A STUDY OF FOUNDRY SAND: OPPORTUNITIES FOR SUSTAINABLE AND ECONOMICAL CONCRETE

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**ABSTRACT:**

Foundries for the metal-casting industry generate by- products such as used foundry sand. Metal foundries use large amounts of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry and the remaining sand that is termed as foundry sand is removed from foundry. Foundry sand is uniformly sized, high quality silica sand that is combined with a binder and used to form molds for ferrous and nonferrous castings. Used foundry-sand properties vary due to the type of equipment used for foundry processing, the types of additives, the number of times the sand is reused, and the type and amount of binder. Within the concrete industry, the most successful examples have been using coal fly ash to make high-quality, durable concrete and recycling old, demolished concrete as aggregate for new concrete. This study presents the information about the opportunities for sustainable and economical concrete. Applications of foundry sand, which is technically, sound, environmentally safe for sustainable development. Use of foundry sand in various engineering applications can solve the problem of disposal of foundry sand and other purposes. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of cement or as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition to achieve different properties of concrete.

**INTRODUCTION**

Foundry sand is high quality silica sand with uniform physical characteristics.It is a by- product of ferrous and nonferrous metal casting industries, where sand has been used for centuries as a molding material because of its thermal conductivity. It is a byproduct from the production of both ferrous and nonferrous metal castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. In modern foundry practice, sand is typically recycled and reused through many production cycles. Industry estimates that approximately 100 million tons of sand is used in production annually of that 6 - 10 million tons are discarded annually and are available to be recycled into other products and in industry. The automotive industries and its parts are the major generators of foundry sand. Foundries purchase high quality size-specific silica sands for use in their molding and casting operations. In the casting process, molding sands are recycled and reused multiple times. Eventually, however, the recycled sand degrades to the point that it can no longer be reused in the casting process. At that point, the old sand is displaced from the cycle as byproduct, new sand is introduced,

and the cycle begins again.

**THE INDIAN FOUNDRY INDUSTRY**

The impetus for foundry sector in India was given by the Jute industry in Bengal and the cotton industry in Mumbai in late 19th century. The establishment of TISCO, Bengal Iron Company and the IISCO led to

some remarkable new uses of castings, in domestic as well as industrial areas .India ranks second in the world based on the number of foundry units present (4550 units) - after China – and fourth in terms of total production(7.8 million tones) (42nd Census of World Casting Production– 2007). As per the IREDA- CII Report 2004, there are around 10,000 foundry units present in India including registered and unregistered units. Considering that 4550 units are registered, the total number of units unregistered is around 5450 units. 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 units data incorporates only those foundry units that are engaged in grey iron casting and use conventional cupola and excludes those units that are too micro in nature and use crucible for melting of metals. Also several foundry units had closed due to non compliance with the pollution standard set by the government for example Howrah, Agra and nearby areas.



**AREA UTILIZATION**

Foundry sand can be suitable for a variety of beneficial reuses. Terminology for defining uses varies across states. For the purposes of this study, common uses of sand in consultation with industry experts. The following are uses of foundry sand approved in one or more states:

**Structural Fill**

Foundry sand can be used as support for structures such as roadways, parking lots, buildings, and pieces of equipment. "Encapsulated" structural fill may involve the use of a liner, cap, or cover, generally made of a clay material, which prevents water from percolating through the foundry sand and minimizes the potential for leaching.

**Manufacturing another Product**

Foundry sand is useful as a raw material in manufacturing other products, such as controlled, low-strength material (CLSM or flowable fill), asphalt, cement, concrete, grout, lightweight aggregate, concrete block, bricks, roofing materials, plastics, paint, glass, ceramics, and Rock wool.

**Specific examples of these uses include:**

• Flowable fill: Flowable fill is a liquid-like material that self-compacts and is used as a substitute for conventional soil backfill. The

product is easily transported and can be readily re-excavated. The typical mixture contains sand, fly ash, portland cement, and water. Foundry sand can readily be substituted for virgin sand in flowable

fill mixtures.

• Cement and Concrete: Sand is acomponent of Portland cement and concrete. Portland cement requires sand with a silica content

of at least 80 percent, which most foundry sands meet. It also requires certain minerals such as iron and aluminum oxides, which

are found in many foundry sands. Cement and additional sand or gravel are components of concrete, allowing further reuse offoundry sand.

**Soil Manufacturing and Amendment**

Commercial soil blending operations can use foundry sand to produce horticultural soils, topsoil, potting soil, and turf mixes. These soil products are typically mixtures of sand or gravel with peat, fertilizers, and/or

top soil. Foundry sand can also improve the performance of agricultural soils, and can be used as a composting ingredient.

**Landfill Uses**

Foundry sand can be used as a cover for the working face of an active landfill, for road construction within the active cell, or as a substitute for virgin aggregate in the construction of drainage layers for landfill

leachate collection systems.

**Pipe Bedding and Backfill**

Foundry sand can serve as backfill for trenches created by the installation

of storm and sanitary sewer lines.

