundry Clusters Of India

Figure: 2 Foundry Clusters
Source: Institute of Indian Foundry Man

III. AREA OF UTILIZATION

For a variety of beneficial reuses foundry sand can be used. The purpose of this study, common benefits of sand in asking with industry Experts. Following are benefits of foundry sand approved in one or more cases:

A. Structural Fill

For structures like roadways, parking lots, buildings foundry sand can be used. Use of a liner, cap in generally made of a clay material in encapsulated structural fill which will not allow water from percolating through the foundry sand and reduces the potential for percolate.

B. Manufacturing of Different Products

Foundry sand is useful as a raw material In manufacturing products, like controlled, low-strength material (CLSM or flow able fill),asphalt, roofing materials, cement, concrete, grout, lightweight aggregate, bricks, plastics, paint, glass, ceramics, concrete blocks.

C. Specific examples of these uses include:

Flow able fill: Flow able fill is similar to liquid material that is used as an alternative for conventional soil backfill and self-compacts and is used as alternative for typical soil backfill. The transportation of this product is easily possible and can be easily re -excavated. The conventional mixture involves portland cement, sand, fly ash, and water. Foundry sand can be easily alternative for virgin sand in flow able fill mixtures. Cement and Concrete: Main component of Portland cement and concrete is sand. At least 80 percent of Portland cement requires sand with a silica content, which fits most foundry sands .In many foundry sands certain minerals such as iron and aluminum oxides certain minerals such as iron and aluminum oxides. Components of concrete are Cement and additional sand or gravel, granting further reuse of foundry sand.

D. Soil Manufacturing and Amendment

Commercially soil mixing operations can utilize foundry sand to produce potting soil, horticultural soils and turf mixes which are commonly mixtures of sand or gravel with peat, fertilizers, and top soil. Foundry sand can be used as a composting ingredient as it can also improve the performance of agricultural soils.

IV. TYPES OF FOUNDRY SAND

In metal casting two general types of binder systems are used depending upon which the foundry sands are divided as chemically- bonded systems and clay bonded systems (Green sand). These types of sands are useful but they carry different physical and environmental characteristics.

In the U.S. green sand molds are used for production about 90% of casting volume .Green sand consisting of naturally occurring materials which are mixed together bentonite clay(4-10%) ,high quality silica sand (85-95%), as a binder, a carbonaceous additive (2-10%) to becoming better the casting surface finish and water (2- 5%). For beneficial reuse Green sand is the most commonly used recycled foundry sand. Due to carbon content its color is black, has a clay content that results in percentage of material that passes a 200 sieve and adheres together because of clay and water. For core making where high strengths are essential to withstand the heat of molten metal and in mold making chemically bonded sands are used. Chemically bonded sands are generally light in texture and light in color than clay bonded sands.

Figure: 3 chemically bonded sands
Source: Foundry Industry, MIDC, Jejuri, Pune, Maharastra

V. PHYSICAL CHARACTERISTICS OF FOUNDRY SAND

Shape of foundry sand is basically sub angular to round in. Considerable number of sand agglomerations after being

Used in the foundry process. The shape of individual sand grains is possible, when these are broken down. Green sands are basically gray or black, not green chemically bonded sand is typically a medium tan or off-white color the unprocessed foundry sand and green sand respectively.

A. Typical Physical Properties Of Spent Green Foundry Sand

Table3:TYPICAL PHYSICAL PROPERTIES OF SPENT GREEN FOUNDRY SAND

[American Foundry man's Society, 1991]

Property	Results	Test Method
Specific Gravity	2.39-2.55	ASTM D854
Bulk Relative Density, kg/m3 (lb/ft3)	2589(160)	ASTMC48 / AASTHO T84
Absorption, %	0.45	ASTM C128
Moisture content, %	0.1-10.1	ASTM D2216
Clay Lumps and Friable Particles	1-44	ASTM C142/ AASTHO T112
Coefficient of Permeability (cm/sec)	10-3-10-6	AASTHO T215/ ASTM D2434
Plastic Limit/Plastic Index	Non plastic	AASTHO T90/ ASTM D4318