**TYPES OF FOUNDRY SAND**

Two general types of binder systems are used in metal casting depending upon which the foundry sands are classified as: clay bonded systems (Green sand) and chemically- bonded systems. Both types of

sands are suitable for beneficial use but they have different physical and environmental characteristics Green sand molds are used to produce about 90% of casting volume in the U.S. Green sand is composed of naturally occurring materials which are blended together; high quality silica sand (85-95%), bentonite clay (4-10%) as a binder, a carbonaceous additive (2-10%) to improve the casting surface finish and water (2- 5%). Green sand is the most commonly used recycled foundry sand for beneficial reuse. It is black in color, due to carbon content, has a clay content that results in percentage of material that passes a 200 sieve and adheres together due to clay and water.Chemically bonded sands are used both in core making where high strengths are necessary to withstand the heat of molten metal, and in mold making. Most chemical binder systems consist of an organic binder that is activated by a catalyst although some systems use inorganic binders. Chemically bonded sands are generally light in color and in texture than clay bonded sands

.

**TYPICAL PHYSICAL PROPERTIES OF SPENT GREEN FOUNDRY SAND**

Foundry sand is typically sub angular to round in shape. After being used in the foundry process, a significant number of sand agglomerations form. When these are broken down, the shape of individual sand

grains is apparent.

|  |  |  |
| --- | --- | --- |
| Property | Results | Test method |
| Specific gravity | 2.39-2.55 | ASTM D854 |
| Bulk relative density, kg/m3 | 2589(160) | ASTMC48 / AASTHO T84 |
| Absorption,% | 0.45 | ASTM C128 |
| Moisture content,% | 0.1-10.1 | ASTM D2216 |
| Clay, lumps and friable particle | 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 |

**CHEMICAL COMPOSITION OF FOUNDRY SAND**

|  |  |
| --- | --- |
| CONSTITUENTS | VALUE(%) |
| Sio2 | 87.91 |
| Al203 | 4.70 |
| Fe203 | 0.94 |
| Ca0 | 0.14 |
| Mg0 | 0.30 |
| So3 | 0.09 |
| Na203 | 0.19 |
| K20 | 0.25 |
| Ti02 | 0.15 |
| Sro | 0.03 |
| L0I | 5.15 |



Green Sands from a gray iron Industry

**ADVANTAGES OF FOUNDRY SAND**

* In Embankments
* In Barrier layers construction
* In Flowable fills
* In Road way construction
* As Soil reinforcement
* In Hot mix asphalt
* In Portland cement concrete

**Other Engineering Application:**

 Portland cement manufacturing

 Mortars

 Agriculture /soil amendments

 Verification of hazardous materials

 Smelting

 Rockwool manufacturing

 Fiberglass manufacturing

**CASE STUDY**

In the present study, effect of foundry sand as fine aggregate replacement on the compressive strength of concrete having mix proportions of 1:1.45:2.20:1.103 was investigated. The percentages of replacements were 0%, 10 %, 20% and 30 % by weight of fine aggregate. Tests were performed for compressive strength for all replacement levels of foundry sand at different curing periods (28-days & 56days).

**PROPORTION OF M-20 GRADE CONCRETE**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| MIX | C kg/m3 | F.A.kg/m3 | C.A(10mm)Kg/m3 | C.A(20mm)Kg/m3 | F.SKg/m3 | WLit/m3 | PLit/m3 |
| M-1 | 372 | 538.4 | 410.4 | 818.5 | 0 | 186 | .28 |
| M-2 | 372 | 538.4 | 410.4 | 818.5 | 54 | 186 | .38 |
| M-3 | 372 | 538.4 | 410.4 | 818.5 | 108 | 186 | .38 |
| M-4 | 372 | 538.4 | 410.4 | 818.5 | 162 | 186 | .38 |

C=Cement, F.A. =Fine Aggregate,

C.A. =Course Aggregate, F.S.=Foundry Sand, W=Water, P= Plasticizer

**COMPRESSIVE STRENGTH (MPA) OF CONCRETE WITH FOUNDRY SAND**

|  |  |  |  |
| --- | --- | --- | --- |
| **Foundry sand** | **Content,****%** | **mix** | **Avg compressie strength** |
|  | **28 days** | **56days** | **0** |
| **M1** | **28.50** | **32.80** | **10** |
| **M2** | **29.7** | **33.13** | **20** |
| **M3** | **30.00** | **34.50** | **30** |
| **M4** | **31.30** | **37.50** |  |

**LIMITATION**

 Foundry sand is black. In some concretes, this may cause the finished concrete to have a grayish/black tint, which may not be desirable.

 A 15% fine aggregate replacement with foundry sand produces a minimal color change.

 Also, the foundry must be able to meet the quantity requirements of the precast manufacturer.

 Foundry sand reduced workability of concrete

**CONCLUSIONS**

We can say that for 1m3 M20 grade of concrete consumption of fine aggregate

is 538.45 kg. Here in specimen M-4 we replace fine aggregate by 162 kg of foundry sand for 1m3 M20 grades of concrete. So, we can say that up to 30% foundry sand utilized for economical and sustainable

development of concrete. Uses of foundry sand in concrete can save the metal industry disposal costs and produce a ‘greener’ concretefor construction. An innovative supplementary Construction Material is

formed through this study.

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