Source: R. Siddique, Waste Materials and By-Products in Concrete, Springer-2008

B. Chemical Composition Of Foundry Sand

Table 4: Chemical Composition of Foundry Sand

Constituent	Value (%)
SiO_2	87.91
Al_2O_3	4.7
Fe_2O_3	0.94
CaO	0.14
MgO	0.3
SO_3	0.09
Na_2O	0.19
K_2O	0.25
TiO_2	0.15
P_2O_5	0
Mn_2O_3	0.02
SrO	0.03
LOI	5.15
TOTAL	99.87

Source: R. Siddique, Waste Materials and ByProductsin Concrete,
Springer-2008

VI. EXPERIMENTAL STUDY

In the present experiment study, effect of foundry sand as fine aggregate replacement on the compressive strength of concrete having mix proportions of 1:2.05:3.45 was investigated. The percentages of replacements were 0%, 10 %, 20%, 30%and 40 % by weight of fine aggregate. Tests were performed to calculate fineness modulus for all replacement levels of foundry sand

Table 5: Sieve Analysis of Fine Aggregate at 0% replacement level

Sr. No.	Sieve No.	Mass Retained (gms)	Percentage Retained,%	Percentage Passing,%	Cumulative %age Retained
1	4.75	2	0.10	99.90	0.10
2	2.36	197	9.85	90.05	9.95
3	1.18	456	22.80	67.25	32.75
4	600	299	14.95	52.30	47.70
5	300	572	28.60	23.52	76.30
6	150	357	17.85	5.05	94.15
7	Pan	116	5.80	0.03	99.95
Fineness Modulus of Fine Aggregate=2.60					∑F= 260.9

Table 6: Sieve analysis of Fine Aggregate at 10% replacement level

Sr. No.	Sieve No.	Mass Retained (gms)	Percentage Retained, %	Percentage Passing %	Cumulative % Retained
1	4.75	312	15.6	84.4	15.6
2	2.36	280	14	70.4	29.6
3	1.18	374	18.7	51.7	48.3
4	600	195	9.75	41.95	58.05
5	300	538	26.9	15.5	84.95
6	150	240	12	3.05	96.95
7	Pan	61	3.05	---	---
Fineness Modulus of Mixture=3.334					∑F= 333.4

Table 7: Sieve Analysis of Fine Aggregates at 20% replacement level

Sr. No.	Sieve No.	Mass Retained (gms)	Percentage Retained, %	Percentage Passing, %	Cumulative % Retained
1	4.75	240	12	88	12
2	2.36	269	13.45	74.55	25.45
3	1.18	361	18.05	56.5	43.5
4	600	190	9.5	47	53
5	300	472	23.6	23.4	76.6
6	150	415	20.75	2.6	97.35
7	Pan	53	2.65	---	---
Fineness Modulus of Mixture=3.079					∑F=307.9

Table 8: Sieve Analysis of Fine Aggregates at 30% replacement level

Sr. No.	Sieve No.	Mass Retained (gms)	Percentage Retained, %	Percentage Passing, %	Cumulative % Retaine
1	4.75	130	6.5	93.5	6.5
2	2.36	182	9.1	84.4	15.6
3	1.18	304	15.2	69.2	30.8
4	600	188	9.4	59.8	40.2
5	300	573	28.65	31.5	68.85
6	150	556	27.3	27.3	96,65
7	Pan	67	3.35	---	---
Fineness Modulus of Mixture = 2.586					∑F=258.6

Table: 9 Sieve Analysis of Fine Aggregates at 40% replacement level

Sr. No.	Sieve No.	Mass Retained (gms)	Percentage Retained, %	Percent-age Passing, %	Cumulative % Retained
1	4.75	106	5.3	100	5.3
2	2.36	158	7.9	94.7	13.2
3	1.18	256	12.8	86.8	26
4	600	172	8.6	74	34.6
5	300	580	29	65.4	63.6
6	150	671	33.55	36.4	97.15
7	Pan	57	-	2.85	-
Fineness modulus of mixture = 2.398					∑F=239.85

VII. CONCLUSIONS

We can say that Fineness modulus for 0% replacement level (Fine aggregate) is 2.60, Fineness modulus for 10% replacement level is 3.334, Fineness modulus for 20% replacement level is 3.079, Fineness modulus for 30% replacement level is 3.334, Fineness modulus for 40% replacement level is 2.398. Environmental issues from disposal problems of waste can be minimize through this research. An innovative supplementary Construction Material is formed through this study.

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